Folder Title:	Screening Study (Phase II) for Transmigration Settlement Development - Data Supplement - Jambi Province and Agricultural Supplement - SKP in Kab Musi Rawas, Sumatera Selatan - May 1983 - Halcrow Fox and Associates in co-operation with Indulexco
Folder ID:	30093723
Series:	Indonesia project and research reports (English)
Dates:	05/01/1983 - 05/31/1983
Fonds:	Personal papers of Gloria Davis
ISAD Reference Code:	WB IBRD/IDA DAVIS-11
Digitized:	05/04/2023

Screening Study (Phase II) Data Supplement and Agricultural Supplement

REPUBLIC OF INDONESIA
MINISTRY OF PUBLIC WORKS, DIRECTORATE GENERAL OF HOUSING, BUILDING, PLANNING AND URBAN DEVELOPMENT (CIPTA KARYA)

SCREENING STUDY (PHASE II) FOR TRANSMIGRATION SETTLEMENT DEVELOPMENT

DATA SUPPLEMENT : JAMBI PROVINCE

SOUTHERN SUMATRA TRANSMIGRATION DEVELOPMENT

HALCROW FOX AND ASSOCIATES in co-operation with
INDULEXCO - PARAMA CONSORTIUM

MAY 1983

CONTENTS

LIST OF TABLES PAGE

LIST OF FIGURES

FOREWORD

In preparing the Phase II studies of six study areas in Jambi Province it was necessary to collect data on three subjects (climate, water resources and agricultural development possibilities) on a provincial basis because of both the limited inputs of the particular team members and the generalised nature of much of the data, analysis and conclusions. Therefore, whilst the specific Phase II reports contain data, conclusions and recommendations relevant to that study area this information is drawn from a much larger body of more general data and analysis.

To avoid duplication of the background data in each Phase II report this Data Supplement has been produced and covers three main topics:

PART 1 - CLIMATE contains meteorological data collected from five meteorological stations lying close to the study areas (see Fig. 1.1). From this data estimates have been made of the likelihood of 5, 10, 15 and 20 day droughts.

PART 2 - WATER SUPPLY examines the present sources of drinking water supply used by the people living in, or close by, the study areas, the quality of the water and the potential for future ground water supplies based on hydrogeological data.

PART 3 - AGRICULTURE reviews present farming methods practiced by local farmers in or close to the study areas and, in particular, on existing transmigration settlements in Jambi Province. In addition it examines alternative methods of land clearing. It should be noted that the data for this part of the Data Supplement was collected during field visits, and from other sources, in December 1982. As a result of the devaluation of the rupiah against the US $ by 38% in March 1983, many of the costs used (especially for fully mechanised land clearing) will now be underestimates.

Finally an evaluation is made of twelve possible cropping models and general recommendations are made for the agricultural development of future transmigration areas on the red-yellow podzolic soils of Sumatra.

PART 1 CLIMATE

1.1 GENERAL

The climate of the study areas varies little throughout the year; the mean temperature is about 26°C and the mean relative humidity about 83%. Average annual rainfall is between 2300 and 2500 mm and mean monthly rainfall varies between about 100 mm and 320 mm.

In Köppen's climate classification the study areas are therefore all classed as Af : Tropical rainy climate with no dry season, as described in Table 1.1.

TABLE 1.1 KÖPPEN'S CLIMATE CLASSIFICATION FOR THE STUDY AREAS

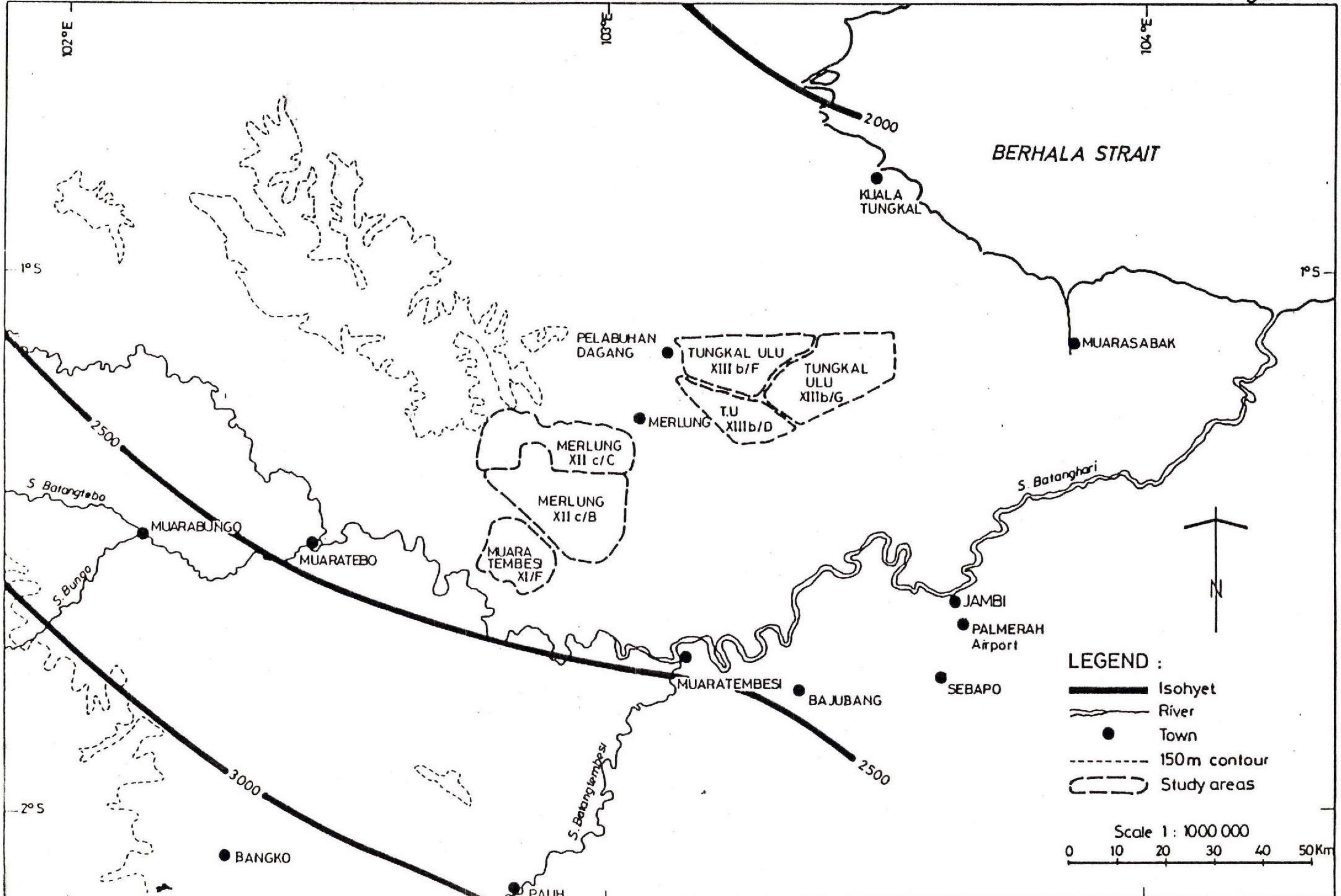
		Description	Criteria
Main Group	A	Tropical Rainy Climate	Mean temperature of coldest month greater than 18°C
Subdivision	f	No dry season	Mean rainfall of driest mon greater than 60 mm
Further subdivision	a	Hot summer	Mean temperature of warmest month greater than 22°C
	i	Isothermal	Annual temperature range less than 5°C.
	m	Monsoon type of tropical climate	

Simple description : Af
Detailed description : Afaim

The nearest climate station to the study areas is at Pelabuhan Dagang, but this was only opened in late November 1982. The most useful meteorological station is Palmerah Airport, a few kilometers south of Jambi, which has a relatively good record of monthly data from 1971. Table 1.2 lists average monthly meteorological values for Palmerah. There is no evaporation pan at the station, and the Table does not include windspeeds as the anemometer registers only relatively high velocities. Table 1.3 lists climatic data (except rainfall) from stations around the study areas. The table shows

JAMBI PROVINCE MEAN ANNUAL RAINFALL (mm)

Figure : 1.1



that all four meteorological parameters appear to be stable within the region and this justifies the adoption of Palmerah data as representative of the study areas. The higher windspeeds at Rengat may represent a local difference, or may be due to the method used to calculate average values.

1.2 RAINFALL

The map of annual average rainfall (Fig. 1.1) has been prepared using all stations with five years of record or more. The resulting isohyets are similar to those given in the Meteorological Office map of Sumatra (Ref.8) and by Binnie and Partners (Ref. 1). As average rainfall often increases with altitude, it is likely that rainfall is higher over the Tigapuluh mountains. The 150 m contour is therefore shown on Fig. 1.1, but as there are no raingauges within this area it is not possible to tell if rainfall is higher, nor to estimate the significance of the effect.

Mean monthly rainfalls are presented in Fig. 1.3 for a number of stations, which all show a similar pattern. Climatic variations during the year are mainly controlled by the north west and south east monsoon circulations, and by the location of the Inter-Tropica Convergence Zone (ITCZ), an area of convergence and instability where the two opposing monsoon circulations meet.

The main wet season occurs during the dominance of the moist north west monsoon from October to January. The driest season occurs during the dry south east monsoon period from May to August. Rainfall will tend to occur when the ITCZ is at its furthest from the study areas, in July (furthest north) and January (furthest south). However, this effect is not apparent with the western rainfall variations of Fig. 1.2 in January, although it is largely responsible for the slight decrease in February rainfalls. A secondary rainfall peak occurs in March and April associated with the change from the north west to south east monsoon and the northward passage of the ITCZ.

Mean monthly rainfalls are considerably in excess of potential evapotranspiration (discussed below) in the wet season, and similar to it in the driest months. However, monthly rainfall is highly variable from year to year, as shown by the high coefficients of variation in

Table 1.2 and even a month with a high average may in some years have significantly low rainfall.

Table 1.4 shows the probability of drought sequences of 10,15 and 20 days occurring within the main growing seasons. A drought is considered to occur if within the stated duration no day has a rainfall of 5 mm or more. Table 1.5 shows the number of 5 day droughts in each month, and Table 1.6 shows the average number of raindays.

Temperature (Tables 1.2 and 1.3)

Mean temperature varies little throughout the year, the higher temperatures occurring in May to August. The mean daily range is about 9-10°C.

Relative humidity (Tables 1.2 and 1.3)

Mean relative humidity also varies little throughout the year, being lowest between June and October. The pattern of diurnal variation is inversely related to temperature, being lowest at mid-day or a little later, and rising to a constant value near 100% at night.

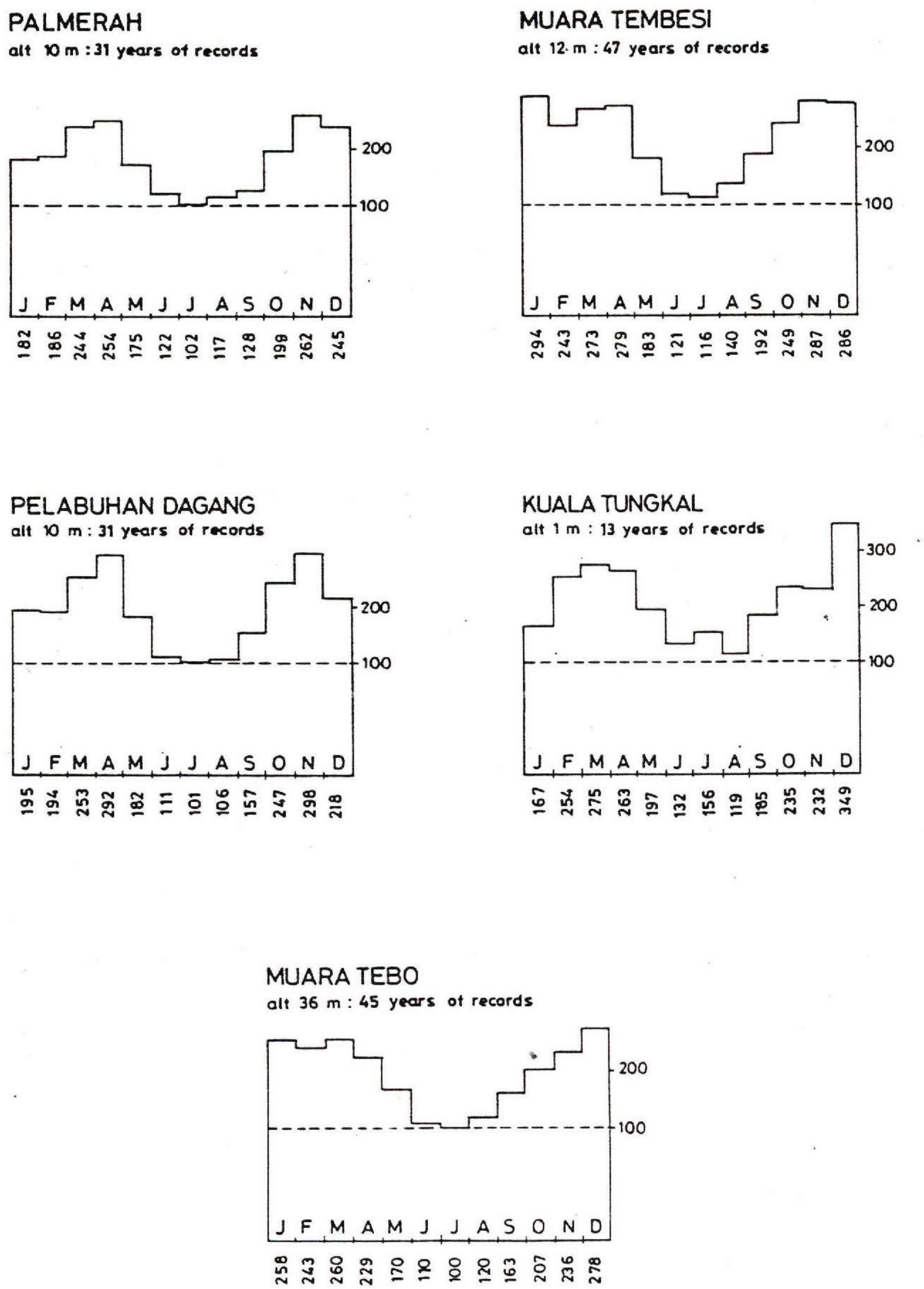
Sunshine (Tables 1.2 and 1.3)

The percentage sunshine (or sunshine hours) in a month is quite variable, as shown by the coefficient of variation in Table 1.2. Sunshine is greatest between May and August, and during November to February falls to nearly two-thirds of that of the greatest month. Values presented in Table 1.2 are the percentage of sunshine between 8 am and 4 pm.

Windspeed (Table 1.3)

There is a dearth of reliable windspeed information. Data for meteorological stations west of the study area indicate average wind runs of 48-86 km/day. Totalizer anemometer readings at Pasir Putih indicate a range of only 45 to 83 km/day, with an average over 44 months of 53 km/day.

MONTHLY RAINFALL **Figure: 1.2**



AVERAGE MONTHLY RAINFALLS IN mm SHOWN BELOW DIAGRAMS

1.3 EVAPORATION

The Penman method has been used to estimate open water evaporation and potential evapo-transpiration. Initially, estimates were made for Belitang (04°09'S 104°39'E), an agro-meteorological station which appears to have reasonably reliable records since 1972 of all the required meteorological variables for the Penman method and also pan evaporation. These estimates were made to select the empirical coefficients in the Penman method; Penman's original (1948) coefficients with wind terms recommended by FAO Paper 24 (Ref.4) gave an estimate close to that obtained from the pan record. In addition, average monthly values of meteorological values gave similar evaporation estimates to the average of individual estimates for each month of record.

Open water evaporation and potential evapo-transpiration were then estimated for Palmerah Airport, using the average monthly values of temperature, relative humidity and sunshine in Table 1.2. A short length of record (May 1979 - February 1982) from Pasir Putih, two or three kilometers from Palmerah, was used to supplement the Palmerah record of sunshine and wind. Sunshine data for 0800 to 1600 at Palmerah was converted to 'whole day' values using a close relationship derived for Pasir Putih. The average wind run of 53 km/day observed at Pasir Putih was distributed according to the apparent monthly distributions at Palmerah and Pasir Putih.

The annual potential evapo-transpiration (Et) was estimated at 1275 mm, distributed monthly as shown in Table 1.7. Table 1.8 summarises evaporation estimates from other reports; differences are largely due to the empirical coefficients selected and the type and quality of the available data. The annual evapo-transpiration estimate of 1275 mm is within the range of the other estimates and the method adopted is considered to be more accurate. Considerations of data uncertainty might raise the Et to about 1320 mm/day (or 110 mm/month). However, Binnie and Partners (Ref. 1) obtain a westward decrease of Et from Palmerah, and adopted the highly value for Palmerah, but allowing for this westward decrease would revise the estimate back to 1250-1300 mm/year for the study areas.

TABLE 1.2

CLIMATE AT PALMERAH AIRPORT

PALMERAH AIRPORT (JAMBI)
BMG (Met. Office) No. : 175 b
Location : 01°38' S 103°39' E
Period : 1971-1982 (Sept)
Altitude : 10 m

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Mean temperature (°C)	25.6	25.8	26.1	26.2	26.4	26.6	26.2	26.3	26.1	26.3	26.0	25.7	26.1
Coeff of variation	2.3	1.6	1.5	1.4	2.1	3.0	1.6	1.9	2.0	1.5	1.4	1.5	
Max temperature (°C) *	30.8	31.2	31.9	32.1	32.3	32.0	32.0	32.1	32.0	32.2	31.5	30.9	32.0
Min temperature (°C) *	22.3	22.3	22.6	22.8	22.8	22.5	22.1	22.2	22.1	22.4	22.4	22.6	22.4
Mean Relative Humidity (%)	83	85	85	86	85	83	82	81	82	83	85	86	84
Coeff of variation	1.9	2.4	1.8	1.3	2.2	2.1	2.3	4.4	3.3	2.4	1.8	1.8	
Sunshine (% 08-16 hrs)	43	41	47	48	55	60	59	59	41	47	41	42	49
Coeff of variation	27	31	25	19	17	28	19	26	37	23	22	27	
Mean Monthly Rainfall (mm)	182	186	244	254	175	122	102	117	128	199	262	245	2216
Coeff of variation	45	39	30	37	31	44	46	53	50	48	36	24	

Note : * 1971-1979

TABLE 1.3 CLIMATE AT SELECTED STATIONS IN JAMBI AND RIAU PROVINCES

		Record	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year	Remarks
Mean Temperature (°C)	Sebapo	76-79	25.7	25.7	26.0	26.2	26.7	26.2	26.0	25.9	26.1	26.4	25.9	25.9	26.1	
	Rengat	71-79	25.5	25.8	26.3	26.8	26.8	26.6	26.2	26.2	26.2	26.4	26.1	25.6	26.2	
	Barisan-Foothills	see note	25.2	25.2	25.6	25.7	26.0	26.2	25.6	25.8	25.4	25.8	25.4	25.2	25.6	
	Palmerah	71-82	25.6	25.8	26.1	26.2	26.4	26.6	26.2	26.3	26.1	26.3	26.0	25.7	26.1	
% Duration of Sunshine	Sebapo	76-79	43	40	40	53	56	50	51	55	53	54	39	35	47	
	Rengat	76-79	43	35	31	41	55	58	45	31	37	39	24	29	39	
	Barisan-Foothills	see note	48	52	56	58	57	61	67	58	55	56	51	41	55	
	Palmerah	71-82	43	41	47	48	55	60	59	59	41	47	41	42	49	
% Relative Humidity	Sebapo	76-79	84	84	85	85	84	84	83	82	83	83	87	87	84	
	Rengat	73-79	84	84	83	85	84	83	83	83	84	83	85	86	84	
	Barisan-Foothills	see note	84	85	85	84	84	83	82	81	84	83	85	86	84	
	Palmerah	71-82	83	85	85	86	85	83	82	81	82	83	85	86	84	
Wind km/day	Sebapo	76-77	108	87	87	43	65	65	87	65	65	65	43	65		Recorded to nearest knot
	Rengat	71-79	173	158	154	149	134	154	182	157	173	154	163	173		
	Barisan-Foothills	see note	60	60	60	60	60	60	60	60	60	60	60	60		
	Palmerah		-	-	-	-	-	-	-	-	-	-	-	-		Unreliable rec.
	Pasir Putih	79-82	67	60	60	42	43	43	60	48	49	43	53	71		Approx.values

Locations :
- Sebapo : 01°30' S 103°15' E
- Rengat : 00°26' S 102°27' E
- Palmerah : 01°38' S 103°39' E
- Pasir Putih : 2-3 km from Palmerah
- Barisan Foothills : taken from Binnie (Ref. 1) where the above values are given as representative of the western edge of the lowland plain, at 100 m. (eg. The short-record meteorological stations of Rantau Panjang (01°51' S 102°18' E), Kota Baru (01°07' S 101°47' E) and Sungai Dareh (00°58' S 101°30' E).

TABLE 1.4(i) PROBABILITY OF OCCURRENCE (%) OF 10,15 AND 20 DAY DROUGHTS MID-OCTOBER TO MID-MARCH

Event	No.of events	Kuala Tungkal	Pelabuhan Dagang	Palmerah	Muara Tembesi	Muara Tebo
10 day drought	0	17	20	26	34	21
	1	30	32	35	37	33
	2	27	26	23	20	26
	3	16	14	10	7	13
	4	7	6	3	2	5
15 day drought	0	55	55	78	73	51
	1	33	33	19	23	34
	2	10	10	2	4	11
	3	2	2	0	0	3
	4	0	0	0	0	0
20 day drought	0	89	82	86	100	90
	1	11	16	13	0	10
	2	1	2	1	0	1
	3	0	0	0	0	0
	4	0	0	0	0	0
Number of years of daily record		11	6	24	10	12

Example : At Pelabuhan Dagang there is a 20% chance (one year in five) that no 10 day drought will occur between mid-October and mid-March; there is thus an 80% chance that one or more 10 day droughts will occur.

TABLE 1.4(ii) PROBABILITY OF OCCURRENCE (%) OF 10, 15 AND 20 DAY DROUGHTS MID-MARCH TO THE END OF JUNE

Event	No.of events	Pelabuhan Dagang	Muara Tebo
10 day drought	0	12	12
	1	25	25
	2	27	27
	3	19	19
	4	10	10
15 day drought	0	56	44
	1	32	36
	2	9	15
	3	2	4
	4	0	1
20 day drought	0	83	64
	1	16	29
	2	1	6
	3	0	1
	4	0	0

Example : At Pelabuhan Dagang there is a 12% chance (one year in eight) that no 10 day drought will occur between mid-March and the end of June; there is thus an 88% chance that one or more 10 day droughts will occur.

TABLE 1.5 NUMBER OF 5-DAY DROUGHTS

Description	Station	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct-March	Year
Average in month	Kuala Tungkal	2.7	1.6	2.0	3.3	1.5	1.7							12.8	
	Pelabuhan Dagang	1.7	1.4	1.0	2.8	2.2	1.0	1.3	2.3	3.8	3.8	3.8	2.2	10.1	27.3
	Palmerah	2.5	1.0	1.2	2.2	1.6	1.7							10.1	
	Muara Tembesi	2.3	2.1	1.4	1.5	0.8	0.7							8.8	
	Muara Tebo	2.6	1.7	1.1	1.3	1.3	1.5	1.5	2.8	3.5	3.2	3.1	2.6	9.5	26.1
Average	All stations	2.3	1.6	1.3	2.2	1.5	1.3	1.4	2.6	3.7	3.5	3.5	2.4	10.3	26.7
1 in 3 years (33%)	"	3.0	2.1	1.9	2.9	2.0	1.8	1.7	3.1	4.3	4.1	4.1	3.0	13.5	33.9
1 in 5 years (20%)	"	3.6	2.6	2.4	3.5	2.5	2.2	2.1	3.6	5.0	4.7	4.6	3.7	16.8	40.4

TABLE 1.6 AVERAGE NUMBER OF RAINDAYS (> 1 mm) IN EACH MONTH

Station Name	Period of Record	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Kuala Tungkal	1960-64; 73-80	7.5	10.5	10.6	10.5	7.2	6.6	6.3	6.2	8.9	9.4	12.9	14.3	111
Pelabuhan Dagang	1973-75; 77-78; 79-82	8.3	9.0	14.3	12.0	7.5	4.4	4.6	5.0	8.0	9.9	14.2	11.2	108
Palmerah	1952-81	14.3	15.1	17.3	17.0	13.4	9.3	9.1	10.0	10.8	13.7	18.2	20.0	168
Muara Tembesi	1952-55; 63-66; 79-81	12.8	13.7	12.7	13.1	9.1	6.5	8.2	7.2	9.3	11.9	10.4	13.0	128
Mersam	1923-41	13.5	12.5	13.1	13.2	10.4	6.2	5.9	7.6	8.7	12.2	15.4	16.4	135
Bajubang	1953-81	13.5	12.6	15.7	14.5	11.0	7.1	8.4	8.0	9.8	11.1	15.7	16.9	144
Muara Tebo	1951-58; 64; 75-77	12.4	10.0	13.5	11.1	8.0	4.5	5.8	6.3	9.0	9.4	12.5	13.5	116
All stations		11.8	11.9	13.9	13.1	9.5	6.4	6.9	7.2	9.2	11.1	14.2	15.0	130

TABLE 1.7 EVAPORATION

Palmerah Airport (01°38' S 103°39' E)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Open water Evaporation(Eo)	130	120	140	130	130	130	135	140	125	135	125	125	1565
Potential Evapotrans-piration(Et) (albedo 0,25)	110	95	115	105	105	105	110	115	105	110	100	100	1275

Estimates by Penman Method in mm.

