Appendix S8 Growth of Mean Diameter

Site	Year	Species	Direction	Type	Month 1	2	3	4	5	6	7	8	9	10	12	18	24	30	36
				B	0.52					0.66					0.99	1.67			
				C	0.54					0.64					1.04	1.52			
				D	0.57					0.71					1.13	1.54			
				E	0.63					0.68					0.91	1.38			
			NS	A	0.45					0.60					0.60	0.84			
				B	0.42					0.55					0.61	0.98			
				C	0.47					0.52					0.73	1.12			
				D	0.41					0.54					0.69	1.18			
				E	0.42					0.50					0.70	1.15			
		Shorea glauca	EW	A	0.40					0.46					0.58	0.81			
				C	0.34					0.39					0.59	0.87			
				D	0.31					0.43					0.53	1.23			
				E	0.34					0.44					0.50	0.61			
		Shorea macroptera	EW	A	0.35					0.46					0.64	0.84			
				B	0.37					0.59					0.68	0.95			
				C	0.35					0.45					0.59	0.64			
				D	0.32					0.44					0.65	0.94			
				E	0.38					0.53					0.68	1.23			
	94	Dipterocarpus cornutus	EW	A	0.66					0.70					0.93				
				B	0.71					0.74					1.02				
				C	0.52					0.57					0.78				
				D	0.59					0.58					0.83				
				E	0.54					0.58					0.80				
		Hopea pubescens	EW	A	0.21					0.35					0.53				
				B	0.44					0.54					0.66				
				C	0.28					0.35					0.41				
				D	0.37					0.46					0.63				
				E	0.42					0.48					0.73				
		Intsia palembanica	EW	A	0.71					0.77					0.99				
				B	0.60					0.68					0.92				
				C	0.80					0.84					1.09				
				D	0.80					0.83					0.95				
				E	0.75					0.88					0.96				
		Shorea assamica	EW	A	0.48					0.77					1.08				
				B	0.54					0.76					1.08				
				C	0.45					0.63					1.06				
				D	0.63					0.72					1.11				
				E	0.65					0.68					0.91				
		Shorea leprosula	EW	C						0.71					1.59				
		Shorea macroptera	EW	C						0.70					1.02				
		Shorea ovalis	EW	A	0.43					0.59					0.99				
				B	0.43					0.66					1.08				
				C	0.39					0.68					1.17				
				D	0.53					0.71					1.26				
				E	0.55					0.66					1.03				
		Shorea ovata	EW	A	0.56					0.63					0.99				
				B	0.48					0.52					0.80				
				C	0.43					0.57					0.84				
				D	0.48					0.56					0.79				
				E	0.57					0.61					0.63				
		Shorea pauciflora	EW	A	0.56					0.65					0.86				
				B	0.60					0.70					1.06				
				C	0.50					0.63					0.96				
				D	0.50					0.62					0.86				
				E	0.52					0.66					0.88				
Belukar	94	Dialium sp.	EW	F	0.73					0.76					0.97				
				G	0.49					0.62					0.96				
		Gonystylus sp.	EW	F	0.70					0.82					1.10				
				G	0.64					0.75					1.03				
		Neobalanocarpus heimii	EW	F	0.73					0.81					1.06				
				G	0.74					0.86					1.04				
				H	0.82					0.96					1.22				
		Shorea acuminata	EW	F	0.57					0.65					0.90				
				G	0.43					0.56					0.82				
		Shorea bracteolata	EW	F	0.66					0.77					1.06				
				G	0.51					0.68					1.02				

Appendix S8 Growth of Mean Diameter

Site	Year	Species	Direction	Type	Month 1	2	3	4	5	6	7	8	9	10	12	18	24	30	36
		Shorea gibbosa	EW	F	0.45					0.52					0.80				
				G	0.34					0.57					0.92				
		Shorea glauca	EW	F	0.50					0.69					1.22				
				G	0.62					0.78					1.34				
		Shorea leprosula	EW	F	0.72					1.08					1.90				
				G	0.58					1.04					1.88				
				H	0.70					1.17					1.85				
		Shorea multiflora	EW	F	0.83					0.90					1.38				
				G	0.44					0.61					0.93				
		Shorea ovalis	EW	F	0.67					0.91					1.55				
				G	0.56					0.89					1.55				
				H	0.76					0.99					1.74				
		Shorea ovata	EW	F	0.65					0.71					1.15				
				G	0.59					0.68					1.14				
				H	0.51					0.66					0.78				
		Shorea parvifolia	EW	F	0.58					0.75					1.17				
				G	0.53					0.79					1.21				
				H	0.53					0.62					1.20				
		Shorea pauciflora	EW	F	0.68					0.95					1.46				
				G	0.62					1.00					1.38				
				H	0.49					0.85					1.47				
		Shorea talura	EW	F	0.79					0.98					1.79				
				G	0.57					0.99					1.95				
		Sindora sp.	EW	F	0.67					0.72					0.96				
				G	0.55					0.64					1.03				
Open	92	Hopea odorata	EW	A			0.58			0.63					0.85	1.11	1.42		
				B			0.65			0.69					0.83	1.01	1.53		
				C			0.59			0.73					1.11	1.38	2.20		
				D			0.52			0.65					0.73	0.82	1.43		
				E			0.64			0.69					0.88	1.07	1.78		
		Neobalanocarpus heimii	EW	A				0.56		0.59					0.66	0.72	0.76	0.83	
				B				0.55		0.53					0.61	0.77	0.75	0.94	
				C				0.49		0.59					0.60	0.65	0.74	0.84	
				D				0.53		0.64					0.60	0.73	0.63	0.80	
				E							0.57			0.61	0.62	0.71	0.74	0.91	
		Shorea leprosula	EW	A				0.65		0.59					0.61	0.68			
				B				0.56		0.60					0.51	0.57			
				C				0.53		0.63					0.68	0.81	1.50		
				D				0.61		0.58					0.55	0.50			
				E						0.57		0.56			0.59	0.58	0.97		
		Shorea parvifolia	EW	A					0.53	0.60					0.68	0.69	0.94		
				B					0.54	0.51					0.59	0.66	0.94