TABLE 1.8 ANNUAL EVAPORATION ESTIMATES PRESENTED IN OTHER REPORTS (mm)

Area	Source	Eo	Et	Remarks
Lowland Jambi Province	1	-	1526	Palmerah Data
Bukit Barisan Foothills	1	-	1320	Representative values for station at 100 m
Sebapo	2	-	1251	
Kuamang Kuning	3	2030	-	West of study areas
Japura	4	-	1470	Japura/Rengat in Riau Province

Note : All estimates by Penman Method.

SOURCE : 1. Binnie & Partners (Ref. 1)
2. Tricon Raya P.T. (Ref. 17)
3. Hunting T.S. & Harrison Fleming A.S. (Ref. 11)
4. Binnie & Partners with Hunting T.S. (Ref. 2)

PART 2 WATER SUPPLY

2.1 GENERAL

The water supply of study areas Merlung XIIc/C, Merlung XIIc/B, Muara Tembesi XI/F and Tungkal Ulu XIIb/D, F and G are considered together to combine information from similar, relatively close, regions, within which there are uninhabited areas where little information is available. With the exception of the north-eastern part of Tungkal Ulu XIIb, the study areas are similar in the following important aspects :

i) annual and monthly rainfall and rainfall excess over evaporation
ii) geology mainly Palembang Beds of Tertiary age
iii) dissected topography and dense drainage network
iv) present water supply mainly from surface streams.

2.2 PRESENT WATER SUPPLY

Nearly all the people in the vicinity of the study areas live in villages along the large rivers - the Batang Hari, S. Ketalo, S. Pengabuhan and S. Betara - and the rivers can supply all their water needs. In larger and more prosperous villages such as Merlung and Sungai Bengkal there are also a number of wells, probably river-fed. Smaller villages, such as Pulaupauh on the S. Pengabuhan, generally do not have wells.

Within the study areas no permanent inhabitants were found except for the two logging companies of Loka Rahayu in Merlung and Heeching in Tungkal Ulu. Both companies use stream water. Loka Rahayu Camp in Merlung had used a well, reportedly about 8 m deep, for two years. This was located in a saddle about 10 m below the hilltop. Heeching in Tungkal Ulu had a well for reserve supply, with water about 3 m below the ground.

Pematanglumut, in the north-eastern part of Tungkal Ulu, was in some ways different from the general pattern. The inhabitants find the river water dirty, and use shallow spring-fed wells on the scarp slope and other shallow wells on the dip slope. It was reported that these latter wells became dry for about 2 months a year, during which time water was supplied from the river.

We were informed at one 2 m deep well that it was not dug deeper because of a layer of clay. The village headman also had a rooftop collection system which appears to be satisfactory in the wet season, although the rainfall is insufficient in the dry season, and it is supplemented by a well. Inland from Pematanglumut two houses also had shallow wells, from 1-1.5 m deep, situated in natural hollows which were 4 or 5 m, below the houses. One of these wells apparently goes dry during which time the inhabitants are forced to leave.

2.3 WATER QUALITY

More than 70 readings of electrical conductivity (EC) have been taken in the study areas as part of this study, mostly from streams but including about 10 wells. All readings were within the range 10-55 micro-Siemens, equivalent to approx. 5-35 ppm total dissolved solids. These low readings suggest that water quality is at present good, as would be expected from areas comprised largely of natural forest with very little development and few inhabitants.

2.4 GROUNDWATER

The hydrogeological map of the area produced by Directorate of Geology (Ref. 5) classifies the rocks within the project areas as follows :

Upper Palembang Beds	Small groundwater potential
Middle Palembang Beds	Groundwater localised
Lower Palembang Beds) Upper Telisa Beds) Lahat Formation)	Groundwater rare Aquifers seldom productive.

Binnie and Partners (Ref. 1) in their first draft of the Groundwater Supplement considered only the Middle Palembang Beds to offer some groundwater potential, in areas where they are sandy and gravelly. The hydrogeological map (refered to above) and a consideration of the lithology suggests these may be some potential in the Upper Palembang Beds. These rocks are found in parts of

Tungkal Ulu XIIb and Muara Tembesi XI/E and XI/F study areas. If other, less expensive means of water supply prove unreliable the possibility of abstraction of groundwater through pumped wells might be considered, if careful site investigation revealed its feasibility.

2.5 EXPERIENCE OF WATER SUPPLY IN AN EXISTING TRANSMIGRATION SCHEME

An existing transmigration scheme was visited to benefit from the transmigrants experience of their water supply.

The relevance of Alai Hilir to the study areas is that as the geology and rainfall are similar, similar conditions may be expected. The transmigration scheme of Alai Hilir is four or five years old and is located a few kilometers east of Muara Bungo on Upper Palembang Beds and Alluvium. Average Annual Rainfall is slightly greater than in the study areas at around 2700 mm.

Initially, one well was provided for every two families, but the transmigrants have since dug additional wells so that there is now one for each household. The topography is gently undulating and houses are spread out along access roads. It appears that wells constructed in the troughs and valleys are generally shallow, perhaps only 2 m deep, and yield water throughout the year. However, wells on the ridges are deeper, perhaps 7-8 m, and sometimes become dry, during which time the inhabitants obtain their water supply from swamps. One family reported that their 8 m deep well was dry for 2 months a year, when they used a swamp about 200 m away; another family had extended their well to 11 m so that it always had water.

The differences between Alai Hilir and the study areas suggest that water supply in the study areas will be more difficult. Whereas at Alai Hilir the topography is gentle, the project areas are generally rolling, so that greater difficulty can be expected in the water supply to houses on ridges and mid-slope locations. The reliability of surface flows in the dry season in the study areas (except probably the middle reaches of major streams) is probably poor, whereas at Alai Hilir surface streams provide an essential reserve supply for the dry season.

2.6 DISCUSSION

With an annual rainfall excess over evaporation of more than 1000 mm, ample water should be available. Difficulties may, however, be encountered in its abstraction and supply.

The recommended supply is from shallow, hand-dug wells. From the previous sections, and the influent nature of many streams described in the main text, it is apparent that to ensure a dependable water supply, shallow wells should be located in low valley sites. Because of the number of times a day that a well is used, it is desirable that wells are not remote from transmigrants houses; thus the houses would also have to be near the valley bottoms. In a transmigration scheme where land is partitioned into regular units such locations may not always be physically possible, and may not co-incide with agricultural and road access requirements.

A typical existing 'shallow' well in the study areas is located in a hollow and is 2-8 m deep. Without field tests it is not possible to estimate required well depths in other locations with any accuracy. A rough guide, however, might be the height of the location above the stream bed plus 2 metres, or roughly 5-10 m on mid-slope sites, 10-20 m on ridges and hilltops. Wells of 10-15 m deep would probably be both acceptable to the transmigrants and normally practical to dig by hand, depending on the depth to hard rock or clay. It is recommended that such wells be lined to reduce maintenance, walled and covered at the top, and that their depth should be at least 1 m below the lowest dry season level.

House locations requiring wells of more than about 15 m will require alternative methods of water supply. Such alternatives could include use of pumped surface water where a clean and reliable resource exists, roof storage, or some form of community system based on deep pumped wells or impounded surface flows.

PART 3 AGRICULTURE

3.1 OBJECTIVES

This appendix has been compiled following extensive tours of Jambi province, including visits to all recent transmigration settlement areas.[1)]

The lessons to be learned from traditional agricultural practices, and the experiences of the transmigrant families on both recently settled and more established holdings, are used to develop a methodology for selecting optimum cropping systems under the wide range of conditions found in prospective transmigration areas.

Increasingly in the future the areas available for transmigration settlement will become more marginal as further settlement continues. It is therefore necessary to modify currently proposed cropping systems to make optimum use of the opportunities arising, to maximise the benefits for transmigrant families and to overcome constraints in the most cost effective manner.

A discussion of current land clearing methods and costs is also justified to examine whether the considerable sums of money spent on full mechanical clean-clearing of forest could not be better spent on alternative, more rewarding inputs.

3.2 EXISTING AGRICULTURAL SITUATION IN JAMBI PROVINCE

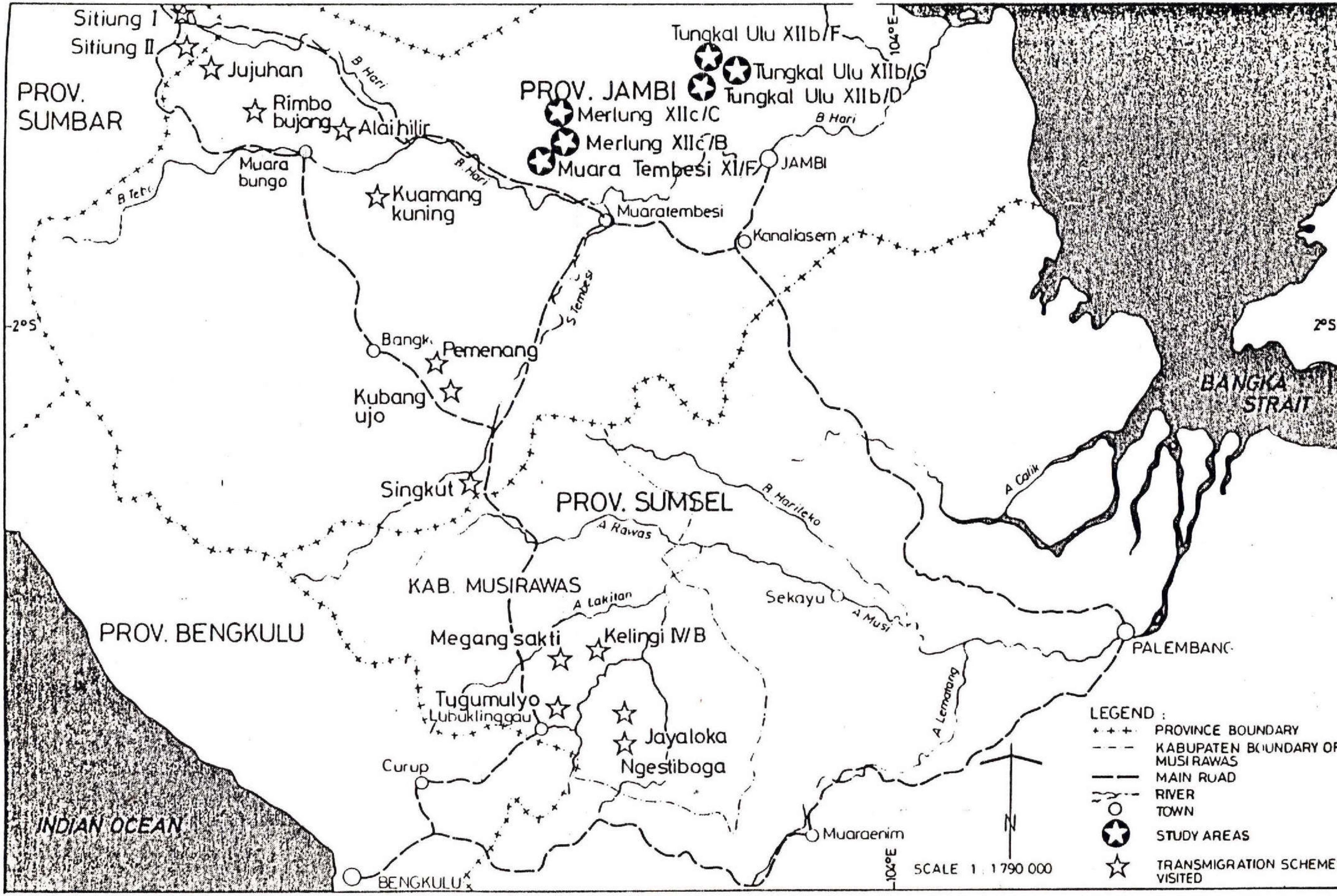
3.2.1 Settlements

Settlement patterns in Jambi province, which has yet to develop an intensive road network, have been mainly riverine for the following three reasons :

- ease of water-borne communications
- reliability of domestic water supplies

1) Alai Hilir, Rimbo Bujang, Jujuhan, Sitiung II (Blocks D & E), Kuamang Kuning, Kubang Ujo, Pemenang, Singkut and Sitiung I (in Sumbar).

MAP: LOCATION OF STUDY AREAS & TRANSMIGRATION SCHEMES VISITED



- proximity of flatter, more fertile, river terrace alluvial soils.

The more recent construction of roads has resulted in agricultural ribbon development, generally on more undulating, less fertile land, but rarely extending more than 2-3 km either side of the newer roads and exploited timber tracks. The only exceptions to this historic trend are the transmigration settlements themselves, usually sited on old logging concessions on undulating, better drained, less fertile soils which previously supported the better diptocarp forests.

3.2.2 Indigenous Agriculture

Jambi province is primarily a tree crop area, for reasons associated with the variable climate, the undulating to rolling land form and the low inherent fertility of its soils. Exceptions to this are the coastal swamps to the east, supporting mainly rice under the pasang surut schemes; and the more fertile valleys of Kerinchi Kabupaten in the high land of the west.

Much of the cultivated area in the province is under some form of shifting cultivation, often on slopes exceeding 10%. Where primary forest land is utilized the custom is to slash and burn 'in-situ' and then plant upland rice (padi go-go or padi ladang) for one, or, in rare cases, two seasons. No tillage is practiced, a stick being used to make holes 30 cm x 30 cm apart in the still soft ground between the charred logs immediately following the burn. Several seeds are dropped into each hole and left to germinate. No further inputs are used. Modest yields are obtained. In a good year perhaps the yield approaches 1200 kg/ha. In a dry, blast-prone year only some 400-500 kg/ha are obtained. It is noticeable that plant establishment is reduced on steeply sloping land, due to erosion, but improves on flatter land, both on the crests and in the valley bottoms, where soils are often deeper and more retentive of moisture.

Following the harvesting of the rice, or sometimes before, seed rubber is planted which gradually achieves full canopy, and can be exploited from year 7, as no inputs are used. In areas with high average family holdings of rubber of all ages, tapping is commenced in year twelve after planting, the family preferring to maximise the return to labour by tapping only mature trees during their peak yielding years. Yields during this period are said to average 350 kg/ha/yr DRC [1], and daily collection can amount to some 15 kg of wet slab rubber per manday.

At the moment, due to the low price of rubber, there is much pure shifting cultivation of padi go-go, generally grown for one year only followed by natural regrowth. This undesirable technique is practiced mainly by poorer indigenous families who then move onto the next area. Land under shifting cultivation rarely extends more than 5 km from major access tracks/rivers, thus confining agricultural usage to secondary forest areas on a 5-8 year cycle; although once rumours of transmigration settlement are confirmed new land is cleared by the indigenes to obtain usufruct rights (hak usaha).

Within communities owning less rubber, as in more recently settled villages, rice followed by rubber or rubber planted into the first and only rice crop is tapped sooner, eg. commencing in year 8 after planting, reflecting the lower opportunity of tapping more mature trees. Average yields in this case are lower, at some 280 kg/ha/yr DRC and the daily collection is only some 12 kg/man-day of wet slab.

In rare cases better farmers practice 'inter-cropping' ie. the growing of food crops between rows of rubber. Several interesting mixed stands of rubber and pineapples, rubber and vegetables, rubber and legume crops, have been observed.

Mixed fruit tree cropping occurs in the house gardens in which jackfruit (nangka), cloves (cengkeh), bananas (pisang), sugar-cane (tebu), coffee (kopi) and coconut (kelapa) are common. More rarely citrus, cashew nuts, cinnamon and local tropical fruits can be seen.

Often cassava (ubi kayu), maize (jagung) and grain legumes (kacang-kacang) are grown between the trees.

1) Source - Farmer estimates, but yields are highly variable - in times of high rubber prices much rubber is tapped (450 kg/ha); in times of low rubber prices, production falls.

Extensive pure stand arable cropping is never practiced except occasionally by the Directorate General of Food Crops on whose holdings serious encroachment of alang-alang (Imperata cylindrica) can be observed.

Adjacent to the more recently opened logging tracks there is much strip clearing, the absence of crops indicating that the 'occupants' are merely attempting to obtain usufruct rights (Hak Usaha) over this land.

The Directorate General of Tree Crops (Dinas Perkebunan - Jambi) is running 17 ten hectare nurseries producing budded stumps sufficient for replanting 8500 ha of rubber. This is for allocation to existing smallholders who are members of the local Kelompok Tani and also for the PRPTE settlement schemes offering 2 ha of high yielding clonal rubber (mainly GTI) to local settlers. This programme appears to be proceeding well, although it is relatively small scale compared to the transmigration programme needs.

There is little sawah in Jambi outside the pasang surut areas and most of central Jambi province is a net importer of rice.

Livestock production in Jambi is not a major activity. Some buffalo are owned, a few sheep and less frequently cattle. Local chickens are widely kept. Meat from the larger animals is rarely consumed in the villages, beast being sold to meet major items of family expenditure. Draft animals are rarely seen and then only in the sawah areas.

3.2.3 Transmigration Agriculture

In contrast to the essentially tree crop orientated indigenous agriculture, the more recently settled transmigration families are attempting to grow food crops, often against insuperable odds. There is an almost universal shortfall in production of pure or mixed stand arable upland food grains and little, or no yield from first crops on mechanically clean-cleared land is a common event.

Yields of rice fluctuate widely from year to year, a range of 200 kg/ha to 1200 kg/ha being reported during interviews with farmers.

Maize is an almost universal failure whilst soya bean yields are highly variable. Only cassava grows reliably, supply often exceeding demand, as this crop is regarded as an emergency standby, rice being the preferred staple.

It is valuable to compare the agricultural patterns of transmigration blocks during their first 3 years, eg. Pemenang Unit VI, VII, VIII, with older, more established blocks such as Singkut I and Rimbo Bujang Unit VI.

Whilst in younger areas arable food grain crops compete poorly with hot, dry infertile soils, erratic input supplies, dubious seed qualities, multitudinous pest and disease attacks, and the ravages of birds and wild animals, in the longer settled units one can observe a gradual shift to mixed tree and food crop agriculture and even to complete tree crop production systems.

From this and the fact that indigenous upland Jambi agriculture is essentially tree cropping, it is reasonable to predict that, in the fullness of time transmigration settlements will gradually take on much of the character of indigenous settlements and will rely heavily on tree crops of different sorts, but mainly rubber.

In spite of this prediction it is never-the-less important to devise a means of maximising the yields and returns to labour and capital from arable food cropping, which is so important for transmigrants during their early years in their new homes in remote locations, where lack of market outlets constrains production of most of the fruit and food crops that can be easily grown.

Before making recommendations later in this report it will be valuable to briefly discuss some of the major problems and opportunities that exist in present transmigration settlements.

3.3 ISSUES ARISING

3.3.1 Soil Fertility and Liming

It is now known (Ref.3) that the red-yellow podsolic soils, that predominate in Jambi province, are universally acidic (pH range

4-5). At this level of acidity, aluminium is freely available which fixed phosphorus (both the little naturally occurring P and also the applied P) rendering it unavailable to plants; and thereby directly inhibiting root formation and development. This is likely to occur when exchangeable Al on the absorption complex exceeds 2 meq./100 g of soil and when the saturation of aluminium exceeds 40% - a situation commonly found in these soils.

Annual plants such as maize, soya beans and rice develop only shallow roots[1)] and therefore become susceptible to periods of drought. In eastern Jambi a 10 day or more drought period occurs with a probability of 70% during the normal growing period (Oct-Mar) of rainfed crops. In addition because of the generally unthrifty growth of annual grain plants they easily succumb to pest and disease attacks.

Aluminium availability increases with depth. Therefore the less the soil profile is disturbed, and the more top soil that can be preserved in the process of jungle clearance, the better will be the growing conditions for future crops.

The application of calcitic or dolomitic limestone can ameliorate the adverse chemical conditions in the soil by raising the pH thus rendering the aluminium less mobile. Experimental work carried out by the IPB in red-yellow podsolic soils has indicated that yields of maize can be improved 1.6 times and yields of soya bean up to 1.7 times. Results with upland rice are more variable - depending on the season. Experiments laid out at the EEC project in Alai Hilir also demonstrate a physical benefit from limestone.

The recommended dosage of lime is between 1.5-2t/ha to raise the pH by a unit. The problem at the moment is one of economics. The delivered price of lime in Jambi province is about Rp. 50,000/t. Newly transmigrated families on low incomes[2)] are unlikely to

1) Sungai Dareh-Situng 1979 - agricultural trials on mechanically cleared red-yellow podsolic soil.
2) Average family cash income from all sources at Kubang Ujo in 1981-82 was Rp. 61.600/KK/yr, although some assistance is still being provided through food aid and subsidised agricultural inputs.

buy lime at these prices even if it was available.

It has been estimated by van Dierendonck (Ref.3) that many outcrops of lime are indicated on the geological maps of Sumatra mostly down the eastern fringe of the Barisan Range. Exploration and exploitation of these sources should not cost more than Rp. 6,000/ton, to which should be added delivery charges of some Rp. 80/ton-km. If this is proven, lime can be recommended as being of economic as well as technical benefit.

There would appear to be a case for applying limestone to house plots, no matter if sub-economic, provided this was supplied as a service from the Government, and executed in the interests of promoting rapid establishment of home-lot production. This limestone should be applied as early as possible to leave sufficient time for it to exert its buffering effect. Ash is also useful but is unlikely to be available in sufficient quantities.

Tree crops, especially rubber, are better able to survive difficult soil conditions and can modify the environment by shading, by soil temperature reduction, and by deposition of organic matter, which helps to maintain the nutrient status of the soil and improves the moisture availability. Tree crops do not really need lime, although coffee and citrus in particular benefit from organic matter in the planting hole.

3.3.2 Multiple Arable Food Grain Systems

The main advantages claimed for a mixed stand of different types of arable food plants are as follows :

- more food can be produced from less land, perhaps up to 1.6 times due to the symbiotic effect of the mixed plant community and the better use of the incoming radiant energy,

- the risk of crop failure are more widely spread,

- the soil is more adequately protected from the sun and rain, and, when under relay cropping, for a greater part of the year than under monocultural arable systems,

- labour needs are more evenly distributed throughout the year, although total labour required per multiple cropped hectare is some 1.4 times that for monocultural crops.

This system, based on multiple and relay cropping of arable food crops including maize, upland rice, cassava, ground nuts or soya beans, and sometimes a further crop of mung beans, has been recommended by the CRIA for a number of years. Under subsidised conditions eg. at Batu Raja and Way Abang, the research institutes have achieved creditable yields from their selected, assisted farmer plots. However the situation in the transmigration schemes is different and in Jambi province fewer than 2% of farmers are following this system in its recommended form. It is reported[1)] that even farmers previously collaborating in the CRIA trials have reverted to lower cost systems on cessation of the financial subsidy. There are a number of difficulties for farmers in following intensive arable cropping systems. These fall into two groups:

- technical
- socio-economic

Technical Constraints

Maize is important in the CRIA multiple cropping systems because the rows, spaced 2 meters apart are designed to reduce evapotranspiration by lessening the velocity of air movement over the inter-planted rice crop and to provide shade protection, thus reducing soil temperature. Drought stress is thereby reduced in the rice and soil moisture conserved. Unfortunately, maize is particularly susceptible to aluminium toxicity and does not grow well in the acid red-yellow podsolic soils of Sumatra. Poorly established maize is unable to shelter the inter-planted rice crop, whilst, in the rare instances where the maize plant does establish well, stemborer and other insect attacks drastically reduce the yields; monkeys take the rest.

1) Personal communication.

The second technical problem is with the legume crop; soya beans in particular do not always thrive on the acid soils generally prevailing as the root nodules develop only poorly at pH's of 4-5, even after inoculation. In many cases total failure has been reported.

A third major constraint lies with the cassava, which is designed to replace the maize as the row protection crop. Although cassava grows probably better than any of the other crops recommended,it faces marketing constraints because rice is the preferred staple. This same problem exists with the Dinas Pertanian recommended system of four square cassava planting surrounding soya bean, groundnuts or rice.

Socio-economic constraints

More serious are the socio-economic constraints of risk and return to labour. Transmigration families fear indebtedness and are reluctant to spend money on the considerable inputs needed to make the improved cropping system work, only to lose the crop due to drought, heavy rainstorms, or predators. An estimated outlay of some Rp. 150,000/ha is needed before the harvest can be taken, so few families have the inclination or recources to stake so much on risky ventures.

Transmigrant families are generally younger, thus having less labour available. Labour availability is more of a constraint than land availability. Transmigrants, where they can, therefore tend to devote their energies to tasks offering greater rewards, once having made some attempt at producing crops for subsistence requiring little capital outlay. Farmer surveys indicate that returns from arable cropping systems lie in the range of Rp. 100-Rp. 300 per manday. The CRIA claim that their recent research trials can yield Rp. 1750/manday for systems requiring 450-550 man-days/ha/season. Few farmers achieve this, whilst most farmers seek off-farm work which averages Rp. 1000/manday at no risk.

It is widely considered, as a general guide, that for success to be claimed from a recommended cropping pattern, it must have been adopted by at least 70% of the target farm families. Currently adoption levels for multiple arable grain (ie. rice, maize, soya beans) in Jambi are so low as to require further thought before pushing the unmodified model in new transmigration areas.

Proposals have been made by research workers, consultants and others for establishing a green manure fallow, as a break in arable cropping rotations. Whilst such a technique can be highly beneficial to the soil it is unrealistic in the context of transmigration where the main concern is one of survival. Very few farmers can afford to expend cash and labour on crops not giving them an immediate income or food supply.

3.3.3 Deterioration of growing conditions from continuous arable grain crop production

Sitiung II Block E provides an example of the soil deterioration that can occur from continuous grain cropping on steep erodible soils. This year it is estimated that upland rice will yield only 200 kg/ha. Although some terracing has been completed in this area it is too little and was constructed too late to save the soil. Sheet and gulley erosion resulting in bare patches can be plainly seen on the slopes. This transmigration area is unique in that, unlike farmers on schemes of similar age elsewhere who have learned from personal experience that tree cropping or tree crop/food crop mixtures are better than pure arable cropping continuously on the same land, the Block E farmers are still growing upland rice, now for the fifth continuous year.

The reason for not modifying the arable system at Sitiung II Block E is that the transmigrants here are still hoping for the promised irrigation water from the Sungai Dareh-Sitiung Irrigation Scheme.

But even here a few realistic farmers have, of their own volition , planted seedling rubber along the field margins and are starting to develop an intercropping system with greatly improved results, both on yield and soil stability.

A further risk from pure-stand arable cropping or annual multiple cropping systems is the risk of alang-alang encroachment. Again this can be seen at Sitiung II on the more fertile lower river terraces. Areas that were in production 3 years ago under rice and soya beans are now completely choked with alang-alang and have been abandoned.

At Rimbo-Bujang the same problem of alang-alang has occurred on the less well - husbanded plots. These farmers find it easier to inter-crop rice between the newly planted budded stump rubber on areas of freshly slashed and burned forest in their LU 2 area rather than to tackle the alang-alang at the back of their houses. The rice inter-planted with rubber is successful but is occurring in spite of a Perkebunan directive that only tree crops should be planted on the LU 2 area designated for treecrops. Conversly many of the better farmers wish to plant rubber in their LU 1 area and intercrop food crops (mainly rice) between the young tree rows.

Pure stand monoculture or multiple arable grain cropping cannot be considered as a viable long term production system capable of sus-tained implementation, on any but the best soils, under the most capital and labour intensive systems. These conditions do not prevail in Jambi province.

3.3.4 Mechanical clean-clearing of land

Introduction

The clean-clearing of forest and alang-alang land by bulldozers and heavy machinery appears to be a well-entrenched practice in trans-migration settlement. This technique has the advantages of speed, thoroughness and timeliness, but is otherwise costly and can be deleterious for future cropping. This section will highlight some of the main features, with the view of (hopefully) promoting a more selective approach to land clearing in the future.

The chain of events

Before being able to objectively discuss the "pro's and cons" of mechanical clean-clearing it is necessary to understand the complete sequence of events between the first arrival of the equipment on site and the transmigrants beginning to farm the areas so cleared.

Whilst the occasional success can be quoted - where land has been mechanically cleared at the optimum time, a good burn achieved, a thorough disc harrowing carried out between the largest standing stumps, cover crop established immediately following harrowing, transmigrants arriving and starting to farm the area at the optimum time with readily available inputs of high quality - often, in practice, such perfection is difficult to achieve. Instead the following sequence of events occurs :

- Land is cleared by bulldozers, in all weathers, using mainly straight blades, at contract rates that offer the clearance contractor little profit and no incentive to invest sufficiently in specialised rakes and 'KG' blades which do less damage to the soil.

- The cleared and burnt land is then harrowed using heavy reclamation 'Rome' machinery which is often incorrectly set, ie. the gangs are used on straight cut which merely cuts surface wood and compacts a series of narrow trenches in the soil, doing little to encourage infiltration of rain water into the profile. The incorrect setting of harrows allows the clearance contractor to recoup his losses on the other operations, which have more tightly drawn specifications and upon which all but the most efficient operators lose money.

- However some land clearing specifications require that the disc gangs be set on minimum cut in order to reduce soil profile disturbance. In these cases the need to harrow at all becomes questionable - as little benefit is derived from the operation - the transmigrants still being obliged to cangkul the area by hand.

- If the clearance contract also includes leguminous cover crop establishment, often there is a delay between final harrowing and cover crop seeding which can be deleterious for cover crop establishment. The reason for this delay is sometimes due to operational expendiencies and at other times due to inadequate seed to cover the whole area cleared. In this case the contractor waits for completion of land clearing in order to more easily select the more steeply sloping land for cover crop seeding. Delays can result in loss of top soil and run-down in fertility making good cover crop establishment more difficult to achieve.

- Where a cover crop has not been sown, or has shown poor growth, the resulting land is then left to the mercy of the heavy rains and intense sunshine to harden further - prior to the arrival of the transmigrants - in some cases for many months. On steeper land, sheet and gulley erosion occurs and the top soil washes downhill.

- The transmigrants, following first arrival, spend a number of months sorting themselves, their houses and their gardens out before starting to farm the mechanically cleared Lahan Usaha I. Unless cover crop establishment has been successful, further hardening, oxidation of the little remaining organic matter and further erosion occurs before the transmigrants are able to work the area.

- In some cases, budgetary constraints on the Directorate General Agraria causes further delays in making out and allocating LU I land to newly arrived transmigrants.

- The transmigrants then often find that the combination of machinery compaction, ground smearing, incorrect setting of the harrows and the effect of the weather during the waiting period has so hardened the ground that they need to cangkul the area before planting, a task that can take up to 3 months per hectare. The danger of aluminium toxicity has meanwhile increased severely.

- Where cover crops have established over the litter of wood chips and broken roots, considerable problems in cultivating the area are encountered.

- This often results in transmigrants raking up and burning the cover crop and underlying wood litter prior to planting their crops - a practice which largely nullifies the benefit of the green mulch

- In order to cultivate and to burn the remaining stumps, the women- folk then laboriously pick up all the wood trash mulch lying on the surface thus exposing the soil fully to erosion and further oxidation.

- Finally the seeds are sown but are often of dubious germination viability, possibly due to unforseen delays, and crops are often inadequately supplied with fertilizer and chemicals.

- The task of adequately maintaining so large a cleared area is quite beyond the means of most transmigration families, so further soil deterioration occurs, and often encroachment by alang-alang, rendering much of the area more difficult to cultivate in the future.

Thus it can be appreciated that all operations must be tightly controlled if the greatest benefit is to be derived from mechanical clean-clearing of forest and alang-alang land.

Advantages of mechanical clean clearing

There are three main advantages of mechanical clean clearing, namely :

- Timeliness
- Increased useable land area
- Ease of execution

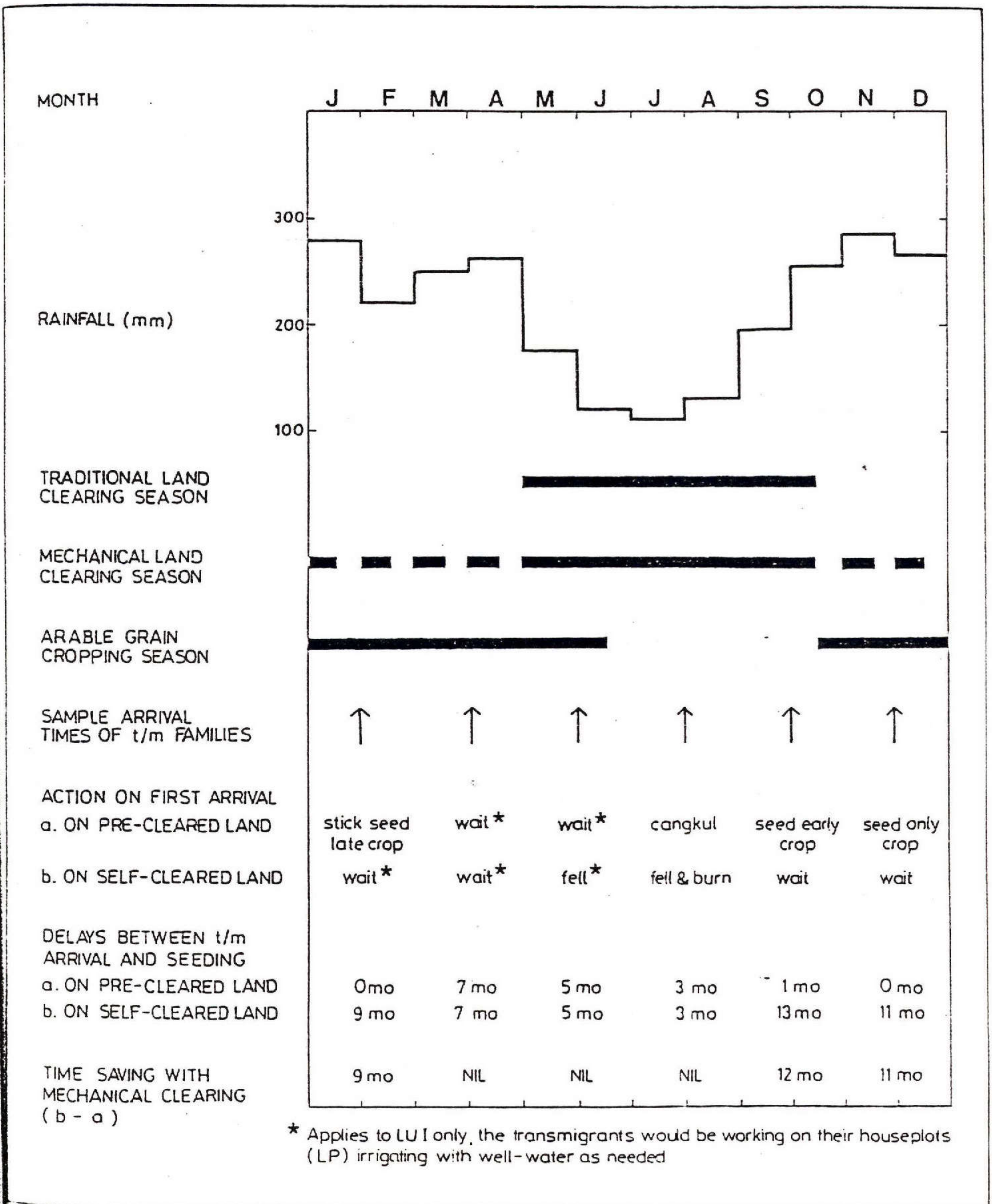
Timeliness

Mechanical clean-clearing of forest using bulldozers can sometimes be justified from improved timeliness. But as is indicated in Fig. 3.1, the benefit is not universal for all transmigrants.

The figure shows the relationship between the wet seasons, the optimum clearing months, and the arable growing season - all

FIGURE : 3.1

COMPARISON OF DELAYS BETWEEN FIRST ARRIVAL OF TRANSMIGRANTS ON SITE AND THEIR STARTING TO SEED THEIR LAHAN USAHA I-FOR TWO ALTERNATIVE SYSTEMS OF LAND CLEARING



related to the time of arrival of the transmigrant families on site, assuming two alternatives :

- land pre-cleared mechanically by contractors before transmigrant arrival,

- land semi-mechanically cleared by transmigrants families themselves after arrival.

It is apparent that transmigrant arrivals between October and February will experience minimum delay in cultivating their pre-cleared land whilst those inheriting uncleared land will need to await the forthcoming dry season before clearing and burning, and the following wet season before planting. Delays could be substantial - in the worst cases up to 13 months.

However for both groupings of transmigrants arriving between April and September, there will be no saving in time from pre-clearing as neither group will be able to successfully plant arable crops before the next wet season. The group inheriting the pre-cleared land would be worse off due to having to put some 120 mandays of effort into cangkuling the hardened deteriorating soil during crop establishment whilst the self-clearing group will be expending only some 90 mandays felling, burning and immediately stick seeding. The yields from semi-mechanical felled and burnt land will be better and more reliably obtained than from mechanically clean-cleared land, so some of the apparent benefits accruing to mechanical clean-clearing will be reduced in the 50% of cases where timeliness is improved.

Were a policy of semi-mechanical land-clearing to be adopted in preference to full mechanical clean-clearing it would appear essential that transmigrant families be paid to clear their own land; for two reasons :

- semi-mechanical pre-clearing would be difficult for land clearance contractors to organise and supervise,

- the transmigrants themselves would greatly benefit from the income derived from semi-mechanical land clearing on their own plots before being able to set seeds for the oncoming wet season.

Increased useable area

It can be observed that some 96% of land mechanically clean-cleared is available for cultivation of crops, whilst with semi-mechanical and hand-clearing methods 80% & 60% only of the total cleared area can be planted, due to the presence of semi-charred logs, but these, gradually rot and enrich the soil, and can be used as erosion control bunds if felled along the contour.

Ease of execution

In the more remote areas it is clearly easier for a contractor to mobilize a smaller number of skilled operators and machines on forest clearing than to import, house and supervise a vast labour force of semi-skilled and unskilled labourers.

However the expediant of employing transmigrants already housed on site on mechanically pre-cleared plots (LP) to semi-mechanically clear their own LU 1 area, could go a long way to achieve a reasonable compromise between the various factors involved in land clearing.

Disadvantages of mechanical clean-clearing

The are two serious disadvantages of mechanical clean-clearing namely :

- the adverse agronomic conditions created for subsequent arable cropping (in the absence of cover crops),

- the high cost of mechanical land-clearing and cover crop establishment.

Agronomic considerations

The agronomic desirability of disturbing jungle soil profiles as little as possible in order to preserve top-soil and organic matter, leaving subsoils containing greater quantities of mobile aluminium undisturbed and keeping as much vegetation sheltering the soil surface from direct sunlight as possible prior to the planting of the crop - is indicated in the more reliable yields from first time planted upland padi (padi go-go) (500-1200 kg/ha) compared with first time planted padi into mechanically clean cleared land (0-800 kg/ha).

Additionally land can be cleared of jungle and the ground stick seeded with padi more quickly than the hardened soil resulting from mechanical land clearing and subsequent erosion (due to incorrect timing of operations and uncontrollable delays) can be cangkuled by transmigrants.

Cost of land clearing

Current land clearance production rates for contract clean-clearing are given below :

TABLE 3.1 MECHANICAL CLEAN-CLEARING PERFORMANCE

Item	Bid schedule per ha	Actual production per ha
Cutting and felling trees 30 cm diameter with chainsaw	3 m^3/hr	32 hrs
Clearing trees 30 cm diameter with KG blade on crawler	4.6 hrs	2.7 - 4.0 hrs
Windrowing and piling	4.7 hrs	5.8 - 9.6 hrs
Burning (group of 5 workers)	1.5 hrs	2.0 hrs
Harrowing	2.0 hrs	1.4 - 2.6 hrs
TOTALS		
Chainsaws + 2 operators	variable	32 hrs
Crawler tractors + operators	11.3 hrs	9.9 - 16.2 hrs
Labour (unskilled)	7.5 manhours	10 manhours

SOURCE : Jambi province - current performance - personal communication

It can be seen that only the efficient contractor will be able to beat the targets set.

Three different methods of land clearing are compared below :

TABLE 3.2 COMPARISON OF LAND CLEARING METHODS (Per ha)

Task	Forest Condition	Method of clearing: A Traditional	B Semi-mechanical	C Full mechanical clean-clearing
Felling	Old rubber	3.5 chs-d[6]	-	-
	Remnant Dipterocarp	-	5 chs-d (all)	4.0 chs-d (30 cm)
Mechanical clearing	Old rubber	-	-	-
	Remnant Dipterocarp	-	-	0.5 m/c-d (30 cm)
Cutting for stacking	Old rubber	3.0 chs-d	-	-
	Remnant Dipterocarp	-	10 chs-d	2.0 chs-d
Manual stacking & burning	Old rubber	10.0 m-d[7]	-	-
	Remnant Dipterocarp	-	20 m-d	-
Mechanical windrowing & piling	Remnant Dipterocarp	-	-	0.7 m/c-d[8]
Burning only	Remnant Dipterocarp	-	-	0.2 m-d
Mechanical harrowing	Remnant Dipterocarp	-	-	0.2 m/c-d
TOTALS	Chainsaw time (days @ 5 hr)	6.5[1]	15[1]	6[1]
	Bulldozer time (hrs)	-	-	13[2]
	Labour skilled (days)	13[3]	30[3]	12[4]
	unskilled (days)	10[5]	20[5]	0.2[5]
Costs (Rp/ha)		70,500	159,000	450,240
Useable land % for arable crops		60%	80%	96%
Cost per equivalent useable area (Rp/ha)		117,500	198,750	437,750

1) @ Rp. 1000/hr ie. O & M Rp. 700/hr; Depreciation Rp. 300/hr.
2) @ Rp. 30,000/bulldozer hr incl. operator
3) @ Rp. 2000/manday
4) @ Rp. 2500/manday
5) @ Rp. 1200/manday
6) chs-d = chainsaw days
7) m-d = mandays
8) m/c-d = machine days

NOTE : Method A - Chainsaw felling, cutting and burning 'en-situ'
Method B - Chainsaw felling and cutting, piling by hand
Method C - Chainsaw felling of large trees, bulldozing of remainder, mechanical stacking and harrowing.

SOURCE : contractors records, local chainsaw operators and farmers.

It can be seen that mechanical clean-clearing of land is at least twice as costly and contrasts strongly with using semi-mechanical methods.

Recommendation

In view of the fact that importation of heavy land-clearing equipment represents valuable foreign exchange, is an expensive operation costing at least Rp. 450,000/ha cleared from forest and does little to preserve a favourable environment for the growing of arable crops, it is suggested that mechanical land clearing be selectively used only in situations that could really benefit from the technique. In these cases timing of all operations should be precise and leguminous cover crops established. In view of the relatively short occupation time of cover crops before farming commences it would prove cheaper to use the more readily available Calopogonium spp rather than the more expensive longer lasting, cover crops employed for estate tree crop practice (Centrosema pubescens, Pueraria spp, Calopogonium spp). Leguminous cover crop seed should be heat-treated overnight before being mixed with a spreader eg. sand or sawdust and then scattered evenly over the previously harrowed land surface whilst the soil is still moist. Ideally seeds should be lightly covered using a light drag chain link harrow. Alternatively a seeding ring roller could do the work.

However the seeding of cover crops is a remedial measure costing money, following the mechanical clean-clearing operation; itself costing a great deal of money. To be effective as a soil improver a cover crop needs to remain 12 months before it is replaced by arable crops. This desirable 12 months period largely nullifies the main advantage to be gained from mechanical clean-clearing - timeliness. Thus the technique of mechanical clean-clearing is largely counter-productive.

The following table contrasts the main considerations :

TABLE 3.3 COMPARISON OF FOREST CLEARING METHODS

Item	Units		Indigenous A Traditional slash & burn		B Semi-mechanical	Transmigrants	C Full mechanical clean-clearing
Costs	Rp/ha		70,500		159,000		450,000
	% of highest		16		35		100
Return to labour[1)]	Kg/manday padi		9-21		5-13		0-3
	av. % of best		100		60		10
Timeliness	Family arrival time	Jan/ Feb.	Mar/ Apr.	May/ Jun.	Jul/ Aug.	Sep/ Oct.	Nov/ Dec.
	Time saving	9 mo.	0	0	0	12 mo.	11 mo.
	% of longest	75	0	0	0	100	90

SOURCE : contractors records and farmers

It is suggested that the best compromise is to pay transmigrants to semi-mechanically clear their own areas thus circumventing the high costs (and foreign exchange components) of using heavy contract land clearing machinery; and reducing the depressive effect on the yields of arable crops grown in the degraded soils so cleared. Transmigrant families would thus be assured of better incomes, both initially during the self land clearance phase, and later when their first crops mature.

3.3.5 The case for mixed tree/arable cropping

From the foregoing it can be concluded that pure stand arable cropping or even multiple cropping of arable food grains is a marginal activity on the red-yellow podsolic soils of Sumatra, especially following mechanical clean-clearing, even given applications of lime. The modification of multiple cropping by interplanting under the gentle shade of tree crops arranged along the contour,

1) up to crop establishment.

with less emphasis on food grain production and more emphasis on starchy food production, vegetables, fruit and tree crops are the only viable agricultural systems capable of sustained production on all but the most favourable flatter areas of alluvial soils, (and areas of padi sawah).

The applicability of this approach is further detailed in the following sections.

3.4 ECONOMIC AND SOCIAL CONSIDERATIONS

Success of transmigration settlement development is as much dependent on socio-economic considerations as on purely technical matters, as the farmers can be clearly observed to base their decisions on survival and what is best for their families rather than necessarily following centralized policy decisions. The following are particularly relevant:

3.4.1 Availability of off-farm employment

This is a controversial subject as many policy-makers are inclined to the view that availability of off-farm employment tends to detract from a programme of self-sufficiency in food stuffs. Whilst acknowledging that in some cases this might be so, for example in the case of a skilled craftsman who could earn Rp. 2500-3500/ day from off-farm work or in the case of a few poorer families who undertake menial low-paid tasks (leaving little time or inclination to farm their holdings) there is a body of opinion, and evidence, to support the contention that the availability of off-farm income cannot but enhance the families' own efforts on their land.

At Singkut (Ref.6) an estimated 450 mandays/year are spent working, of which 50% is spent off farm; earning some Rp. 225,000/year at an average rate of Rp. 1000/manday whilst on Singkut Unit 1, farm income grosses Rp. 107,000 and nets only Rp. 76,000, returning only Rp. 340 per manday. On Singkut Unit V, a more recent settlement with a lower proportion of tree crops, farm income grosses Rp. 78,000 and nets only Rp. 38,000, a return per man-day of only Rp. 170 from predominantly arable cropping. Whilst there is such an imbalance between risky on farm activities and risk free off-farm activities it is unrealistic to plan on transmigrants becoming full-time farmers, until all off-farm work opportunities are exhausted. The most contented transmigration schemes are those where new-comers have merged into the general economy of their new regions. Most of the failures have been on remote sites offering little alternatives to arable farmers and/or having poor water supplies.

Seasonal employment off-the-farm can be a valuable addition to family income as instanced at Alai Hilir where the labour force for the EEC mechanical soya bean project is drawn from the nearby transmigration settlement, such labour earning Rp. 1250/day for weeding etc. but only being available for this work during slack periods on their own farms. It is noticeable on the older settlements that the farmers with the best holdings, and the most improved houses, are those growing a large proportion of tree crops which gives them more time to undertake off-farm employment. These earnings are often put into the development of the holding including the purchase of expensive young trees for planting on their land. Less enterprising farmers are still growing poor crops of cassava or padi and their houses are little changed from those originally constructed for them. Interiews with a number of farmers have confirmed these trends.

Availability of off-farm employment varies from scheme to scheme but appears greatest in areas of active timber production or in the vicinity of Rimbo Bujang NES III and the EEC project at Alai Hilir. Some transmigrants share tap for the local indigenous rubber garden owners. Some 30% of families in Alai Hilir have worked with Perkebunan on estate crop development and the EEC project employs some 30 transmigrant workers per month.

In discussions, many persons suggested paying transmigrants to undertake some of the work presently being executed by the land clearance contractor. Such work might include semi-mechanical land clearing, burning, fertilizing, liming, terracing and cover crop establishment.

The Estate Crops Directorate has for a long time followed a policy of paying participants to establish rubber and then recouping the costs by deductions from rubber sales at a later date. Such a policy has much to recommend it, as transmigrants are assured of an income at a time when they need it most.

The future availability of off-farm work opportunities is more difficult to assess. Whilst activities in logging and forest product exploitation would be expected to decline as local sources of timber become exhausted, over say some 5 years, it is possible that as the transmigration settlements develop, service industries will increase and the project achieve 'lift-off'.

Opportunities for rubber planting and replanting and for tapping rubber would be expected to increase both with increasing areas under rubber and improved yields from those areas.

3.4.2 Return to labour

In the consultants opinion it is fruitless to continue to promote a solely arable food grain system currently returning not more than Rp. 200/manday in the teeth of technical and economic constraints. Which family provider will put high labour inputs into a system giving him so little return to his efforts or stake large capital sums, even if he had the resources, on risky ventures ? It is most important to so modify the system by introducing mixed diversified tree crops and interplanted food crops together in the same area and thus improve yields from both. This in fact is happening in the better managed holdings in the more established transmigration blocks/units. Such a trend should receive greater official recognition and technical assistance.

Evidence points to better yields at lower labour inputs obtained from rice planted into slash and burn crops rather than into mechanically clean-cleared land. Almost all transmigrant families interviewed expressed a preference for clearing their LU 1 areas themselves and planting rice between the charred logs, as labour inputs would be less (given access to a chainsaw) and yield would be more certain.

The local land clearing technique is as follows :

Operation	Labour needed (mandays/ha) A	B	Time lapsed (weeks) A	B
Cutting trees with chainsaw	7	10	0.5	1
Wait 3 months to dry	-	-	12.0	12
Manual stacking and burning	16	40	2.5	7
Wait for rains	-	-	?	?
Planting (with stick)	34	40	3	4
TOTALS	57	90	18 +	24 +

SOURCE : Farmer interviews.
A = Old rubber and secondary forest B = Remnant Dipterocarp

This contrasts with the labour required to cangkul areas of mechanically clean-cleared land, where the soils have hardened due to improper harrowing, raindrop compaction, organic top soil loss and baking due to direct sunlight. Such soils are also too hard to be worked by draft animals.

The following table summarises the returns to transmigrant labour input following the three alternative systems of land opening.

TABLE 3.4 RETURNS TO LAND CLEARING (per ha)

Operation	A Traditional shifting cultivation in secondary forest or old rubber	B Semi-mechanical clearing with chainsaw hand stacking & burning in remnant Dipterocarp forest	C Mechanical clean-clearing with bulldozers in remnant Dipterocarp forest
Clearing & burning	23 mandays	50 mandays	-1)
Preparing land & seeding	34 mandays	40 mandays	120 mandays2)
Lapsed time	18 weeks	24 weeks	13 weeks
Yields of upland rice	500-1200 kg	500-1200 kg	0-400 kg
Return to labour required to establish the crop	9-21 kg/m-d	5-13 kg/m-d	0-3 kg/m-d

SOURCE : Contractors records, discussions with farmers.

1) All operations carried out by contractor prior to arrival of t/m
2) Transmigrants, manually by cangkul

Thus transmigrant income would be improved by clearing land semi-mechanically, and better environmental conditions retained for future arable and tree crop growth.

At present prices, rubber tapping would be expected to return Rp.800 - Rp.1500 per manday for some 4 days a week throughout most of year giving some Rp.180,000 - Rp.200,000 per worker per year, a better and less risky return to labour than is likely to be derived from arable cropping.

3.4.3 Marketing constraints

Whilst there will always be a market on transmigration schemes for the products of an enterprising fish farmer, vegetable grower or coffee producer who gets in first, the question of markets arises for many diversified tree crop and horticultural products if many transmigration families are producing the same crops at the same times.

Good examples of this are pineapples at Rp. 50/each, cassava at Rp.20/kg and nangka which has no sale value as almost every one has too many. The same could happen if everybody grew coffee successfully the present price being Rp. 500-600/kg dried beans : and also to coconuts (Rp. 100-120/fresh nut) unless a processing facility is established in the neighbourhood. Perhaps only rubber is likely to remain immune from a long term price decline.

Thus marketing constraints are likely to confine the area of diversified tree cropping to say 1 ha per family. Experience would indicate that this area should be interplanted with food crops for subsistence needs only, where soil and slope conditions permit. The remaining area of the holding should probably be rubber or coconuts for processing.

Coconuts make an excellent shade crop for both coffee and food crops, and, in the fullness of time, for grass and animal grazing, whilst dwarf hybrids give three times the copra yield. Processing facilities for copra will need to be organised for each area of transmigration to reduce transportation costs.

3.4.4 Prices of basic commodities

It is noticeable that areas of Jambi province with poor access suffer from lower selling prices and higher buying prices. Thus rice can vary in price from Rp. 240/kg in Jambi Town to Rp. 400/kg in Lubuk Kambing whilst rubber declines from Rp. 190/kg in Jambi Town for good quality wet slab to Rp. 80/kg in remote reverine locations. Improved transportation will tend to reduce the differences.

3.5 AGRICULTURAL DEVELOPMENT POSSIBILITIES

The wealth of agricultural experience accumulated from transmigration schemes over the past few years, and the increasingly marginal nature of remaining areas available for transmigration in Sumatra, dictate that careful thought be given to developing agricultural cropping models, capable of giving sustained yields, yet going some way to meeting the need for basic food. This section has this aim in view.

3.5.1 Land-use considerations

Figure 3.2 is a decision diagram designed to allow the user to choose the most appropriate cropping option for any particular transmigration scheme, or part of scheme, based on the physical resources and the socio-economic conditions prevailing.

It poses a number of key questions, set out thus ◇ , which form the main criteria for selection. These main questions and their relevance are tabulated below.

Question	Relevance
a. Is area poor draining and relatively flat ?	Whether wetland rice can be grown, being the main staple.
b. Is pasang surut irrigation possible ?	Whether lower lying areas of the transmigration zones can be tidally irrigated and thus produce food crops more reliably.

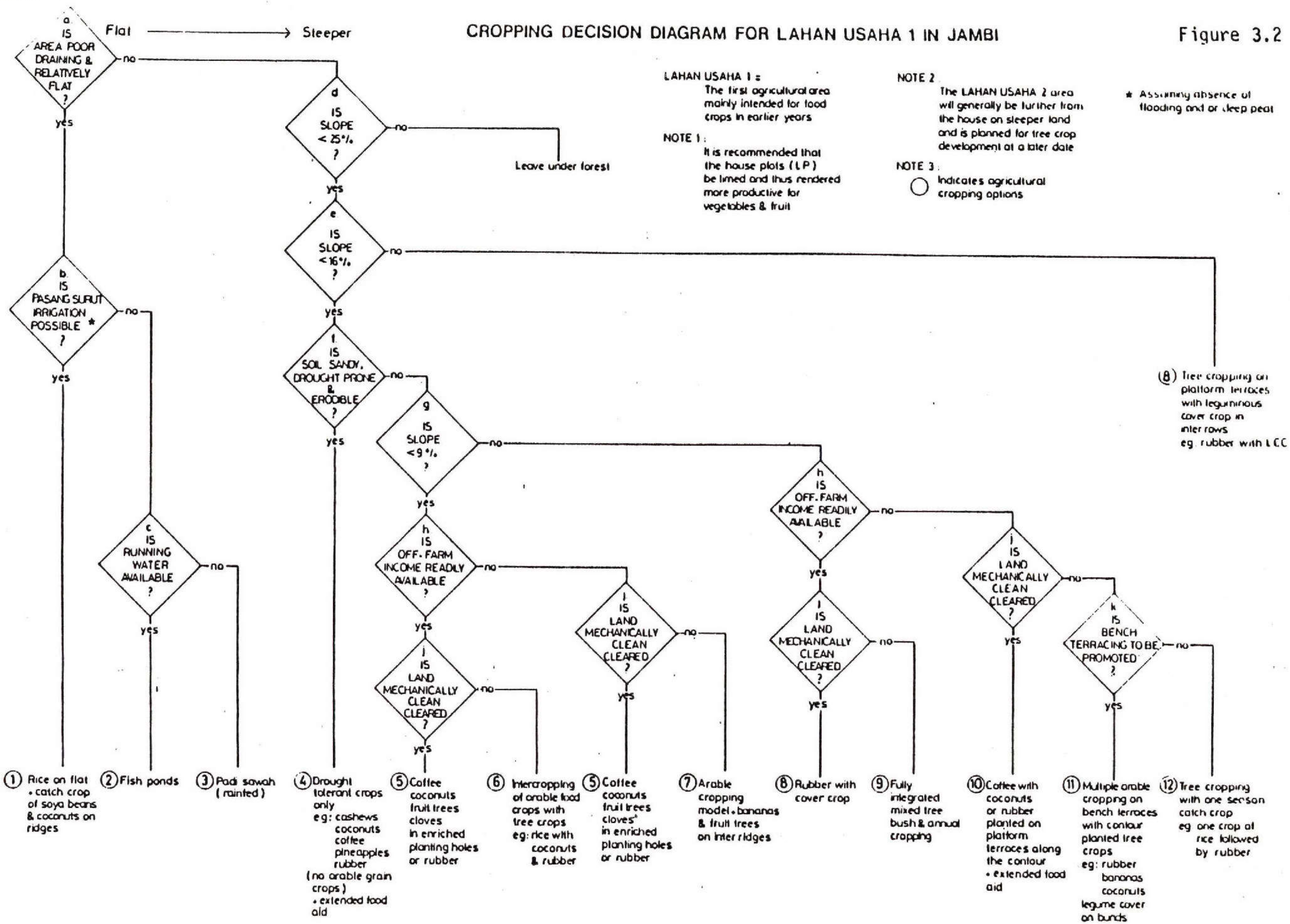
c. Is running water available ?	The limited flow in the many small streams can be used to greatest effect for fish ponds. Failing this rice can be grown in the valley bottoms using rainfall.
d. Is slope less than 25% ?	Land more steeply sloping is excluded by the TOR's and is best left under regenerating forest.
e. Is slope less than 16% ?	Land between 16% and 25% is more suitable for tree crops preferably with leguminous cover crops in the inter-rows.
f. Is soil sandy, drought-prone and erodible ?	All these conditions are found together in sandier soils and, where periods of drought are likely, preclude the planting of arable food grain crops. Should the decision be taken to develop these areas, tree crops would be the most suitable development and extended food aid will be needed, or paid work found for the transmigrants, whilst tree crops are maturing. Mechanical clean-clearing of this land is ill-adviseable, on all slope classes.
g. Is land slope less than 9%	According to the TOR's 8% is the limit above which terracing will be needed if food crops are to be grown. In practice terracing or contour strip cropping would be desirable for all land above 5% slope.

h. Is off-farm income readily available ?	This question is important for the well-being of the transmigrant farmers during their earlier years on site, and determines the priority they will attach to food cropping and land terracing. An arduous land terracing programme will be difficult to 'sell' if adequate off-farm employment opportunities exist. On the other hand a paid work programme may need to be implemented to achieve success in difficult areas.
j. Is land mechanically clean-cleared by bulldozer	Full mechanical clean-clearing can jeopardize soil condition and fertility. It is generally unrewarding to attempt to grow shallow rooted arable crops in land so treated, especially if the ground has been left bare for months. The best use of such areas is for tree crops, which are generally less affected by land clearance methods.
k. Is bench terracing to be promoted ?	Steep land can only be used for arable food crops if it is adequately terraced. Timely terracing however will only be promoted by cash payment to transmigrants and is therefore costly, and likely to be developed only in extreme circumstances.

The answers given to the above critical questions lead to the selection of the optimum cropping system, numbered 1 thru 12, to be proposed for an area or part area of land to be allocated for transmigration.

CROPPING DECISION DIAGRAM FOR LAHAN USAHA 1 IN JAMBI

Figure 3.2



A brief description of the cropping options is given in the next section.

3.5.2 Cropping models

The following options result from the use of the decision diagram given in Fig. 3.2.

Model 1 RICE WITH PALAWIJA CROPS AND COCONUTS IN PASANG SURUT AREAS

The regular twice daily inundation of the growing areas in tidal zones provides good conditions for growing rice in the wet season, palawija in the dry season and coconuts on raised beds. Difficult soil conditions however, and problems of water control, may limit yields to 1000-2000 kg padi/ha, and 500 kg of soya or groundnuts per hectare. Yields of coconut depend on drainage.

Model 2 FISH PONDS

Inland fish culture offers the best use of available small stream flow and when fish fingerlings can be organised it can be worthwhile to construct fish ponds and raise fish for sale, or for home consumption. Two transmigration schemes in Jambi province are already in fish production, namely:

Singkut	26 ha of fish ponds
Rimbo Bujang	16 ha of fish ponds

The Fisheries Directorate estimate yields as follows :

- from ponds with adequate running water - 1000 kg/ha/yr of fresh fish
- from stagnant ponds - 500 kg/ha/yr of fresh fish.

Costs of fish pond construction can be high, the standard rate being Rp. 1000/m^3 of earth moved. Thus a 100 $m^{2)}$ pond will cost some Rp. 50,000 a time if labour has to be purchased or some 30 transmigrant man-days, and will produce at least 10 kg of fish per year valued at Rp.1500/kg live weight or Rp. 15,000 worth per year. The first fingerlings cost Rp. 15/each and some 300 would be needed allowing for mortality, to stock a 10 m x 10 m pond initially. The first crop can be taken at 4-5 months.

Family fish intake is estimated at 22.5 kg/ha/yr for Indonesia as a whole but 13 kg for Jambi province, so the demand is considerable, the supply primarily being regulated by a shortage of suitable sites having running water. A flow of some 5-10 ltr/min/ha is needed or in volumetric terms a water change of 0.1%.

Common species raised are Tilapia, Common carp, Kissing gurame & Giant gurame. Considerable skill is needed to avoid disease and it is estimated that only 10% of transmigrants have any experience of fish farming. In view of the scarcity of surface water supplies it would be expedient to ensure that farmers who are skilled in fish culture are allocated plots close to running streams, for development of fish ponds, as individual rather than co-operative management is more likely to succeed. The Fisheries Directorate should be required to increase its level of technical assistance on transmigration schemes.

Model 3 RAINFED SAWAH

Rainfed sawah construction is often possible in small valley and swamp areas. Acidity may check yields but reliability of obtaining a crop will be greater than from hill padi. IR 36 should be chosen where water depth can be regulated to some 10 cm max. The soils should contain sufficient clay to achieve a puddle, thus retaining water in the sawah. Yields could approach 2000 kg/ha, given sufficient inputs and attention to pest control. Generally only one crop will be possible although low lying areas with low percolation losses might support two crops per year.

Up to 300 mandays are likely to be needed for initial sawah construction, depending on terrain. If small tractor or animal cultivation is possible labour needs will be between 120-240 mandays per crop. Entirely manual cultivation will add a further 100 mandays. With some 450 mandays per year available a family could just manage to find enough labour for a crop of padi over 4-5 months

Model 4 DROUGHT TOLERANT TREE AND FRUIT CROPS

Sandy soils are notoriously drought-prone especially for shallow rooting food grain crops. The inherent infertility of the soil does little to encourage deep rooting of maize, rice and legumes and where - as in Jambi - one or more 10 day drought periods occur with a probability of 70% during the growing season these soils must be considered unsuitable for arable cropping in normal years. Even bananas will not grow well on these soils. Only tree crops having drought tolerant characteristics are suitable. Hence this model proposes cashews, coconuts, coffee (under coconuts), citrus, and pineapples; all plants with specially waxy leaves to reduce transpiration. Rubber can grow on these soils but first tapping age will probably increase to year 6 or even 7 and yields of latex may be reduced in subsequent dry years.

Transmigrants farming these crops will certainly need extended food aid or a work creation programme and processing facilities will be needed for copra, and cashew nuts later in the life of the project.

Cashew nuts could start bearing in year 3 so any processing facility would need to be commissioned by that time. Yield estimates at maturity are estimated as follows :

Cashews	950 kg/ha/yr
Coconuts (copra)	800 kg/ha/yr
Coffee	400 kg/ha/yr
Citrus (limes)	70 kg/tree/yr

Pineapples (underplanted)	10,000 fruits/ha/yr
Rubber (seedling)	280 kg DRC/ha/yr
Rubber (budded stump) GT 1	1100 kg DRC/ha/yr

Model 5 TREE CROPS ON MECHANICALLY CLEARED LAND

The growing of first time arable food crops on mechanically cleared land has frequently resulted in no yield. Consequently if bulldozers must be used it is preferable that tree crops be planted into the cleared area during the first year. Most trees benefit if the planting hole is given some humus or leaf mould and fertilizer or manure. This is less necessary for rubber but is highly beneficial for coffee bushes and citrus. Coffee under shade, (artificial shade initially) followed by Leucaena (Lamtoro), Glyricidea shade, coconuts, fruit trees, and cloves are recommended, whilst rubber would be a safer choice under poorer conditions.

Ideally the clearance contractor would already have sown a leguminuous cover crop mixture of Calopogonium mucunoides, Centrosema pubescens and Pueraria phaseoloides, preferably with 1 ton of limestone per hectare and fertiliser. Leguminous trees & bushes are sensitive to acid soils.

Yields will be modest due to the poor soils and the type of land clearing employed. Yields at maturity are estimated as follows :

Coffee	450 kg/ha/yr
Coconuts (Talls)	900 kg/ha/yr
Coconuts (Hybrids)	1800 kg/ha/yr
Cloves	2 kg/tree/yr
Fruit trees	50-600 fruits/tree/yr
Bananas	35,000 kg/ha/yr
Rubber (seedling) (PBIG)	900 kg DRC/ha/yr
Rubber (budded stump) (GT 1)	1100 kg DRC/ha/yr

Model 6 INTER-CROPPING ARABLE WITH TREE CROPS

Slopes 9% can be inter-cropped, ie. food crops sown between tree crop rows. This old-established technique is capable of yielding reasonable food crops including pure stand rice, multiple cropped rice/maize/cassava/soya or groundnuts/mung beans between rows of rubber spaced 7 m apart or rows of coconuts spaced 10 m apart. Rubber can be intercropped for 2-3 years whilst tall coconuts, widely spaced, provide useful shade for many years. Many other useful mixtures are possible including pasture grasses and pineapples. The key to success is to slash and burn the forest stand, felling the logs as far as possible along the contour and planting at the start of the wetter season into moist soil retaining its ash residues and top soil.

Calcitic or dolomitic limestone should be applied by spinner (hand or tractor) as early as possible at the rate of 2 t/ha. Planting would be with a stick or hoe used under minimum tillage. Planting of tree crops would be carried out almost simultaneously. Highly acid soils with concentrations of aluminium should be avoided.

Tree crop yields resulting from this model are likely to be slightly higher than from model 5 due to the better start given to the young trees.

The crop yields are estimated :

Rubber seedling (PBIG)	1000 kg/ha/yr
Rubber budded stump (GT 1)	1200 kg/ha/yr
Coconuts (talls) (copra)	1000 kg/ha/yr
Coconuts (hybrids) (copra)	2000 kg/ha/yr
Cloves	2 kg/tree/yr
Coffee	500 kg/ha/yr

Inter-planted arable crops, although occupying some 80% of the area would be expected to yield the same as an entirely arable crop stand in a wet year but are more likely to give a better yield in a hot dry year due to the shading effect of the tree crop, and the greater moisture available in the top soil.

Average[1] arable yields over a run of wet and dry years are estimated as follows :

	Without lime-stone Kg/ha[1]	With lime stone kg/ha[2]	% Occu-pation	Without lime-stone Yield in mixed stand kg/ha/yr	With lime-stone
Padi	800	1280	80%	640	1020
Maize	570	900	20%	110	180
Groundnuts (unshelled)	550	910	40%	220	360
Soya beans	400	680	40%	160	270
Mung beans	300	450	80%	240	360
Total mixed arable dry grain				1370	2190
Arable crop total adjusted for tree crop occupation (20%)				1100	1750

SOURCE: Discussions with farmers[1] and researchers[2]

MODEL 7 MIXED FOOD CROPS FROM ARABLE AND FAST GROWING PERENNIALS

Where lack of off-farm paid employment creates a higher priority for food crop production for subsistence, earlier maturing food/tree crops should replace coconuts/rubber and cassava must be used as a staple, along with sweet potatoes and yams. Most rice will need to be imported into the scheme unless a significant amount of padi sawah is available for cropping option 3.

1) for red yellow podzolic soils, but the range of yields can be very great as instanced by a succession of upland padi crops at:

	1978	1979	1980	1981	1982
Situng II, Pure stand padi	-	0	100	600	300
Singkut I, Mixed cropping	700	1100	1300	1400	1100

2) Assuming a cheap source of limestone, applied at 2t/ha once.

Thus bananas and fast maturing fruit trees, eg. nangka, are recommended as shade crops for the interplanted CRIA proposed multiple cropped arable food plants (rice/soya beans/groundnuts/cassava/sweet potatoes). The area should be limed at 2t/ha, once, assuming a cheap source of limestone.

The tree crops will provide shading from the sun and shelter from the wind, thus reducing evapotranspiration losses from the arable food crop stand. Soils will remain cooler and more moist, and plant drought stress will be reduced. This will be particularly beneficial during dry years or late arrival of the wet season, as in 1982.

Yields are estimated as follows :

	Without lime-stone kg/ha[1)]	With lime-stone kg/ha[2)]	% Occu-pation	Without lime-stone Yield in mixed stand kg/ha/yr	With lime-stone Yield in mixed stand kg/ha/yr
Bananas	40000	40000	15%	6000	6000
Nangka etc[3)]	50000	50000	5%	2500	2500
CRIA mixed multiple arable grain crops	1200	1900	70%	840	1330
Cassava	7000	9000	5%	350	450
Sweet potatoes	10000	12000	5%	500	600
Total farm mixed stand				10190	10880

SOURCE : Discussions with farmers (1) and researchers (2)

Model 8 RUBBER WITH LEGUMINOUS CROP

On more steeply sloping land arable cropping becomes hazardous and where farmers have adequate off-farm employment, it would be better that they plant their steeply

3) Tropical fruits yielding 250 kg/tree.

sloping land to rubber, preferably using a cover crop between the rows. Arable food cropping on mechanically clean-cleared land is not recommended for slopes above 8%. Indeed mechanical clearing of steep land is not recommended either - but in practice such land does get cleared.

Yields are estimated :

Rubber seedling (PBIG)	1000 kg DRC/ha/yr at maturity
Rubber budded stump (GT 1)	1200 kg DRC/ha/yr at maturity

Nurseries for budded stump production or PBIG seedlings should be established preferably one year before the arrival of the transmigrants. Dinas Perkebunan would be the most competent authority but will need special funds to undertake this work for the transmigration programme.

Model 9 FULLY INTEGRATED TREE, BUSH AND ARABLE CROPPING

Steep land is really best protected by tree crops, maintaining a canopy cover at all times. A fully integrated mixed tree crop/bush crop/ground crop system is recommended, comprising a high level canopy eg. coconuts (talls), a middle layer canopy, eg. coffee, pepper (up the base of coconuts), mixed fruit, and at ground level vegetables, root crops, spices and the occassional maize and sugar cane.

Estimates of yield are complex, and will depend on the whims of the families concerned. The aim should be self sufficiency.

The following species should be represented.

Species	Yield per tree/bush/plant per year
Coconuts	50 nuts/tree
Cloves	3 kg/tree
Mixed fruits	250 fruits/tree (average)
Bananas	2 bunches/plant
Coffee	1-1.5 kg/bush
Pepper	1.5 kg/plant
Ginger	0.7 kg/plant
Turmeric	0.8 kg/plant
Cinnamon	0.06 kg/tree
Cardamom	10 seeds/plant
Lime	70 kg/tree
Papaya	70 fruits/plant
Maize	2 cobs/plant
Sugar	0.5 kg sugar/plant
Cassava	3 kg/roots/plant
Sweet potatoes	3 kg/plant
Pulses	2 gm/plant
Pineapples	1 pineapple/plant
Cocoa	0.3 kg/tree
Leucaena	-
Tea	0.9 kg/bush
Nutmeg	20 fruits/tree
Avocado	-
Napier grass	-

SOURCE : discussions with farmers.

A similar model has been developed in Sri Lanka by FAO involving some 3680 plants/ha. Income on this project was estimated at US.\$. 2000/ha[1].

The secret of success lies in maintaining a natural soil mulch and preserving useful existing young trees as shade for the young tree crops planted into the undisturbed soil profile. The whole 'garden' has to be carefully planted to provide areas of different exposure to cater for

1) "Mixed cropping" - Ceres May-June 1981.

species of differing habit. The area should not be clean-felled because selective shading will be required from the jungle bushes.

Model 10 TREE CROPS IN POCKET TERRACES ON MECHANICALLY CLEAN-CLEARED LAND

Where land has been mechanically clean-cleared and few job opportunities exist outside the farm then it will be necessary to make every effort to get rapid results from a food crop/cash crop system. It should be stressed however that on steep land such a course may well fail. Coffee under coconuts, or coffee under rubber planted in platform terraces along the contour should be tried.

Extended food aid may be needed - perhaps for 3-4 years. Yields are expected to be the same as in Model 5, although the risks will be greater during tree establishment.

Model 11 BENCH TERRACED ARABLE CROPPING WITH DIVERSIFIED TREE CROPS

On steep land that has been semi-mechanically cleared using chainsaws and in-situ burning, serious attempts to grow food crops can only be made if bench terraces are constructed immediately with tree crops planted along the bunds. Most food and tree crops can be grown in this manner but the problem is pursuading the farmer to undertake the enormous task of earth moving. For example an 8% slope, bench terraced at 20 metres, will require the moving of some 6.3 m^3 per linear metre of terrace, or some 4 mandays per linear metre at 1.5 m^3 of earth moved per manday. Terracing could well form the target of a job creation programme funded from money saved by not deploying bulldozers on agricultural land. Some Rp. 300,000/ha could be so redeployed, enough for 300-600 mandays.

Yields from this bench terraced area would be expected to be much the same as from Model 6 once the soil profile had settled down. Yields in the first year would be poor. Lime at the rate of 2 t/ha should be applied[1)], immediately following terracing to give the maximum time for the soil amelioration processes.

Model 12 TRADITIONAL RICE-RUBBER

Where manual construction of terraces cannot be financed, terracing is unlikely to be timely. The need for food crops will probably dictate that transmigrants on steeply sloping land will follow the traditional Jambi system of slashing and burning the forest and stick planting hill rice between the charred logs for one season, quickly followed by planting of rubber trees. The first time crop of rice could yield 800-1200 kg/ha depending on season.

Provided sufficient budded stumps can be raised, rubber tapping should start in year 6 after transplanting; the following yields being achievable from well-maintained and fertilized trees. eg. GT 1 (t/ha DRC).

Year	6	7	8	9	10	11-15	16-20	21-30
Yield DRC t/ha	0.2	0.6	0.8	1.0	1.3	1.4-1.8	1.8	1.6-1.4

3.5.3 Land utilisation types (LUT's)

In order to allow Phase II planning to proceed according to established criteria the twelve cropping models discussed in the previous section are now grouped into the main LUT's commonly used for transmigration screening studies ie. :

LUT's	Cropping models
1. Rainfed upland arable farming with fruit trees	7
2. Wetland rice/palawija farming	1, 3

1) Assuming cheaper supplies of lime.

3. Tree crops	4, 5, 8, 10
4. Village sites & houselots	6, 9, 11

Plus a suggested additional mixed cropping LUT

5. Mixed arable/tree cropping	6, 9, 11, 12

The agronomic reasons for LUT 5 have been advanced in the foregoing sections. It is worthy of note that this system of land utilisation is gradually evolving on transmigration settlements, although receiving little official assistance.

RAINFED UPLAND ARABLE FARMING (MODIFIED)

This LUT is only suited to flatter areas of more easily worked fertile alluviums not suffering from drought or flooding conditions. On slopes of more than 5%, terracing is recommended, and liming would be desirable.

WETLAND RICE/PALAWIJA FARMING

Low lying areas with stream access, or with reliable recharge can be used for padi sawah for 2 crops, or when rainfed only sometimes for one crop of padi followed by one crop of palawija. The palawija crop may often fail due to water shortage.

TREE CROPS

Well-drained land on slopes up to 25% can be used for tree crops. Land clearance can be restricted to slashing and burning en-situ.

VILLAGE SITES AND HOUSEPLOTS (LP)

Generally these areas can be on moderately sloping land as terracing is more likely to be completed on house lots than on the more remote Lahan Usaha I. Ideally of course the land should be flat, but given the rolling nature of the terrain in Merlung, flatter land is more likely to be found on the crests of the ridges than in the valleys. However it is likely that water supply will prove difficult if housing occupies the tops of the crests, whilst road construction and maintenance will be more costly if housing is located on the slopes.

It is recommended that limestone be applied to the garden plots prior to the arrival of the transmigrants, at the rate of 2 t/ha. Plots should ideally be seeded with Calopogonium spp in which case 1 t/ha of limestone may suffice.

MIXED ARABLE/TREE CROPPING

This is the generally preferred LUT and the one most commonly observed in older transmigration settlements. It allows greater flexibility in cropping marginal areas and gives greater insurance against crop failure, as well as promoting a sound agricultural system capable of continuous sustained cropping.

3.6 GENERAL RECOMMENDATIONS FOR DEVELOPMENT OF FUTURE TRANSMIGRATION AGRICULTURAL AREAS ON RED-YELLOW PODSOLIC SOILS IN SUMATRA

3.6.1 Preferably slash and burn trees and bushes remaining after sale of marketable timber. Not only is this cheaper and faster but also disturbs the soil profile the least, enriches the top soil with wood ash, reduces the risk of aluminium salts in the subsoil upsetting plant nutritional balances and preserves soil moisture. Some 60-80% of the land area is useable between the logs for stick planting a food crop, which is more likely to give a useful yield than when planted into mechanically clean-cleared land.

3.6.2 There would be much to recommend that the transmigrants themselves clear their own areas, being employed to do so. Local land clearance charges for a man with a chainsaw are around Rp. 35-40,000 per hectare felled. To this should be added the cost of additional mandays at Rp. 1000/manday to achieve a good burn. The total cost of Rp. 160,000/ha is considerably less than the present Rp. 450,000 allocated for bulldozer clearing, which uses valuable foreign exchange.

3.6.3 On sloping land, trees should be felled along the contour and thus act as temporary erosion control bunds rather than down-the-hill, as is more usually seen.

3.6.4 Care should be taken not to block the stream courses as rice sawahs and fish ponds can be developed in the valley bottoms.

3.6.5 Where land is mechanically clean-cleared a cover crop, following a dressing of at least 1 t/ha of limestone and a basal dressing of N & P, should be established immediately after harrowing whilst there is still some moisture in the top soil to promote cover-crop germination. Cover crop seed should be planted some 1 cm deep in a regular stand at the correct seeding rate.

3.6.6 Sufficient budget should be allocated for 100% cover crop establishment.

3.6.7 Lime applications for arable cropping are clearly technically viable, yields being boosted by some 160% for maize & grain legumes, but economic viability will depend on the location and development of closer, cheaper sources of calcitic and dolomitic limestone. It has estimated (Ref.1) that limestone should cost no more than Rp. 14,000/ton delivered to a transmigration site within 100 km of the quarry, whereas at the moment limestone, ex Sumbar, costs Rp. 50,000/t delivered Jambi.

3.6.8 Land cleared by chainsaw with manual stacking and burning will require less lime to ameliorate unfavourable soil chemical conditions than land subjected to mechanical clean-clearing by bulldozer.

3.6.9 Lime should be applied to house plots immediately after clearing at the rate of 500 kg to each 0.25 ha. The importance of the LP area is such that even at the present cost of lime (Rp. 50,000/t delivered) this application should be born by Government.

3.6.10 Every effort should be made to co-ordinate site work & minimise the delay between land being cleared and the transmigrants starting to farm the cleared area. Otherwise irreparable damage is done to the soil during the waiting period. There would be much to recommend the appointment of one competent contractor responsible for all phases of development, and the appointment of one consultant for feasibility, design and implementation.

3.6.11 Allocation of LU 1 area to transmigrants should proceed without delay[1)] and the Directorate General Agraria should be given a contingency floating fund to utilize in emergencies, in order to allow timely completion of cadastral surveys.

3.6.12 Where land has been mechanically clean-cleared in sloping areas, a practice to be avoided, it would be better to use the area for tree crops planted in the first year and to plant arable food crops into freshly slashed and burned areas.

3.6.13 Generally an integrated mixture of tree crops and food crops is recommended in order to promote retention of soil moisture, lower soil surface temperatures, lower drought stresses in shallow rooting annuals, thus promoting their better growth and higher yields, whilst, at the same time, advancing the planting of tree crops in time so that transmigrants can begin harvesting the tree crops sooner.

3.6.14 Where coconuts or cashews are advocated, processing facilities will also be needed within a few years of scheme initiation.

3.6.15 The limited stream flow in the Merlung area would be better used for fish ponds as the value of the catch can approach Rp.1,500,000/ha/yr - a return exceeding that of most planted crops; also the fish can be harvested within 5 months of commissioning a pond. Private ponds are more likely to be successful than co-operative ventures until management become more enlightened.

1) Delays between the arrival of transmigrant families and their first cultivation of their Lahan Usaha I area (LU I) can in some cases exceed 12 months. This partly due to budgetary constraints within the Directorate General of Agraria. If the actual number of settlers on any particular scheme exceeds the budgetary target, eg. if 6200 families arrive in an area originally targeted and budgeted for only 6000, the excess 200 must await the release of the next years' DIP Funds, generally available in August, before Agraria cadastral survey teams can stake out their Lahan Usaha (LU 1) and the Kepala Kantor Unit Transmigrasi can allocate families to their new LU 1 areas. During this time mechanically cleared land can be permanently damaged by erosion unless a cover crop has been established and transmigrant families can incur hardship unless off-farm work is available. In addition stocks of seed given under the T/M agricultural package can deteriorate in storage and be useless when needed, hence transmigrants complaints about seed quality.

3.6.16 No attempt should be made to mechanically clean-clear or grow arable food crops on steep land, unless terracing is undertaken immediately, and no attempt should be made to grow arable grain crops on sandy soils, where drought conditions are likely to result in moisture stress.

3.6.17 On the LU 2 area, it is difficult to conceive of a crop more suitable than rubber from both an agronomic and marketing point of view.

3.6.18 However the provision of budded stumps of high clonal rubber to all transmigrants in Jambi province is a task of enormous magnitude. A temporary measure might be to use the ex-Malaysian seed rubber PBIG which reportedly yields some 80% of budded GT 1. This would greatly speed up the transmigration planting programme and simplify the otherwise considerable logistical problems.

3.6.19 There is a need for a greatly accelerated programme of hybrid coconut production. Waiting for the F1 generation can take many years. The use of F2 generation material would be attractive as at least 50% of the resulting F1 crosses are phenotypically and genotypically hybrids.

3.6.20 The development of blast resistant rices is required as most current entries appear to be at least partially susceptible. The variety C 22 currently under trials does not seem to be tolerant of dry conditions.

3.6.21 The allocation of poultry and goats to transmigrant families could usefully supplement their income and improve their diet. In terms of value for capital outlay this would be better initially than concentrating on bovines.

APPENDIX A.1

CRIA MULTIPLE ARABLE FOOD CROPPING PERFORMANCE

Place	Cropping pattern	Gross return Rp/ha	Material costs Rp/ha	Nett return Rp/ha	Labour input m-d/ha	Return to labour Rp/m-d
Bandar Agung '75-'76 Lampung (Old alang-alang)	Corn + upland-rice	173.520	56.440	117.080	434	270
Komering Putih Lampung '75-'76 (newly opened areas)	Corn + upland-rice	202.260	57.700	144.560	559	259

SOURCE : Mc Intosh, Effendi, Syarifuddin, CRIA Bogor.
"Testing cropping patterns for upland conditions" 1976.

Babcock

REPUBLIC OF INDONESIA
MINISTRY OF PUBLIC WORKS, DIRECTORATE GENERAL OF HOUSING, BUILDING, PLANNING, & URBAN DEVELOPMENT.
(CIPTA KARYA)

SCREENING STUDY (PHASE II) FOR TRANSMIGRATION SETTLEMENT DEVELOPMENT.

AGRICULTURAL SUPPLEMENT

SKP's in KAB. MUSI RAWAS, SUMATERA SELATAN

SSTD SOUTHERN SUMATRA TRANSMIGRATION DEVELOPMENT

HALCROW FOX AND ASSOCIATES in co-operation with
INDULEXCO-PARAMA CONSORTIUM.

CONTENTS

LIST OF TABLES

LIST OF FIGURES

1. OBJECTIVES

This supplement has been compiled following extensive tours of Jambi province and Kab. Musi Rawas in Sumatera Selatan province, including visits to all recent transmigration settlement areas in the vicinity of the study areas[1], or having relevance to the locations being studied[2].

The lessons to be learned from traditional agricultural practices, and the experiences of the transmigrant families on both recently settled and more established holdings, are used to develop a methodology for selecting optimum cropping systems under the wide range of conditions found in prospective transmigration areas.

Increasingly in the future the areas available for transmigration settlement will become more marginal as further settlement continues. It is therefore necessary to modify currently proposed cropping systems to make optimum use of the opportunities arising, to maximise the benefits for transmigrant families and to overcome constraints in the most cost effective manner.

A discussion of current land clearing methods and costs is also justified to examine whether the considerable sums of money spent on full mechanical clean-clearing of forest and alang-alang could not be better spent on alternative, more rewarding inputs.

2. EXISTING AGRICULTURAL SITUATION IN KAB. MUSI RAWAS

2.1 Settlements in Kab. Musi Rawas tend to fall into two groups:

- Older larger and more recent, smaller, riverine settlements inhabited by indigenous and local (within Sumatera Selatan) settlers

1) Tugumulyo, Megang Sakti, Klingi B, Jayaloka, Dharmasakti, Ngestiboga.
2) Alai Hilir, Rimbo Bujang, Jujuhan, Sitiung II (Blocks D & E), Kuamang Kuning, Kubang Ujo, Pemenang, Singkut and Sitiung I (in Sumbar).

- Essentially Javanese settlements, some of at least 3 generations (eg. Tugumulyo), comprising spontaneous transmigrants as well as transmigrants of very recent origin eg. Klingi B (1982) and Ngestiboga (1981).

2.2 Established agriculture

Upland areas in Kab. Musi Rawas mainly support tree crops, particularly rubber and coffee, with some shifting rice cultivation on the undulating land forms, in soils of low inherent fertility. The notable exception to this is the Tugumulyo Irrigation Scheme near Lubuk Linggau which is achieving high yields of double cropped rice from irrigated fertile soils. There are large expanses of swamp-forest prone to inundation, and riverine flooding is a common event. Vast tracts of alang-alang exist, particularly in Kec. Jayaloka.

Where primary or secondary forest land is utilized the custom is to slash and burn 'in-situ' and then plant upland rice (padi go-go, padi ladang) for one or, in rare cases, two seasons. No tillage is practiced, a stick being used to make holes some 30 cm x 30 cm apart in the still soft ground between the charred logs immediately following the burn. Several seeds are dropped into each hole and left to germinate. No further inputs are used. Modest yields are obtained. In a good year perhaps the yield approaches 1400 kg/ha. In a dry, blast-prone year only some 400-500 kg/ha are obtained. It is noticeable that plant establishment is reduced on more steeply sloping areas, due to erosion, but improves on flatter land, both on the crests and in the valley bottoms, where soils are often deeper and more retentive of moisture.

Following the harvesting of the rice, or sometimes before, seed rubber is planted which gradually achieves full canopy, and can be exploited from year 8, as no inputs are used. In areas with high average family holdings of rubber of all ages, tapping is commenced in year twelve after planting, the family preferring to maximise the return to labour by tapping only mature trees during their peak

1) Source - Farmer estimates, but yields are highly variable. In times of high rubber prices more rubber is tapped (450 kg/ha), but in times of low rubber prices production falls.

yielding years. Yields during this period are said to average 350 kg/ha/yr DRC[1)] and daily collection can amount to some 15 kg of wet slab rubber per manday. In more densely settled areas the average size of rubber holdings is smaller and the system of 'bagi hasil' (share tapping) prevails. There is an increasing trend towards 'bagi dua' where the tapper earns only 50% of the days rubber collection rather two thirds. This reflects increasing population pressure on the existing rubber areas and, competing, labour. Transmigrants of some 3-6 years standing tap for the indigenous rubber garden owners.

At the moment, due to the low price of rubber, there is much pure shifting cultivation of padi go-go, generally grown for one year only followed by natural regrowth. This undesirable technique is practiced mainly by poorer indigenous families who then move onto the next area. Land under shifting cultivation rarely extends more than 5 km from major access tracks/rivers, thus confining agricultural usage to secondary forest areas on a 5-8 year cycle; although once rumours of transmigration settlement are confirmed new land is cleared by the indigenes to obtain usufruct rights (hak usaha).

Within communities owning less rubber, as in more recently settled villages, rice followed by rubber or rubber planted into the first and only rice crop is tapped sooner, eg. commencing in year 8 after planting, reflecting the lower opportunity of tapping more mature trees. Average yields in this case are lower, at some 280 kg/ha/yr DRC and the daily collection is only some 12 kg/man-day of wet slab.

In rare cases better farmers practice 'inter-cropping' ie. the growing of food crops between rows of rubber. Several interesting mixed stands of rubber and pineapples, coconuts and vegetables, coconuts and coffee can be observed. Coffee cultivation is important with Lubuk Linggau being the main buying centre. Some 12 tons/day of dried coffee beans are sent by road, during the season, to Palembang for export to Singapore.

Mixed fruit tree cropping occurs in the house gardens in which jack-fruit (nangka), rambutan, cloves (cengkeh), bananas (pisang), sugar-cane (tebu), coffee (kopi) and coconut (kelapa) are common. Citrus and local tropical fruits are grown. Often cassava (ubi kayu), maize (jagung) and grain legumes (kacang-kacangan) are grown between the trees.

Extensive pure stand arable cropping is never practiced except on irrigated and rainfed sawah. Yields of padi on the Tugumulyo Irrigation Scheme average some 4.5 t/ha/crop and some areas are growing 5 crops of padi over 2 years.

Adjacent to the more recently opened logging tracks there is much strip clearing, the 'occupants' attempting to obtain usufruct rights (Hak Usaha) over this land.

A feature of the Kabupaten is the vigorous growth of alang-alang (Imperata cylindrica) which covers vast tracts of non-flooding upland.

Production by Dinas Perkebunan of budded stumps for rubber replanting is lagging behind Jambi province and much old rubber exists. There is a little rainfed sawah in riverine terrace situations along major, less incised, rivers. Most isolated communities need to buy rice.

Livestock production in Kab. Musi Rawas is not a major activity. Some buffalo are owned, a few sheep and less frequently cattle. Local chickens are widely kept. Meat from the larger animals is rarely consumed in the villages, beast being sold to meet major items of family expenditure. Draft animals are important only in the irrigated sawah areas, a customary rate for land preparation is Rp. 40,000/ha for 3 passes.

Transmigration agriculture

In contrast to the essentially tree crop orientated established agriculture and the developed padi sawahs, the more recently arrived transmigration families are attempting to grow food crops, often against insuperable odds. There is an almost universal shortfall in production of pure or mixed stand arable upland food grains and little, or no yield from first crops on mechanically clean-cleared forest land is a common event.

Yields of rice fluctuate widely from year to year, a range of 200 kg/ha to 1200 kg/ha being reported during farmers interviews.

Maize is an almost universal failure on upland red-yellow podsolic soils whilst soya bean yields are highly variable. Only cassava grows reliably, supply often exceeding demand, as this crop is regarded as an emergency stand- by, rice being the preferred staple.

It is valuable to compare the agricultural patterns of transmigration blocks during their first years, eg. Kelingi B & Ngestiboga, with older, more established blocks such as Singkut I, Jayaloka and Tugumulyo Unit J.

Whilst in younger areas arable food grain crops compete poorly with hot, dry infertile soils, aggressive alang-alang, erratic input supplies, dubious seed qualities, multitudinous pest and disease attacks, and the ravages of birds and wild animals, in the longer settled units one can observe a gradual shift to mixed tree and food crop agriculture and even to complete tree crop production systems.

From this and the fact that successful land use tends to polarise into tree crops on uplands and padi sawah in the wetlands, it is reasonable to predict that, in the fullness of time recent transmigration settlements will gradually take on much of the character of longer established settlements and will rely heavily on tree crops of different sorts, but mainly rubber, with rice grown under irrigation wherever possible.

In spite of this prediction it is never-the-less important to devise a means of maximising the yields and returns to labour and capital from arable food cropping, which is so important for transmigrants during their early years in their new homes in remote locations, where lack of market outlets constrains production of most of the fruit and food crops that can be easily grown.

Before making recommendations later in this report it will be valuable to briefly discuss some of the major problems and opportunities that exist in present transmigration settlements.

3 ISSUES ARISING

3.1 Soil fertility & liming

It is well known[1] that the red-yellow podsolic soils that predominate in upland areas of Kab. Musi Rawas are universally acidic (pH range 4-5). At this level of acidity, aluminium is freely available which fixes phosphorus (both the little naturally occurring P and also the applied P) rendering it unavailable to plants; and thereby directly inhibiting root formation and development. This is likely to occur when exchangeable Al on the absorption complex exceeds 2 meq./100 g of soil and when the saturation of aluminium exceeds 40% - a situation commonly found in these soils.

Annual plants such as maize, soya beans and rice develop only shallow roots[2] and therefore become susceptible to periods of drought. In Kab. Musi Rawas a 10 day or more drought period occurs with a probability of 70% during the normal growing period (Oct-Mar) of rainfed crops. In addition because of the generally unthrifty growth of annual grain plants they easily succumb to pest and disease attacks.

Aluminium availability increases with depth. Therefore the less the soil profile is disturbed, and the more top soil that can be preserved in the process of jungle clearance, the better will be the growing conditions for future crops.

The application of calcitic or dolomitic limestone can ameliorate the adverse chemical conditions in the soil by raising the pH thus rendering the aluminium less mobile. Experimental work carried out by the IPB in red-yellow podsolic soils has indicated that yields of maize can be improved 1.6 times and yields of soya bean up to 1.7 times. Results with upland rice are more variable - depending on the season. Experiments laid out at the EEC project in Alai Hilir also demonstrate the benefits of limestone application.

1) van Dierendonck 1982; IPB 1982.

2) Sungai Dareh-Sitiung 1979 - agricultural trials on mechanically cleared red-yellow podsolic soil.

The recommended dosage of limestone is between 1.5-2t/ha to raise the pH by a unit. The problem at the moment is one of economics. The delivered price of lime in Kab. Musi Rawas is about Rp. 50,000/t. Newly transmigrated families on low incomes[1] are unlikely to buy lime at these prices even if it was available.

It has been estimated by van Dierendonck of FAO that many outcrops of limestone are indicated on the geological maps of Sumatra mostly down the eastern fringe of the Barisan Range. Exploration and exploitation of these sources should not cost more than Rp. 6.000/ton, to which should be added delivery charges of some Rp. 80/ton/km. If this is proven, ground limestone can be recommended as being of economic as well as technical benefit.

There would appear to be a case for applying limestone to house plots, no matter if sub-economic, provided this was supplied as a service from the Government, and executed in the interests of promoting rapid establishment of home-lot production. This limestone should be applied as early as possible to leave sufficient time for it to exert its buffering effect. Ash is also useful but is unlikely to be available in sufficient quantities.

Tree crops, especially rubber, are better able to survive difficult soil conditions and can modify the environment by shading, by soil temperature reduction, and by deposition of organic matter, which helps to maintain the nutrient status of the soil and improves the moisture availability. Tree crops do not really need lime, although coffee and citrus in particular benefit from organic matter in the planting hole.

The application of irrigation water to, or amassing of rainwater in, suitable sawahs can also ameliorate difficult chemical conditions in the soil by fostering the establishment of anaerobic soil microflora and microfauna. The soil profile gradually

1) Average family cash income from all sources at Kubang Ujo in 1981-82 was Rp. 61.600/KK/yr, although some assistance is still being provided through food aid and subsidised agricultural inputs. Estimated total annual income for the average settler at Megang Sakti (a more established spontaneous migration settlement) is about Rp. 200.000/yr from all sources.

becomes more chemically reduced, darkens in colour and its pH rises from 4-5 to 5-6.5. At this pH, aluminium (Al) and iron (Fe), become less mobile and cease to interfere with applied phosphatic fertiliser and plant-growth; nitrogenous fertiliser becomes more effective and the plant-growth improves dramatically. Newly created sawahs in previously dryland situations are liable to take a few seasons under saturated conditions to achieve good yield levels of padi[1]. Although costly, irrigation is a sure way of improving self-sufficiency in rice. A large element of risk is removed and farmers will use higher levels of inputs.

3.2 Multiple arable food grain systems

The main advantages claimed[2] for a mixed stand of different types of arable food plants are as follows:

- more food can be produced from less land, perhaps up to 1.6 times, due to the symbiotic effect of the mixed plant community and the better use of incoming radiant energy,
- the risks of crop failure are more widely spread,
- the soil is more adequately protected from the sun and rain and, when under relay cropping, for a greater part of the year than under monocultural arable systems,
- labour needs are more evenly distributed throughout the year although total labour required per multiple cropped hectare is some 1.4 times that for monocultural crops.

This system, based on multiple and relay cropping of arable food crops including maize, upland rice, cassava, ground nuts or soya beans, and sometimes a further crop of mung beans, has been recommended by the CRIA for a number of years. Under subsidised conditions eg. at Batu Raja and Way Abang, the research institutes have achieved creditable yields from their selected, assisted-farmer plots. However the situation in the transmigration schemes is different and in Kab. Musi Rawas very few farmers are follow-

1) Sungai Dareh-Sitiung Irrigation Project 1977-82
2) Willem C Beets, 1982, "Multiple cropping and tropical farming systems"

ing this system in its recommended form. It is reported[1] that even farmers previously collaborating in the CRIA trials have reverted to lower cost systems on cessation of the financial subsidy. There are a number of difficulties for farmers in following intensive arable cropping systems. These fall into two groups:

- technical
- socio-economic

Technical constraints

Maize is important in the CRIA multiple cropping systems because the rows, spaced 2 meters apart are designed to reduce evapotranspiration by lessening the velocity of air movement over the inter-planted rice crop and to provide shade protection, thus reducing soil temperature. Drought stress is thereby reduced in the rice and soil moisture conserved. Unfortunately, maize is particularly susceptible to aluminium toxicity and does not grow well in the acid red-yellow podsolic soils of Sumatra. Poorly established maize is unable to shelter the inter-planted rice crop, whilst, in the rare instances where the maize plant does establish well, stemborer and other insect attacks drastically reduce the yields: monkeys take the rest.

The second technical problem is with the legume crop; soya beans in particular do not always thrive on the acid soils generally prevailing as the root nodules develop only poorly at pH's of 4-5, even after inoculation. In many cases total failure has been reported.

A third major constraint lies with the cassava, which is designed to replace the maize as the row protection crop. Although cassava grows probably better than any of the other crops recommended,it faces marketing constraints because rice is the preferred staple. This same problem exists with the Dinas Pertanian recommended system of four square cassava planting surrounding soya bean, groundnuts or rice. Cassava, unless fertilised - a rare event - is also extremely exhaustive of soil nutrients.

1) Personal communication

Socio-economic constraints

More serious are the socio-economic constraints of risk and return to labour. Transmigration families fear indebtedness and are reluctant to spend money on the considerable inputs needed to make the improved cropping system work, only to lose the crop due to drought, heavy rainstorms, or predators. An estimated outlay of some Rp. 150,000/ha is needed before the harvest can be taken, so few families have the inclination or recources to stake so much on risky ventures.

Transmigrant families are generally younger, thus having less labour available. Labour availability is more of a constraint than land availability. Transmigrants, where they can, therefore tend to devote their energies to tasks offering greater rewards, once having made some attempt at producing crops for subsistence requiring little capital outlay. Farmer surveys indicate that returns from arable cropping systems lie in the range of Rp. 100-Rp. 300 per manday. The CRIA claim that their recent research trials can yield Rp. 1750/manday for systems requiring 450-550 man-days/ha/season. Few farmers achieve this, whilst most farmers seek off-farm work which averages Rp. 1000/manday at no risk.

It is widely considered, as a general guide, that for success to be claimed from a recommended cropping pattern, it must have been adopted by at least 70% of the target farm families. Currently adoption levels of the CRIA multiple grain cropping system (rice-maize-beans) in Kab. Musi Rawas are so low as to require further thought before pushing the unmodified model in new transmigration areas.

Proposals have been made by research workers, consultants and others for establishing a green manure fallow, as a break in arable cropping rotations. Whilst such a technique can be highly beneficial to the soil it is unrealistic in the context of transmigration where the main concern is one of survival. Very few farmers are aware of the benefits or can afford to expend cash and labour on crops not giving them an immediate income or food supply.

3.3 Deterioration of growing conditions from continuous arable grain crop production

Sitiung II Block E provides an example of the soil deterioration that can occur from continuous grain cropping on steep erodible soils. This year it is estimated that upland rice will yield only 200 kg/ha. Although some terracing has been completed in this area it is too little and was constructed too late to save the soil. Sheet and gulley erosion resulting in bare patches can be plainly seen on the slopes. This transmigration area is unique in that, unlike farmers on schemes of similar age elsewhere who have learned from personal experience that tree cropping or tree crop/food crop mixtures are better than pure arable cropping continuously on the same land, the Block E farmers are still growing upland rice, now for the fifth continuous year.

The reason for not modifying the arable system at Sitiung II Block E is that the transmigrants here are still hoping for the promised irrigation water from the Sungai Dareh-Sitiung Irrigation Scheme. But even here a few realistic farmers have, of their own volition, planted seedling rubber along the field margins and are starting to develop an intercropping system with greatly improved results, both on yield and soil stability.

A further risk from pure-stand arable cropping or annual multiple cropping systems is the risk of alang-alang encroachment. Again this can be seen at Sitiung II on the more fertile lower river terraces. Areas that were in production 3 years ago under rice and soya beans are now completely choked with alang-alang and have been abandoned.

Vast tracts of land in Kec. Jayaloka are similarly afflicted with alang-alang, whilst on the new settlement at Klingi B old alang-alang, disc harrowed in 1982, was seen invading the crops in early 1983.

At Rimbo-Bujang the same problem of alang-alang has occurred on the less well-husbanded plots. These farmers find it easier to intercrop rice between the newly planted budded stump rubber on areas of freshly slashed and burned forest in their LU 2 area rather than to tackle the alang-alang at the back of their houses. The rice interplanted with rubber is successful but is occurring in spite of a Perkebunan directive that only tree crops be planted on the LU 2 area designated for tree crops. Conversely many of the better farmers wish to plant rubber in their LU 1 area and intercrop food crops (mainly rice) between the young tree rows. Their desire to intercrop should be supported.

Pure stand monoculture or multiple arable grain cropping in upland areas cannot be considered as a viable long term production system capable of sustained implementation, on any but the best soils, under the most capital and labour intensive systems. These conditions do not prevail in Kab. Musi Rawas.

3.4 Mechanical clean-clearing of land

Introduction

The clean-clearing of forest and alang-alang land by bulldozers and heavy machinery appears to be a well-entrenched practice in transmigration settlement. This technique has the advantages of speed, thoroughness and timeliness, but is otherwise costly and can be deleterious for future cropping. This section will highlight some of the main features, with the view of (hopefully) promoting a more selective approach to land clearing in the future.

The chain of events

Before being able to objectively discuss the "pro's and cons" of mechanical clean-clearing it is necessary to understand the complete sequence of events between the first arrival of the equipment on site and the transmigrants beginning to farm the areas so cleared.

Whilst the occassional success can be quoted - where land has been mechanically cleared at the optimum time, a good burn achieved, a thorough disc harrowing carried out between the largest standing stumps, cover crop established immediately following harrowing, transmigrants arriving and starting to farm the area at the optimum time with readily available inputs of high quality - often, in practice, such perfection is difficult to achieve. Instead the following sequence of events occurs:

- Land is cleared by bulldozers, in all weathers, using mainly straight blades, at contract rates that offer the clearance contractor little profit and no incentive to invest sufficiently in specialised rakes and 'KG' blades which do less damage to the soil.

- The cleared and burnt land is then harrowed using heavy reclamation 'Rome' machinery which is often incorrectly set, ie. the gangs are used on straight cut which merely cuts surface wood and compacts a series of narrow trenches in the soil, doing little to encourage infiltration of rain water into the profile. The incorrect setting of harrows allows the clearance contractor to recoup his losses on the other operations, which have more tightly drawn specifications and upon which all but the most efficient operators lose money.

- However some land clearing specifications require that the disc gangs be set on minimum cut in order to reduce soil profile disturbance. In these cases the need to harrow at all becomes questionable - as little benefit is derived from the operation - the transmigrants still being obliged to cangkul the area by hand.

- If the clearance contract also includes leguminous cover crop establishment, often there is a delay between final harrowing and cover crop seeding which can be deleterious for cover crop establishment. The reason for this delay is sometimes due to operational expendiencies and at other times due to inadequate seed to cover the whole area cleared. In this case the contractor waits for completion of land clearing in order to more easily select the more steeply sloping land for cover crop seeding. Delays can result in loss of top soil and run-down in fertility making good cover crop establishment more difficult to achieve.

- Where a cover crop has not been sown, or has shown poor growth, the resulting land is then left to the mercy of the heavy rains and intense sunshine to harden further prior to the arrival of the transmigrants - in some cases many months later. On steeper land, sheet and gulley erosion occurs and the top soil washes downhill.

- where alang-alang has been heavy disc harrowed the previous year, it often sprouts with renewed vigour and re-establishes cover before the new transmigrants start cultivating for the next planting season.

- The transmigrants, following first arrival, spend a number of months sorting themselves, their houses and their gardens out before starting to farm the mechanically cleared Lahan Usaha I. Unless cover crop establishment has been successful, further hardening, oxidation of the little remaining organic matter and further erosion occurs before the transmigrants are able to work the area, or alang-alang has re-established control.

- In some cases, budgetary constraints on the Directorate General Agraria causes further delays in marking out and allocating LU I land to newly arrived transmigrants.

- The transmigrants then often find that the combination of machinery compaction, ground smearing, incorrect setting of the harrows and the effect of the weather during the waiting period has so hardened the ground that they need to cangkul the area before planting, a task that can take up to 3 months per hectare. The danger of aluminium toxicity has meanwhile increased severely. Where alang-alang is prevalent the trans- migrants are faced with a tangle of grass roots necessitating painstaking and arduous cangkul and hand pulling.

- Where cover crops have established over the litter of wood chips and broken roots, considerable problems in cultivating the area are encountered.

- This often results in transmigrants raking up and burning the cover crop and underlying wood litter prior to planting their crops - a practice which largely nullifies the benefit of the green mulch.

- In order to cultivate and burn the remaining stumps, the women then laboriously pick up all the wood trash mulch lying on the surface thus exposing the soil fully to erosion and further oxidation.

- Finally the seeds are sown but are often of dubious germination viability, possibly due to unforseen delays, and crops are often inadequately supplied with fertilizer and chemicals.

- The task of adequately maintaining so large a cleared area is quite beyond the means of most transmigration families, so further soil deterioration occurs, and often encroachment by alang-alang, rendering much of the area more difficult to cultivate in the future.

Thus it can be appreciated that all operations must be tightly controlled if the greatest benefit is to be derived from mechanical clean-clearing of forest and alang-alang land.

Advantages of mechanical clean clearing

There are three main advantages of mechanical clean clearing, namely :

- Timeliness
- Increased useable land area
- Ease of execution

Timeliness

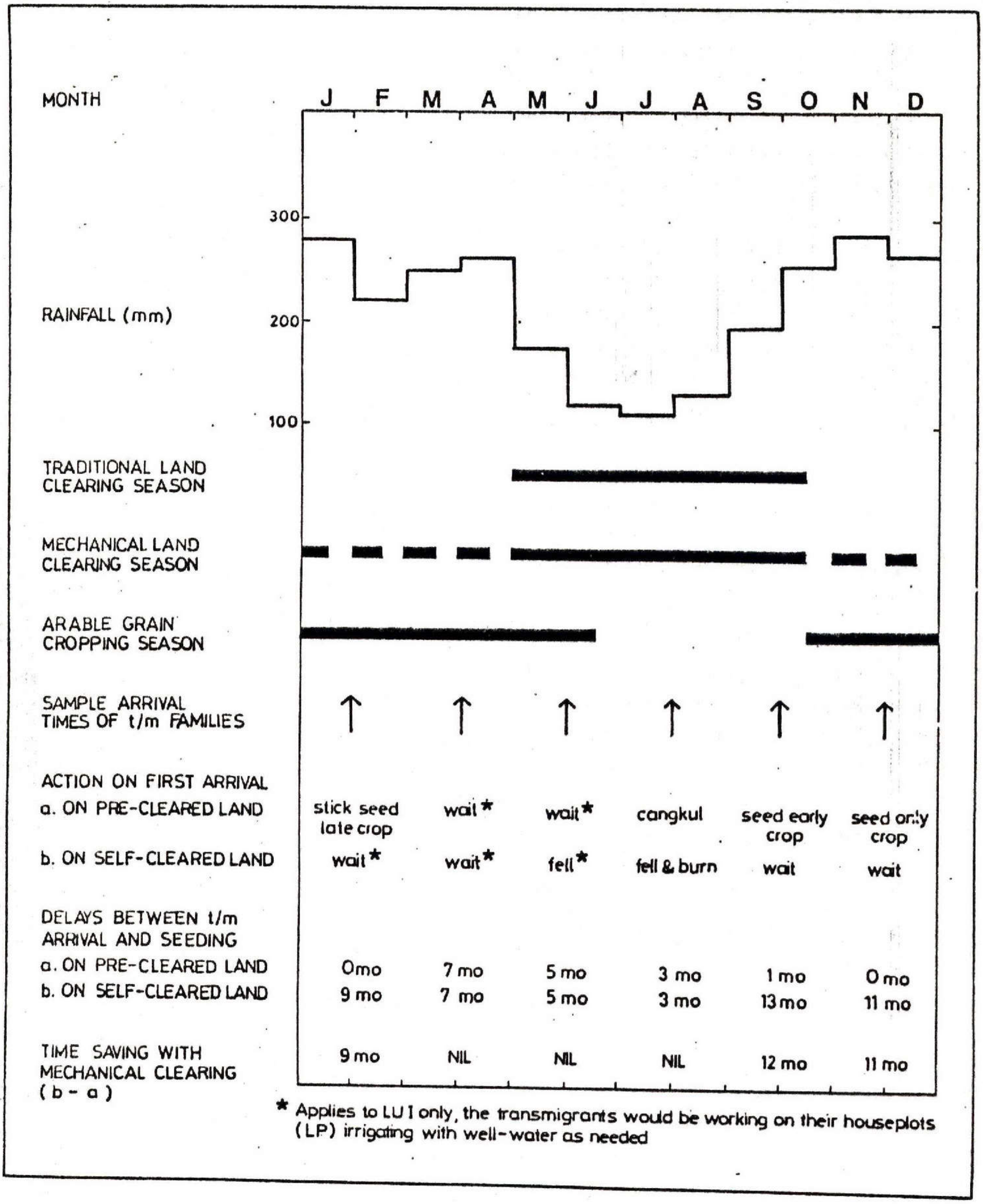
Mechanical clean-clearing of forest using bulldozers can sometimes be justified from improved timeliness. But as is indicated in Fig. 1, the benefit is not universal for all transmigrants.

The figure shows the relationship between the wet seasons, the optimum clearing months, and the arable growing season - all related to the time of arrival of the transmigrant families on site, assuming two alternatives :

- land pre-cleared mechanically by contractors before transmigrant

COMPARISON OF DELAYS BETWEEN FIRST ARRIVAL OF TRANSMIGRANTS ON SITE AND THEIR STARTING TO SEED THEIR LAHAN USAHA I-FOR TWO ALTERNATIVE SYSTEMS OF LAND CLEARING

FIGURE: D1



arrival.

- land semi-mechanically cleared by transmigrant families themselves after arrival.

It is apparent that transmigrants arriving between October and February will experience minimum delay in cultivating their pre-cleared land, whilst those inheriting uncleared land will need to await the forthcoming dry season before clearing and burning, and the following wet season before planting. Delays could be substantial - in the worst cases up to 13 months.

However for both groupings of transmigrants arriving between April and September, there will be no saving in time from pre-clearing as neither group will be able to successfully plant arable crops before the next wet season. The group inheriting the pre-cleared land would be worse off due to having to put some 120 mandays of effort into cangkuling the hardened deteriorating soil during crop establishment whilst the self-clearing group will be expending only some 90 mandays felling, burning and immediately stick seeding. The yields from semi-mechanically felled and burnt land will be better and more reliably obtained than from mechanically clean- cleared land, so some of the apparent benefits accruing to mechanical clean-clearing will be reduced in the 50% of cases where timeliness is improved.

Were a policy of semi-mechanical land-clearing to be adopted in preference to full mechanical clean-clearing it would appear essential that transmigrant families be paid to clear their own land; for two reasons :

- semi-mechanical pre-clearing would be difficult for land clearance contractors to organise and supervise,

- the transmigrants themselves would greatly benefit from the income derived from semi-mechanical land clearing on their own plots before being able to set seeds for the oncoming wet season,

Increased useable area

It can be observed that some 96% of land mechanically clean-cleared is available for cultivation of crops, whilst with semi-mechanical and hand-clearing methods 80% & 60% only of the total cleared area can be planted, due to the presence of semi-charred logs, but these gradually rot and enrich the soil, and can be used as erosion control bunds if felled along the contour.

Ease of execution

In the more remote areas it is clearly easier for a contractor to mobilize a smaller number of skilled operators and machines on forest clearing than to import, house and supervise a vast labour force of semi-skilled and unskilled labourers.

However the expediant of employing transmigrants already housed on site on mechanically pre-cleared plots (LP) to semi-mechanically clear their own LU 1 area, could go a long way to achieve a reasonable compromise between the various factors involved in land clearing.

Disadvantages of mechanical clean-clearing

The are two serious disadvantages of mechanical clean-clearing namely:

- the adverse agronomic conditions created for subsequent arable cropping (in the absence of cover crops)

- the high cost of mechanical land-clearing and cover crop establishment.

Agronomic considerations

The agronomic desirability of disturbing jungle soil profiles as little as possible in order to preserve top-soil and organic matter, leaving subsoils containing greater quantities of mobile aluminium undisturbed and keeping as much vegetation sheltering the soil surface from direct sunlight as possible prior to the planting of the crop -is indicated in the more reliable yields from first time planted upland padi (padi go-go) (500-1200 kg/ha) compared with first time planted padi into mechanically clean cleared land

(0-800 kg/ha).

Additionally land can be cleared of jungle and the ground stick seeded with padi more quickly than the hardened soil resulting from mechanical land clearing and subsequent erosion (due to incorrect timing of operations and uncontrollable delays) can be cangkuled by transmigrants.

Cost of land clearing

Current land clearance production rates for contract clean-clearing are given below :

TABLE 1 : MECHANICAL CLEAN-CLEARING PERFORMANCE

Item	Bid schedule per ha	Actual production per ha
Cutting and felling trees > 30 cm diameter with chainsaw	3 m^3/hr	32 hrs
Clearing trees < 30 cm diameter with KG blade on crawler	4.6 hrs	2.7 - 4.0 hrs
Windrowing and piling	4.7 hrs	5.8 - 9.6 hrs
Burning (group of 5 workers)	1.5 hrs	2.0 hrs
Harrowing	2.0 hrs	1.4 - 2.6 hrs
TOTALS		
Chainsaws + 2 operators	variable	32 hrs
Crawler tractors + operators	11.3 hrs	9.9 - 16.2 hrs
Labour (unskilled)	7.5 manhours	10 manhours

SOURCE : Jambi province - current performance - personal communication

It can be seen that only the efficient contractor will be able to beat the targets set.

Three different methods of land clearing are compared below :

TABLE 2 : COMPARISON OF LAND CLEARING METHODS (Per ha)

Task	Forest Condition	Method of clearing A Tradi-tional	B Semi-mechanical	C Full mechanical clean-clearing
Felling	Old rubber	3.5 chs-d[6)]	-	-
	Remnant Dipterocarp	-	5 chs-d (all)	4.0 chs-d (>30 cm)
Mechanical clearing	Old rubber	-	-	-
	Remnant Dipterocarp	-	-	0.5 m/c-d (<30 cm)
Cutting for stacking	Old rubber	3.0 chs-d	-	-
	Remnant Dipterocarp	-	10 chs-d	2.0 chs-d
Manual stacking & burning	Old rubber	10.0 m-d[7)]	-	-
	Remnant Dipterocarp	-	20 m-d	-
Mechanical windrowing & piling	Remnant Dipterocarp	-	-	0.7 m/c-d[8)]
Burning only	Remnant Dipterocarp	-	-	0.2 m-d
Mechanical harrowing	Remnant Dipterocarp	-	-	0.2 m/c-d
TOTALS	Chainsaw time (days @ 5 hr)	6.5[1)]	15[1)]	6[1)]
	Bulldozer time (hrs)	-	-	13[2)]
	Labour skilled (days)	13[3)]	30[3)]	12[4)]
	unskilled (days)	10[5)]	20[5)]	0.2[5)]
Costs (Rp/ha)		70,500	159,000	450,240
Useable land % for arable crops		60%	80%	96%
Cost per equivalent useable area (Rp/ha)		117,500	198,750	470,000

1) @ Rp. 1000/hr ie. O & M Rp. 700/hr; Depreciation Rp. 300/hr.
2) @ Rp. 30,000/bulldozer hr incl. operator
3) @ Rp. 2000/manday
4) @ Rp. 2500/manday
5) @ Rp. 1200/manday
6) chs-d = chainsaw days
7) m-d = mandays
8) m/c-d = machine days

NOTE : Method A - Chainsaw felling, cutting and burning 'in-situ':limited t/m.
Method B - Chainsaw felling and cutting, piling by hand
Method C - Chainsaw felling of large trees, bulldozing of remainder, mechanical stacking and harrowing.

SOURCE : contractors records, local chainsaw operators and farmers.

It can be seen that mechanical clean-clearing of land is at least twice as costly and contrasts strongly with using semi-mechanical methods.

Recommendation

In view of the fact that importation of heavy land-clearing equipment represents valuable foreign exchange, is an expensive operation costing at least Rp. 450,000/ha cleared from forest and does little to preserve a favourable environment for the growing of arable crops, it is suggested that mechanical land clearing be selectively used only in situations that could really benefit from the technique. In these cases timing of all operations should be precise and leguminous cover crops established. In view of the relatively short occupation time of cover crops before farming commences it would prove cheaper to use the more readily available Calopogonium spp rather than the more expensive longer lasting, cover crops employed for estate tree crop practice (Centrosema pubescens, Pueraria spp, Calopogonium spp). Leguminous cover crop seed should be heat-treated overnight before being mixed with a spreader eg. sand or sawdust and then scattered evenly over the previously harrowed land surface whilst the soil is still moist. Ideally seeds should be lightly covered using a light drag chain link harrow. Alternatively a seeding ring roller could do the work.

However the seeding of cover crops is a remedial measure costing money, following the mechanical clean-clearing operation; itself costing a great deal of money. To be effective as a soil improver a cover crop needs to remain 12 months before it is replaced by arable crops. This desirable 12 months period largely nullifies the main advantage to be gained from mechanical clean-clearing - timeliness. Thus the technique of mechanical clean-clearing is largely counter-productive.

The following table contrasts the main considerations :

TABLE 3 COMPARISON OF FOREST CLEARING METHODS

Item	Units		Indigenous A Traditional slash & burn		Transmigrants B Semi-mechanical		C Full mechanical clean-clearing
Costs	Rp/ha		70,500		159,000		450,000
	% of highest		16		35		100
Return to labour[1]	Kg/manday padi		9-21		5-13		0-3
	av. % of best		100		60		10
Timeliness	Family arrival time	Jan/ Feb.	Mar/ Apr.	May/ Jun.	Jul/ Aug.	Sep/ Oct.	Nov/ Dec.
	Time saving	9 mo.	0	0	0	12 mo.	11 mo.
	% of longest	75	0	0	0	100	90

SOURCE : contractors records and farmers

It is suggested that the best compromise is to pay transmigrants to semi-mechanically clear their own areas thus circumventing the high costs (and foreign exchange components) of using heavy contract land clearing machinery; and reducing the depressive effect on the yields of arable crops grown in the degraded soils so cleared. Transmigrant families would thus be assured of better incomes, both initially during the self land clearance phase, and later when their first crops mature.

In alang-alang areas chemical control methods are likely to prove more effective and longer lasting than purely mechanical methods.

1) Up to crop establishment.

2) In secondary forest and old rubber areas only

3.5 Alang-alang land

Much of the area proposed for transmigrant settlement development in Kab. Musi Rawas is presently covered with alang-alang (Imperata cylindrica). This aggressive rhizomatous grass thrives in cleared upland forest areas and is capable of establishing a complete canopy within months of opening the land. Repeated annual burning serves to maintain alang-alang as the climax vegetation.

The difficulties of checking the alang-alang by hand methods, or animal cultivation, are such that land infested with this grass is invariably abandoned. The thick mat of roots survive burning and have to be dug out manually by cangkul and hand pulling. Such work can require some 80-100 mandays/ha and is rarely sufficiently thorough to prevent re-infestation. Consequently the allocation of alang-alang land to transmigrants is rarely contested by the local population!

Contract mechanical harrowing of alang-alang is commonly performed, sometimes up to 11 months before the transmigrants arrive on site. Although visually land prepared by this method is ready for planting immediately following a good harrowing,it is not long before the alang-alang regrows and competes with the planted crops. When transmigrant arrival is delayed,it has to be hand pulled by families before planting their field crops. Cassava is the preferred crop for planting in reclaimed alang-alang land, and this can thrive without fertiliser. However the first crop so exhausts the little fertility built up by the alang-alang over the previous years that, in the absence of applied fertiliser, the following crop cannot grow sufficiently quickly and becomes choked by the re-emerging alang-alang. At this stage the land is often abandoned and the alang-alang proliferates unchecked.

The use of Glyphosate (eg. 'Round-up') on young alang-alang, following a burn, is the most effective control measure and, whilst being expensive, costs less than manual or mechanical clearing without the use of chemicals. The following table contrasts four different methods of clearing alang-alang in potential transmigration settlement areas:

TABLE 4 INPUT & COSTS OF CLEARING ALANG-ALANG (per ha)

Item	A Manual method only	B Chemical + manual	C Chemical + mechanical	D Mecahnical only
Slashing (manual)	18 m-d	18 m-d	-	-
Slashing (machine)			2 m/c-hr	2 m/c-hr
Felling (chainsaw)	2 m-d	2 m-d	1 m-d	1 m-d
Burning	·1 m-d	1 m-d	1 m-d	1 m-d
Collecting & burning logs 15 cm dia.	5 m-d	5 m-d	3 m-d	3 m-d
Spraying glyphosate at 6 litre/ha.	- -	4 m-d 4 spr-d	4 m-d 4 spr-d	- -
Harrowing ("Rome") (1x,4x)	-	-	1.5m/c-hr	6 m/c-hr
Other	1 m-d	2 m-d	3 m-d	3 m-d
Respraying	- -	1 m-d 1 spr-d	1 m-d 1 spr-d	- -
<u>Sub-totals</u>				
a). Inputs				
Mandays (m-d)	27	33	13	8
Machine-hrs (m/c-hr)	-	-	3.5	8
Chainsaw-hrs (chs-hr)	12	12	6	6
Chemical (ltr)	-	6	6	-
Sprayer-days (spr-d)	-	5	5	-
b). Costs				
Labour @ (av) Rp.1,500/hr	40,500	49,500	19,500	12,000
Machines @ Rp.30,000/hr	-	-	105,000	240,000
Chainsaws @ Rp.1,000/hr	12,000	12,000	6,000	6,000
Chemicals @ Rp.18,000/ltr	-	108,000	108,000	-
Low Vol. Sprayers @ Rp.300/ha	-	300	300	-
TOTALS Rp/ha	52,500	169,800	238,800	258,000
Add value of t/m labour for removal of roots by hand 100 m-d at Rp.1200/day	120,000	60,000	-	-
GRAND TOTAL COST	172,500	229,800	238,800	258,000

SOURCE : Biotrop, chemical company literature, Estate Crops Directorate data.

METHOD A, whilst cheaper, is short lived and not recommended as alang-alang soon rejuvenates and re-infests the area, and then rapidly gets out of control.

METHOD B is a mixture of chemicals and strip-cultivation and is the most cost effective method, provided that the transmigrant is prepared to spend the necessary time on properly establishing seeds/ seedlings into the mass of chemically killed roots. Given good husbandry and appropriate cropping systems, re-infestation by seed should be controlled. It would be advisable to pay transmigrants for this work.

METHOD C, a combination of chemicals and mechanical cultivation is the quickest and the most thorough, although expensive and risky if rain falls within 6 hours of the application of chemicals. But the mechanical cultivation can bring up unwanted subsoil with consequent aluminium problems, and is not advised for steeper land prone to erosion.

METHOD D is expensive and prolonged. Its success depends on exhausting the energy reserves stored in the rhizomes by repeated cultivation, interspersed with waiting periods, to allow regrowth before again dicing the alang-alang by another pass with the disc harrows to 20 cm deep. At least 4 passes, with a 3 week waiting period between each pass, will greatly reduce the capacity of the expensive equipment (D5 and 'Rome' harrow) used for this operation. Greater flexibility would be introduced by the use of large, high horsepower, 4 wheel drive tractors, but such equipment is of limited application as it is unsuitable for forest clearance activities and therefore is special purpose and costly.

The installation of transmigrants on old alang-alang areas should only follow a thorough, well-timed, kill of the alang-alang, preferably using chemicals containing glyphosate. Yields from undisturbed profiles where alang-alang has been effectively killed, using chemicals, could initially be higher than from mechanically cleared forest land. This is due to the improved chemical and physical conditions prevailing in the rooting zones of the alang-alang ie. the top 20 cm. Failing a good kill, once the first flush of crops has occured, subsequent crops will fail and transmigrants will be obliged to seek off-farm work in order to exist.

As tracts of alang-alang have replaced the climax vegetation type (forest) little opportunity for logging or wood production exists, making the prospective transmigrants even more dependent on the meagre living to be made from their land. Alternatively they are forced to seek off-farm work further afield in order to support their families.

3.6 The case for mixed tree/arable cropping

From the foregoing it can be concluded that pure stand arable cropping or even multiple cropping of arable food grains is a marginal activity on the red-yellow podsolic soils of Sumatra, especially following mechanical clean-clearing, even given applications of lime. The modification of multiple cropping by interplanting under the gentle shade of tree crops arranged along the contour, with less emphasis on food grain production and more emphasis on starchy food production, vegetables, fruit and tree crops are the only viable agricultural systems capable of sustained production on all but the most favourable flatter areas of alluvial soils, (and areas of padi sawah).

The applicability of this approach is further detailed in the following sections.

4 ECONOMIC AND SOCIAL CONSIDERATIONS

Success of transmigration settlement development is as much dependent on socio-economic considerations as on purely technical matters, as the farmers can be clearly observed to base their decisions on survival and what is best for their families,rather than necessarily following centralized policy decisions. The following are particularly relevant:

4.1 Availability of off-farm employment

This is a controversial subject as many policy-makers are inclined to the view that availability of off-farm employment tends to detract from a programme of self-sufficiency in food stuffs. Whilst acknowledging that in some cases this might be so, for example in the case of a skilled craftsman who could earn Rp. 2500-3500/ day from off-farm work or in the case of a few poorer families who undertake menial low-paid tasks (leaving little time or inclination to farm their holdings) there is a body of opinion, and evidence, to support the contention that the availability of off-farm income cannot but enhance the families' own efforts to utilise their land in the most appropriate way.

At Singkut[1] an estimated 450 mandays/KK/year are spent working, of which 50% is spent off farm; earning some Rp. 225,000/year at an average rate of Rp. 1000/manday whilst on Singkut Unit 1, farm income grosses Rp. 107,000 and nets only Rp. 76,000, returning only Rp. 340 per manday. On Singkut Unit V, a more recent settlement with a lower proportion of tree crops, farm income grosses Rp. 78,000 and nets only Rp. 38,000, a return per man-day of only Rp. 170 from predominantly arable cropping. Whilst there is such an imbalance between risky on-farm activities and risk free off-farm activities is it realistic to plan on transmigrants becoming full-time farmers, until all off-farm work opportunities are exhausted? The most contented transmigration schemes are those where new-comers have merged into the general economy of their new regions. Most of the failures have been on remote sites offering little alternatives to arable farming and/or having poor water supplies.

A similar situation prevails at Megang Sakti, a spontaneous transmigration settlement of many years standing, where it is calculated that farmers earn between Rp. 100/day-200/day from their dryland arable farming activities and Rp. 1000/day from cutting wood in the nearby forest.

Seasonal employment off-the-farm can be a valuable addition to family income as instanced at Alai Hilir where the labour force for the EEC mechanical soya bean project is drawn from the nearby transmigration settlement, such labour earning Rp. 1250/day for weeding etc. but only being available for this work during slack periods on their own farms. It is noticeable on the older settlements that the farmers

1) See Marshall Khan, UNDP - FAO Project INS/78/012 1980

with the best holdings, and the most improved houses, are those growing a large proportion of tree crops which gives them more time to undertake off-farm employment. These earnings are often put into the development of the holding including the purchase of expensive young trees for planting on their land. Less enterprising farmers are still growing poor crops of cassava or padi and their houses are little changed from those originally constructed for them. Interviews with a number of farmers have confirmed these trends.

Availability of off-farm employment varies from scheme to scheme but appears greatest in areas of active timber production eg. Megang Sakti, or where transmigrants share-tap for the local indigenous rubber garden owners, eg. Ubi Talang in Kec. Jayaloka.

In discussions, many persons suggested paying transmigrants to undertake some of the work presently being executed by the land clearance contractor. Such work might include semi-mechanical land clearing, burning, alang control, fertilizing, liming, terracing and cover crop establishment.

The Estate Crops Directorate has for a long time followed a policy of paying participants to establish rubber and then recouping the costs by deductions from rubber sales at a later date. Such a policy has much to recommend it, as transmigrants are assured of an income at a time when they need it most.

The future availability of off-farm work opportunities is more difficult to assess. Whilst activities in logging and forest product exploitation would be expected to decline as local sources of timber become exhausted, over say some 5 years, it is possible that as the transmigration settlements develop, service industries will increase and the project achieve 'lift-off'. This is more uncertain on remote schemes, with poor communications, than in areas immediately adjacent to larger population centres. Such areas should claim a higher priority for the establishment of tree crops.

Opportunities for rubber planting and replanting and for tapping rubber would be expected to increase both with increasing areas under rubber and improved yields from those areas.

4.2 Return to labour

In the consultants opinion it is fruitless to continue to promote a solely upland arable food grain system currently returning not more than Rp. 200/manday in the teeth of technical and economic constraints. Which family provider will put high labour inputs into a system giving him so little return to his efforts or stake large capital sums, even if he had the resources, on risky ventures ? It is most important to so modify the system by introducing mixed diversified tree crops and interplanted food crops together in the same area and thus improve yields from both. This in fact is happening in the better managed holdings in the more established transmigration blocks/units. Such a trend should receive greater official recognition and technical assistance.

Evidence points to better yields at lower labour inputs obtained from rice planted into slash and burn areas rather than into mechanically clean-cleared land. Almost all transmigrant families interviewed expressed a preference for clearing their LU 1 areas themselves and planting rice between the charred logs, as labour inputs would be less (given access to a chainsaw) and yield would be more certain. Although a number of management problems would need to be resolved, the benefits to the transmigrants could be substantial.

The local land clearing technique is as follows :

Operation	Labour needed (mandays/ha)		Time lapsed (weeks)	
	A	B	A	B
Cutting trees with chainsaw	7	10	0.5	1
Wait 3 months to dry	-	-	12.0	12
Manual stacking and burning	16	40	2.5	7
Wait for rains	-	-	?	?
Planting (with stick)	34	40	3	4
TOTALS	57	90	18 +	24 +
Effective area cleared	60%	80%		

NOTES : A = Old rubber and secondary forest B = Remnant Dipterocarp
SOURCE: Farmer interviews.

This contrasts with the labour required to cangkul areas of mechanically clean-cleared land, where the soils have hardened due to improper harrowing, raindrop compaction, organic top soil loss and baking due to direct sunlight. Such soils are also too hard to be worked by draft animals.

The following table summarises the returns to transmigrant labour input following the three alternative systems of forest opening:

TABLE 5 RETURNS TO FOREST CLEARING (per ha)

Operation	A Traditional shifting cultivation in secondary forest or old rubber	B Semi-mechanical clearing with chainsaw hand stacking & burning in remnant Dipterocarp forest	C Mechanical clean-clearing with bulldozers in remnant Dipterocarp forest
Clearing & burning	23 mandays	50 mandays	-1)
Preparing land & seeding	34 mandays (by stick)	40 mandays (by stick)	120 mandays 2) (by cangkol)
Lapsed time	18 weeks	24 weeks	13 weeks
Yields of upland rice	500-1200 kg	500-1200 kg	0-400 kg
Return to labour required to establish the crop	9-21 kg/m-d	5-13 kg/m-d	0-3 kg/m-d

SOURCE : Contractors records, discussions with farmers.

Thus transmigrant income would be improved by clearing forest land semi-mechanically and better conditions retained for future arable and tree crop growth.

1) All operations carried out by contractor prior to arrival of transmigrants on site.
2) Done by transmigrants manually, using cangkols.

Similarly costs, timeliness and returns to inputs from the three viable alang-alang clearance methods can be compared:

Item	B Chemical + manual	C Chemical + mechanical	D Mechanical only
Contract cost Rp/ha	170.000	239.000	258.000
Preparing land (mandays/ha) by transmigrants	50	-1)	-1)
Lapsed time (incl. waiting periods)	6 wks	2 wks	9 wks
Seeding (mandays/ha)	40	40	40
Yields of upland padi/ha	1400 kg	1200 kg	1000 kg
Capital cost of production (Rp/kg of padi)2)	120	199	258
Return to transmigrants labour kg/manday3)	16	30	25

Note : 1) Mechanical cultivation by contractor
2) Contract cost divided by 1st yield
3) Kg of padi per transmigrant manday up to crop establishment only

It is concluded that the use of chemicals for alang-alang eradication is preferable from many points of view, including effectiveness, cost and timeliness.

The lower return to transmigrant labour resulting from Method B above is due to transmigrants being required to strip cultivate between dead rhizomes. If this work was funded by Government it would add to the capital costs, although it would still be cheaper than other methods. However it would increase the return to transmigrants own labour in establishing rice on their own plots up to 35 kg/manday of padi. An additional advantage would be the guaranteed income to the transmigrant families during their first year, when it is most needed.

Should Method C be employed, care would need to be taken that the final cultivation of dead alang-alang roots was followed by early crop establishment.

At present prices, rubber tapping would be expected to return Rp. 800 - Rp. 1500 per manday for some 4 days a week throughout most of year giving some Rp. 180,000 - Rp. 200,000 per worker per year, a better and less risky return to labour than is likely to be derived from arable cropping. The cash from rubber sales would be used to buy rice, as in the indigenous situation.

4.3 Marketing constraints

Whilst there will always be a market on transmigration schemes for the products of an enterprising fish farmer, vegetable grower or coffee producer who gets in first, the question of markets arises for many diversified tree crop and horticultural products if many transmigration families are producing the same crops at the same times.

Good examples of this are pineapples at Rp. 50/each, cassava at Rp. 20/kg and nangka which has no sale value as almost every one has too many. The same could happen if everybody grew coffee successfully the present price being Rp. 500-600/kg dried beans : and also to coconuts (Rp. 100-120/fresh nut) unless a processing facility is established in the neighbourhood. Perhaps only rubber is likely to remain immune from a long term price decline.

Thus marketing constraints are likely to confine the area of diversified tree cropping to say 1 ha per family. Experience would indicate that this area should be interplanted with food crops for subsistence needs only, where soil and slope conditions permit. The remaining area of the holding should probably be rubber or coconuts for processing.

Coconuts make an excellent shade crop for both coffee and food crops, and, in the fullness of time, for grass and animal grazing, whilst dwarf hybrids give three times the copra yield. Processing facilities for copra will need to be organised for each area of transmigration to reduce transportation costs.

4.4 Prices of basic commodities

It is noticeable that areas of Kab. Musi Rawas with poor access suffer from lower selling prices and higher buying prices. Thus rice can vary in price from Rp. 325/kg in Lubuk Linggau to Rp. 360/kg in Binjai whilst rubber declines from Rp. 150/kg in Lubuk Linggau for good quality wet slab to Rp. 100/kg in remote riverine locations and coffee from Rp. 1100/kg to Rp. 700/kg dry bean. Improved transportation will tend to reduce the differences, whilst the recent increased costs of petrol (Jan 1983) will accentuate price differences as outboard petrol engined boats are widely used.

5 AGRICULTURAL DEVELOPMENT POSSIBILITIES

The wealth of agricultural experience accumulated from transmigration schemes over the past few years, and the increasingly marginal nature of remaining areas available for transmigration in Sumatra, dictate that careful thought should be given to developing agricultural cropping models capable of giving sustained yields, yet going some way to meeting the need for basic food. This section has this aim in view.

5.1 Land use considerations

Figure 2 is a decision diagram designed to allow the user to choose the most appropriate cropping option for any particular transmigration scheme, or part of scheme, based on the physical resources and the socio-economic conditions prevailing.

It poses a number of key questions, set out thus ◇?, which form the main criteria for selection. These main questions and their relevance are tabulated below.

Question	Relevance
a. Is area poor draining and relatively flat, yet non-flooding?	Whether wetland rice can be grown, being the main staple.

b. Is irrigation possible at some future date?	Whether lower lying areas of the transmigration zones can eventually be irrigated and thus produce food crops more reliably.
c. Is running water available ?	The limited flow in the many small streams can be used to greatest effect for fish ponds. Failing this rice can be grown in the valley bottoms using rainfall.
d. Is slope less than 25% ?	Land more steeply sloping is excluded by the TOR's and is best left under regenerating forest.
e. Is slope less than 16% ?	Land between 16% and 25% is more suitable for tree crops preferably with leguminous cover crops in the inter-rows.
f. Is soil sandy, drought-prone and erodible ?	All these conditions are found together in sandier soils and, where periods of drought are likely, preclude the planting of arable food grain crops. Should the decision be taken to develop these areas, tree crops would be the most suitable development and extended food aid will be needed, or paid work found for the transmigrants, whilst tree crops are maturing. Mechanical clean-clearing of this land is ill-adviseable, on all slope classes.
g. Is land slope less than 9%	According to the TOR's 8% is the limit above which terracing will be needed if food crops are to be contour strip cropping would be

contour strip cropping would be desirable for all land above 5% slope.

h. Is off-farm income readily available ?

This question is important for the well-being of the transmigrant farmers during their earlier years on site, and determines the priority they will attach to food cropping and land terracing.

An arduous land terracing or alang-alang control programme will be difficult to 'sell' if adequate off-farm employment opportunities exist. On the other hand a paid work programme may need to be implemented to achieve success in difficult areas.

j. Is land mechanically clean-cleared by bulldozer?

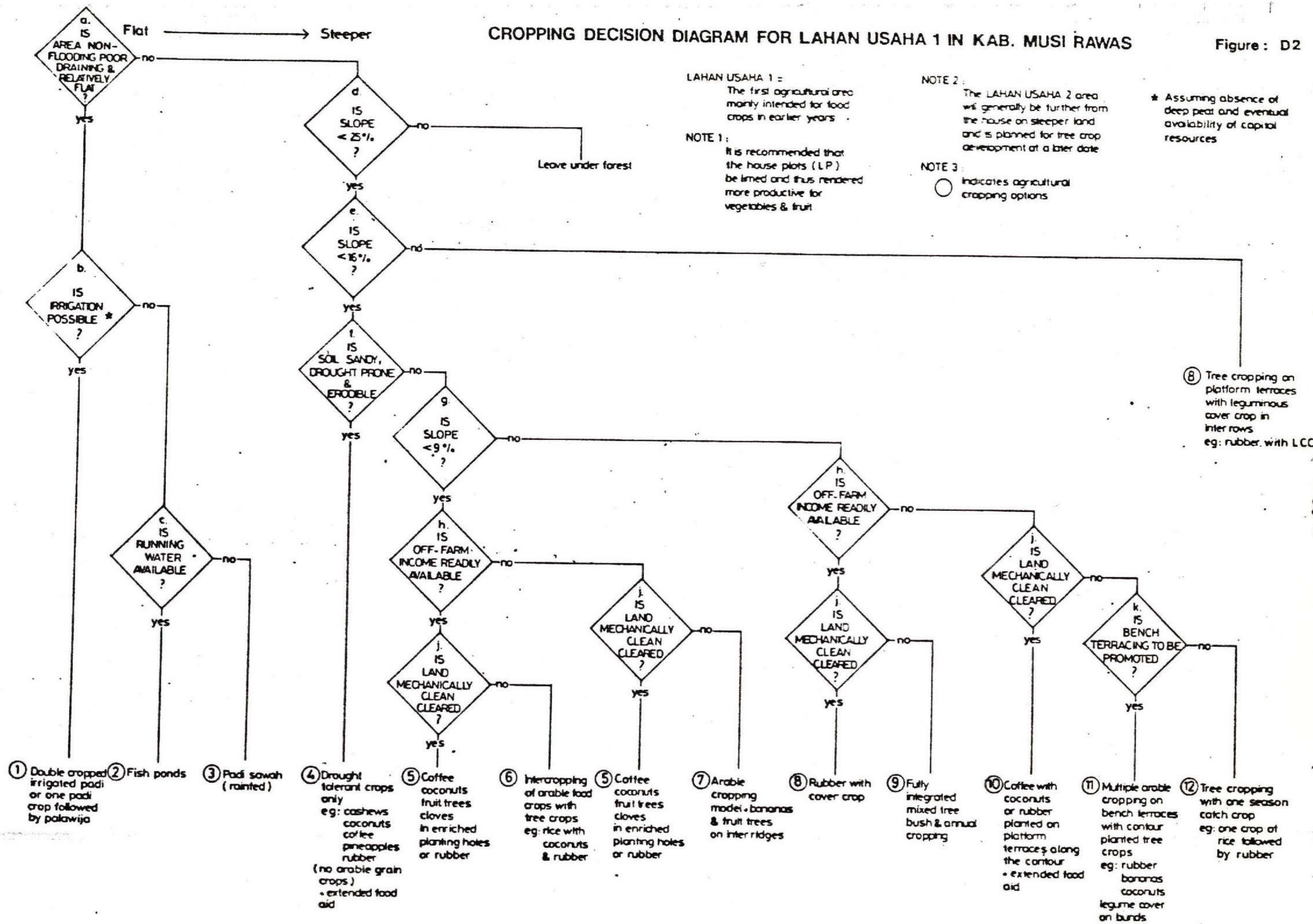
Full mechanical clean-clearing can jeopardize soil condition and fertility. It is generally unrewarding to attempt to grow shallow rooted arable crops in land so treated, especially if the ground has been left bare for months. The best use of such areas is for tree crops, which are generally less affected by land clearance methods.

k. Is bench terracing to be promoted ?

Steep land can only be used for arable food crops if it is adequately terraced. Timely terracing however will only be promoted by cash payment to transmigrants and is therefore costly, and likely to be developed only in extreme circumstances.

CROPPING DECISION DIAGRAM FOR LAHAN USAHA 1 IN KAB. MUSI RAWAS

Figure: D2



The answers given to the above critical questions lead to the selection of the optimum cropping system, numbered 1 thru 12, to be proposed for an area or part area of land to be allocated for transmigration.

A brief description of the cropping options is given below:

5.2 Cropping models

The following options result from the use of the decision diagram given in Fig. 2.

Model 1 IRRIGATED SAWAH - DOUBLE CROPPED PADI OR PADI PLUS PALAWIJA CROPPING

The eventual provision of irrigation water will result in reliable padi production and high yields, due not only to the better environment created for crop growth, but also due to the improved level of inputs and husbandry practices associated with the removal of a high element of risk. Padi (gabah) yields could approach 4.5 t/ha per crop, given full BIMAS inputs, on irrigated sawah. At least two crops per year should be possible given sufficient water supply. Where water is likely to prove insufficient, one crop of rice in the wet season followed by palawija cropping should be possible. Yields of soya beans could approach a 100 fold increase ie. 100 times the seed originally set. Some decline in the palawija yields may be experienced over time as the organic matter in the soil becomes depleted, but frequent inundation and correct use of crop residues should check this trend.

Model 2 FISH PONDS

Inland fish culture offers the best use of available small stream flow and when fish fingerlings can be organised it can be worthwhile to construct fish ponds and raise fish for sale, or for home consumption. Two transmigration schemes in Jambi province are already in fish production, namely:

Singkut 26 ha of fish ponds
Rimbo Bujang 16 ha of fish ponds
and many ponds can be observed between Tugumulyo and Megang Sakti.

The Fisheries Directorate estimate yields as follows :

- from ponds with adequate running water - 1000 kg/ha/yr of fresh fish
- from stagnant ponds - 500 kg/ha/yr of fresh fish.

Costs of fish pond construction can be high, the standard rate being Rp. $1000/m^3$ of earth moved. Thus a 100 m^2 pond will cost some Rp. 50,000 a time if labour has to be purchased or some 30 transmigrant man-days, and will produce at least 10 kg of fish per year valued at Rp.1500/kg live weight or Rp. 15,000 worth per year. The first fingerlings cost Rp. 15/each and some 300 would be needed allowing for mortality, to stock a 10 m x 10 m pond initially. The first crop can be taken at 4-5 months.

Family fish intake is estimated at 22.5 kg/head/yr for Indonesia as a whole but 13 kg for Jambi province, so the demand is considerable, the supply primarily being regulated by a shortage of suitable sites having running water. A flow of some 5-10 ltr/min/ha is needed or in volumetric terms a water change of 0.1%.

Common species raised are Tilapia, Common carp, Kissing gurame & Giant gurame. Considerable skill is needed to avoid disease and it is estimated that only 10% of transmigrants have any experience of fish farming. In view of the scarcity of surface water supplies it would be expedient to ensure that farmers who are skilled in fish culture are allocated plots close to running streams, for development of fish ponds, as individual rather than co-operative management is more likely to succeed. The Fisheries Directorate should be required to increase its level of technical assistance on transmigration schemes.

Model 3 RAINFED SAWAH

Rainfed sawah construction is often possible in small valley and swamp areas. Acidity may check yields but reliability of obtaining a crop will be greater than from hill padi. IR 36 should be chosen where water depth can be regulated to some 10 cm max. The soils should contain sufficient clay to achieve a puddle, thus retaining water in the sawah. Yields could approach 2000 kg/ha, given sufficient inputs and attention to pest control. Generally only one crop will be possible although low lying areas with low percolation losses might support one padi crop followed by palawija crops. Soya bean yields could approach 600 kg/ha, depending on the season.

Up to 300 mandays/ha are likely to be needed for initial sawah construction, depending on terrain. If small tractor or animal cultivation is possible labour needs will be between 120-240 mandays/ha/crop. Entirely manual cultivation will add a further 100 mandays. With some 450 mandays per year available a family could just manage to find enough labour for a hectare of padi over 4-6 months season.

Model 4 DROUGHT TOLERANT TREE AND FRUIT CROPS

Sandy soils are notoriously drought-prone especially for shallow rooting food grain crops. The inherent infertility of the soil does little to encourage deep rooting of maize, rice and legumes and where one or more 10 day drought periods occur with a probability of 70% during the growing season these soils must be considered unsuitable for arable cropping in normal years. Even bananas will not grow well on these soils. Only tree crops having drought tolerant characteristics are suitable. Hence this model proposes cashews, coconuts, coffee (under coconuts), citrus, and pineapples; all plants with specially waxy leaves to reduce transpiration. Rubber can grow on these soils but first tapping age will probably increase to year 6 or even 7 and yields of latex may be reduced in subsequent dry years.

Transmigrants farming these crops will certainly need extended food aid or a work creation programme and processing facilities will be needed for copra, and cashew nuts later in the life of the project.

Cashew nuts could start bearing in year 3 so any processing facility would need to be commissioned by that time. Yield estimates at maturity are estimated as follows :

Cashews	950 kg/ha/yr
Coconuts (copra)	800 kg/ha/yr
Coffee	400 kg/ha/yr
Citrus (limes)	70 kg/tree/yr
Pineapples (underplanted)	10,000 fruits/ha/yr
Rubber (seedling)	280 kg DRC/ha/yr
Rubber (budded stump - GT 1)	1100 kg DRC/ha/yr

Model 5 TREE CROPS ON MECHANICALLY CLEARED LAND

The growing of first time arable food crops on mechanically cleared land has frequently resulted in no yield. Consequently if bulldozers must be used it is preferable that tree crops be planted into the cleared area during the first year. Most trees benefit if the planting hole is given some humus or leaf mould and fertilizer or manure. This is less necessary for rubber but is highly beneficial for coffee bushes and citrus. Coffee under shade, (artificial shade initially) followed by Leucaena (Lamtoro), Glyricidea shade, coconuts, fruit trees, and cloves are recommended, whilst rubber would be a safer choice under poorer conditions.

Ideally the clearance contractor would already have sown a leguminuous cover crop mixture of Calopogonium mucunoides, Centrosema pubescens and Pueraria phaseoloides, preferably with 1 ton of limestone per hectare and fertiliser. Leguminous trees and bushes are sensitive to acid soils.

Yields will be modest due to the poor soils and the type of land clearing employed. Yields at maturity are estimated as follows :

Coffee	450 kg/ha/yr
Coconuts (Talls)	900 kg/ha/yr
Coconuts (Hybrids)	1800 kg/ha/yr
Cloves	2 kg/tree/yr
Fruit trees	50-600 fruits/tree/yr
Bananas	35,000 kg/ha/yr
Rubber (PBIG)	900 kg DRC/ha/yr
Rubber (budded stump - GT 1)	1100 kg DRC/ha/yr

Care should be taken to check any possible invasion of alang-alang during the establishment of the trees.

Model 6 INTER-CROPPING ARABLE WITH TREE CROPS

Slopes less than 9% can be inter-cropped, ie. food crops sown between tree crop rows. This old-established technique is capable of yielding reasonable food crops including pure stand rice, multiple cropped rice/maize/cassava/soya or groundnuts/mung beans between rows of rubber spaced 7 m apart or rows of coconuts spaced more than 10 m apart. Rubber can be intercropped for 2-3 years whilst tall coconuts, widely spaced, provide useful shade for many years. Many other useful mixtures are possible including pasture grasses and pineapples. The key to success is to slash and burn the forest stand, felling the logs as far as possible along the contour and planting at the start of the wetter season into moist soil retaining its ash residues and top soil.

Calcitic or dolomitic limestone should be applied 1) by spinner (hand or tractor) as early as possible at the rate of 2 t/ha. Planting would be with a stick or hoe used under minimum tillage. Planting of tree crops would be carried out almost simultaneously. Highly acid soils with concentrations of aluminium should be avoided.

1) Assuming a cheaper source of limestone.

Tree crop yields resulting from this model are likely to be slightly higher than from model 5 due to the better start given to the young trees.

The crop yields are estimated :

Rubber seedling (PBIG)	1000 kg/ha/yr
Rubber budded stump (GT 1)	1200 kg/ha/yr
Coconuts (talls) (copra)	1000 kg/ha/yr
Coconuts (hybrids) (copra)	2000 kg/ha/yr
Cloves	2 kg/tree/yr
Coffee	500 kg/ha/yr

Average[1)] arable yields over a run of wet and dry years are estimated as follows :

	Without lime-stone kg/ha[a)]	With lime stone kg/ha[b)2)]	% Occu-pation	Without lime-stone	With lime-stone
				Yield in mixed stand kg/ha/yr	
Padi	800	1280	80%	640	1020
Maize	570	900	20%	110	180
Groundnuts (unshelled)	550	910	40%	220	360
Soya beans	400	680	40%	160	270
Mung beans	300	450	80%	240	360
Total mixed arable dry grain				1370	2190
Arable crop total adjusted for tree crop occupation (20%)				1100	1750

SOURCE: Discussions with farmers[a)] and researchers[b)]

1) For red yellow podzolic soils, but the range of yields can be very great as instanced by a succession of upland padi crops at:

	1978	1979	1980	1981	1982
Sitiung II, Pure stand padi	-	0	100	600	300
Singkut I, Mixed cropping	700	1100	1300	1400	1100

2) Assuming a cheap source of limestone, applied at 2t/ha once.

Inter-planted arable crops, although occupying some 80% of the area would be expected to yield the same as an entirely arable crop stand in a wet year but are more likely to give a better yield in a hot dry year due to the shading effect of the tree crop, and the greater moisture available in the top soil.

Yields from land previously under alang-alang may be some 20% higher initially, but will soon decline as the higher inherent fertility of the soils declines.

Model 7 MIXED FOOD CROPS FROM ARABLE AND FAST GROWING PERENNIALS

Where lack of off-farm paid employment creates a higher priority for food crop production for subsistence, earlier maturing food/tree crops should replace coconuts/rubber and cassava must be used as a staple, along with sweet potatoes and yams. Most rice will need to be imported into the scheme unless a significant amount of padi sawah is available for cropping option 3.

Thus bananas and fast maturing fruit trees, eg. nangka, are recommended as shade crops for the interplanted CRIA proposed multiple cropped arable food plants (rice/soya beans/groundnuts/cassava/sweet potatoes). The area should be limed at 2t/ha, once, assuming a cheap source of limestone.

The tree crops will provide shading from the sun and shelter from the wind, thus reducing evapotranspiration losses from the arable food crop stand. Soils will remain cooler and more moist, and plant drought stress will be reduced. This will be particularly beneficial during dry years or late arrival of the wet season, as in 1982.

Yields are estimated as follows :

	Without lime-stone kg/ha[1]	With lime-stone kg/ha[2]	% Occu-pation	Without lime-stone Yield in mixed stand kg/ha/yr	With lime-stone
Bananas	40000	40000	15%	6000	6000
Nangka etc[3]	50000	50000	5%	2500	2500
CRIA mixed multiple arable grain crops	1200	1900	70%	840	1330
Cassava	7000	9000	5%	350	450
Sweet potatoes	10000	12000	5%	500	600
Total farm mixed stand				10190	10880

SOURCE : Discussions with farmers (1) and researchers (2)

Yields from land previously under alang-alang may be 20% higher initially, but are likely to decline following exhaustion of the higher inherent fertility of those soils. Continual control of alang-alang will be necessary.

Model 8 RUBBER WITH LEGUMINOUS CROP

On more steeply sloping land arable cropping becomes hazardous and where farmers have adequate off-farm employment, it would be better that they plant their steeply sloping land to rubber, preferably using a cover crop between the rows. Arable food cropping on mechanically clean-cleared land is not recommended for slopes above 8%. Indeed mechanical clearing of steep land is not recommended either - but in practice such land does get cleared.

Yields are estimated :

Rubber seedling (PBIG)	1000 kg DRC/ha/yr at maturity
Rubber budded stump (GT 1)	1200 kg DRC/ha/yr at maturity

3) Tropical fruits yielding 250 kg/tree, 200 trees/ha.

Nurseries for budded stump production or PBIG seedlings should be established preferably one year before the arrival of the transmigrants. Dinas Perkebunan would be the most competent authority but will need special funds to undertake this work for the transmigration programme.

Model 9 FULLY INTEGRATED TREE, BUSH AND ARABLE CROPPING

Steep land is really best protected by tree crops, maintaining a canopy cover at all times. A fully integrated mixed tree crop/bush crop/ground crop system is recommended, comprising a high level canopy eg. coconuts (talls), a middle layer canopy, eg. coffee, pepper (up the base of coconuts), mixed fruit, and at ground level vegetables, root crops, spices and the occassional maize and sugar cane.

Estimates of yield are complex, and will depend on the whims of the families concerned. The aim should be self-sufficiency.

The following species should be represented

Species	Yield per tree/bush/plant per year
Coconuts	50 nuts/tree
Cloves	3 kg/tree
Mixed fruits	250 fruits/tree (average)
Bananas	2 bunches/plant
Coffee	1-1.5 kg/bush
Pepper	1.5 kg/plant
Ginger	0.7 kg/plant
Turmeric	0.8 kg/plant
Cinnamon	0.06 kg/tree
Cardamom	10 seeds/plant
Lime	70 kg/tree
Papaya	70 fruits/plant
Maize	2 cobs/plant
Sugar	0.5 kg sugar/plant
Cassava	3 kg/roots/plant
Sweet potatoes	3 kg/plant

Pulses	2 gm/plant
Pineapples	1 pineapple/plant
Cocoa	0.3 kg/tree
Leucaena	-
Tea	0.9 kg/bush
Nutmeg	20 fruits/tree
Avocado	100 fruits/tree
Napier grass	1200 kg LWG/ha/yr

SOURCE : discussions with farmers.

A similar model has been developed in Sri Lanka by FAO involving some 3680 plants/ha. Income on this project was estimated at US.$. 2000/ha[1]. A similar, but less comprehensive model, has been developed at Project J east of Tugumulyo, which is noted for its fruit production.

The secret of success lies in maintaining a natural soil mulch and preserving useful existing young trees as shade for the young tree crops planted into the undisturbed soil profile. The whole 'garden' has to be carefully planted to provide areas of different exposure to cater for species of differing habit. The area should not be clean-felled because selective shading will be required from the jungle bushes.

Model 10 TREE CROPS IN POCKET TERRACES ON MECHANICALLY CLEAN-CLEARED LAND

Where land has been mechanically clean-cleared and few job opportunities exist outside the farm then it will be necessary to make every effort to get rapid results from a food crop/cash crop system. It should be stressed however that on steep land such a course may well fail. Coffee under coconuts, or coffee under rubber planted in platform terraces along the contour should be tried.

1) "Mixed cropping" - Ceres May-June 1981.

Extended food aid may be needed - perhaps for 3-4 years. Yields are expected to be the same as in Model 5, although the risks will be greater during tree establishment.

Model 11 BENCH TERRACED ARABLE CROPPING WITH DIVERSIFIED TREE CROPS

On steep land that has been semi-mechanically cleared using chainsaws and in-situ burning, serious attempts to grow food crops can only be made if bench terraces are constructed immediately with tree crops planted along the bunds. Most food and tree crops can be grown in this manner but the problem is pursuading the farmer to undertake the enormous task of earth moving. For example an 8% slope, bench terraced at 20 metres, will require the moving of some 6.3 m^3 per linear metre of terrace, or some 4 mandays per linear metre at 1.5 m^3 of earth moved per manday. Terracing could well form the target of a job creation programme funded from money saved by not deploying bulldozers on agricultural land. Some Rp. 300,000/ha could be so redeployed, enough for 300-600 mandays.

Yields from this bench terraced area would be expected to be much the same as from Model 6 once the soil profile had settled down. Yields in the first year would be poor. limestone at the rate of 2 t/ha should be applied[1), immediately following terracing to give the maximum time for the soil amelioration processes.

Model 12 TRADITIONAL RICE-RUBBER

Where manual construction of terraces cannot be financed, terracing is unlikely to be timely. The need for food crops will probably dictate that transmigrants on steeply sloping land will follow the traditional system of slashing and burning the forest and stick planting hill rice between the charred logs for one season, quickly followed by planting of rubber trees. The first crop of rice could yield 800-1400 kg/ha depending on season, soil type and position relative to the water table.

1) Assuming cheaper supplies of limestone

Provided sufficient budded stumps can be raised, rubber tapping should start in year 6 after transplanting; the following yields being achievable from well-maintained and fertilized trees. eg. GT 1 (t/ha DRC).

Year	6	7	8	9	10	11-15	16-20	21-30
Yield DRC t/ha	0.2	0.6	0.8	1.0	1.3	1.4-1.8	1.8	1.6-1.4

5.3 Land utilisation types (LUT's)

In order to allow Phase II planning to proceed according to established criteria the twelve cropping models discussed in the previous section are now grouped into the main LUT's commonly used for transmigration screening studies ie. :

LUT's	Cropping models
1. Rainfed upland arable farming with fruit trees	7
2. Wetland rice/palawija farming	1, 3
3. Tree crops	4, 5, 8, 10
4. Village sites & houselots	6, 9, 11

Plus a suggested additional mixed cropping LUT

5. Mixed arable/tree cropping	6, 9, 11, 12

The agronomic reasons for LUT 5 have been advanced in the foregoing sections. It is worthy of note that this system of land utilisation is gradually evolving on transmigration settlements, although receiving little official assistance.

Rainfed upland arable farming (modified)

This LUT is only suited to flatter areas of more easily worked fertile alluviums not suffering from drought or flooding conditions. On slopes of more than 5%, terracing is recommended, and liming would be desirable.

1) Assuming cheaper supplies of limestone.

Wetland rice/palawija farming

Low lying areas with stream access, or with reliable recharge can be used for padi sawah for 2 crops, or when rainfed only, sometimes for one crop of padi followed by one crop of palawija. The palawija crop may often fail due to water shortage.

Tree crops

Well-drained land on slopes up to 25% can be used for tree crops. Land clearance can be restricted to slashing and burning en-situ.

Village sites and houseplots (LP)

Generally these areas can be on moderately sloping land as terracing is more likely to be completed on house lots than on the more remote Lahan Usaha I. Ideally of course the land should be flat, but where rolling terrain is found, flatter land is more likely to be found on the crests of the ridges than in the valleys. However it is likely that water supply will prove difficult if housing occupies tops of the crests, whilst road construction and maintenance will be more costly if housing is located on slopes.

It is recommended that limestone be applied to the garden plots prior to the arrival of the transmigrants, at the rate of 2 t/ha. Plots should ideally be seeded with Calopogonium spp in which case 1 t/ha of limestone may suffice.

Mixed arable/tree cropping

This is the generally preferred LUT and the one most commonly observed in older transmigration settlements. It allows greater flexibility in cropping marginal areas and gives greater insurance against crop failure, as well as promoting a sound agricultural system capable of continuous sustained cropping.

6 GENERAL RECOMMENDATIONS FOR DEVELOPMENT OF FUTURE TRANSMIGRATION AGRICULTURAL AREAS ON RED-YELLOW PODSOLIC SOILS IN SUMATRA

6.1 Preferably slash and burn trees and bushes remaining after sale of marketable timber. Not only is this cheaper and faster but also disturbs the soil profile the least, enriches the top soil with wood ash, reduces the risk of aluminium salts in the subsoil upsetting plant nutritional balances and preserves soil moisture. Some 60-80% of the land area is useable between the logs for stick planting a food crop, which is more likely to give a useful yield than when planted into mechanically clean-cleared land.

6.2 There would be much to recommend that the transmigrants themselves clear their own areas, being employed to do so. Local land clearance charges for a man with a chainsaw are around Rp. 35-40,000 per hectare felled. To this should be added the cost of additional mandays at Rp. 1000/manday to achieve a good burn. The total cost of Rp. 160,000/ha is considerably less than the present Rp. 450,000 allocated for bulldozer clearing, which uses valuable foreign exchange.

6.3 On sloping land, trees should be felled along the contour and thus thus act as temporary erosion control bunds rather than down-the-hill, as is more usually seen.

6.4 Care should be taken not to block the stream courses as rice sawahs and fish ponds can be developed in the valley bottoms.

6.5 Where land is mechanically clean-cleared a cover crop, following a dressing of at least 1 t/ha of limestone and a basal dressing of N & P, should be established immediately after harrowing whilst there is still some moisture in the top soil to promote cover-crop germination. Cover crop seed should be planted some a 1 cm deep in a regular stand at the correct seeding rate.

6.6 Sufficient budget should be allocated for 100% cover crop establishment.

6.7 Limestone applications for arable cropping are clearly technically viable, yields being boosted by some 160% for maize and grain legumes, but economic viability will depend on the location and development of closer, cheaper sources of calcitic and dolomitic limestone. It has been estimated[1)] that limestone should cost no more than Rp. 14,000/ton delivered to a transmigration site with -in 100 km of the quarry, whereas at the moment limestone, ex Sumbar, costs Rp. 50,000/t delivered Jambi.

6.8 Land cleared by chainsaw with manual stacking and burning will require less limestone to ameliorate unfavourable soil chemical conditions than land subjected to mechanical clean-clearing by bulldozer.

6.9 Limestone should be applied to house plots immediately after clearing at the rate of 500 kg to each 0.25 ha. The importance of the LP area is such that even at the present cost of lime (Rp. 50,000/t delivered) this application should be born by Government.

6.10 Where the allocated area is heavily infested with alang-alang a combination of chemical eradication and mechanical cultivation will prove the quickest and most long-lasting method. A preferable course however may be to pay the transmigrants to strip cultivate between dead and dormant alang-alang rhizomes on their own area following the timely application of Glyphosate.

6.11 Every effort should be made to co-ordinate site work and minimise the delay between land being cleared and the transmigrants starting to farm the cleared land. Otherwise irreparable damage is done to the soil during the waiting period. There would be much to recommend the appointment of one competent contractor responsible for all phases of development, and the appointment of one consultant for feasibility, design and implementation.

1) Van Dierendonck, FAO 1982

6.12 Allocation of LU 1 area to transmigrants should proceed without delay[1] and the Directorate General Agraria should be given a contingency floating fund to utilize in emergencies, in order to allow timely completion of the cadastral surveys.

6.13 Where land has been mechanically clean-cleared in sloping areas, a practice to be avoided, it would be better to use the area for tree crops planted in the first year and to plant arable food crops into freshly slashed and burned areas.

6.14 Generally an integrated mixture of tree crops and food crops is recommended in order to promote retention of soil moisture, lower soil surface temperatures, lower drought stresses in shallow rooting annuals, thus promoting their better growth and higher yields, whilst, at the same time, advancing the planting of tree crops in time so that transmigrants can begin harvesting tree crops sooner.

6.15 Where coconuts or cashews are advocated, processing facilities will also be needed within a few years of scheme initiation.

6.16 The limited stream flow in the study areas would be better used for fish ponds as the value of the catch can approach Rp. 1,500,000/ha/yr - a return exceeding that of most planted crops; also the fish can be harvested within 5 months of commissioning a pond. Private ponds are more likely to be successful than co-operative ventures until management become more enlightened.

1) Delays between the arrival of transmigrant families and their first cultivation of their Lahan Usaha I area (LU I) can in some cases exceed 12 months. This is partly due to budgetary constraints within the Directorate General of Agraria. If the actual number of settlers on any particular scheme exceeds the budgetary target, eg. if 6200 families arrive in an area originally targeted and budgeted for only 6000, the excess 200 must await the release of the next years' DIP Funds, generally available in August, before Agraria cadastral survey teams can stake out their Lahan Usaha (LU 1) and the Kepala Kantor Unit Transmigrasi can allocate families to their new LU 1 areas. During this time mechanically cleared land can be permanently damaged by erosion unless a cover crop has been established and transmigrant families can incur hardship unless off-farm work is available. In addition stocks of seed given under the T/M agricultural package can deteriorate in storage and be useless when needed, hence transmigrants complaints about seed quality.

6.17 No attempt should be made to mechanically clean-clear or grow arable food crops on land exceeding 8% slope, unless adequate terracing is undertaken immediately, and no attempt should be made to grow arable grain crops on sandy soils where drought conditions are likely to result in moisture stress.

6.18 On the LU 2 area, it is difficult to conceive of a crop more suitable than rubber from both an agronomic and marketing point of view.

6.19 However the provision of budded stumps of H.Y. clonal rubber to all transmigrants in Jambi province is a task of enormous magnitude. A temporary measure might be to use the ex-Malaysian seed rubber PBIG which reportedly yields some 80% of budded GT 1. This would greatly speed up the transmigration planting programme and simplify the otherwise considerable logistical problems.

6.20 There is a need for a greatly accelerated programme of hybrid coconut production. Waiting for the F1 generation can take many years. The use of F2 generation material would be attractive as at least 50% of the resulting F1 crosses are phenotypically and genotypically hybrids.

6.21 The development of blast resistant rices is required as most current entries appear to be at least partially susceptible. The variety C 22 currently under trials does not seem to be tolerant of dry conditions.

6.22 The allocation of poultry and goats to transmigrant families could usefully supplement their income and improve their diet. In terms of value for capital outlay this would be better initially than concentrating on bovines.

ATTACHMENT 1

CRIA MULTIPLE ARABLE FOOD CROPPING PERFORMANCE

Place	Cropping pattern	Gross return Rp/ha	Material costs Rp/ha	Nett return Rp/ha	Labour input m-d/ha	Return to labour Rp/m-d
Bandar Agung '75-'76 Lampung (Old alang-alang)	Corn + upland-rice	173520	56440	117080	434	270
Komering Putih Lampung '75-'76 (newly opened areas)	Corn + upland-rice	202260	57700	144560	559	259

SOURCE : Mc Intosh, Effendi, Syarifuddin, CRIA Bogor.
"Testing cropping patterns for upland conditions" 1976.

REFERENCES

1.	Sinotech Engineering Consultants Inc.	1980	"Feasibility Report on Air Beliti (Irrigation) Project" for Directorate General of Water Resources Development.
2.	Biotrop - Bogor Anwar Arif and Heru Subagio	1976	Studies on alang-alang control with Dalapon Sodium in open and shade conditions.
3.	Rubber Research Institute - Malaysia. Yeoh Chong Hoe		Control of Imperata Cylindrica in Malaysia's small holdings.
4.	Monsanto Chemical Co.	1982	Technical literature.
5.	Estates Crop Directorate	1983	Land Clearing for Estate Crops.
6.	Biotrop - Bogor Goeswono Soepardi	1976	Aland-alang and soil fertility.
7.	Willem C. Beets (Gower Press)	1982	Multiple cropping and tropical farming systems.
8.	van Dierendonck, F.J.	1982	Rock phosphate and lime in transmigration areas. FAO, Project Working Document (INS/78/012) Dept. of Manpower and Transmigration.
9.	Marshal Khan	1980	An Inquiry into the agricultural economy in Singkut. Draft Report; FAO Project INS/78/012.
10.	McIntosh J.L.; Effendi S. and Syarifuddin A.	1976	Testing Cropping Patterns Upland Conditions. 1976 Cropping Systems Symposium.
11.	Dinas Pertanian Tanaman Pangan Prop. Jambi	1982	Laporan Percobaan Tanaman Pendahuluan di Daerah Transmigrasi ABT 1980/1981.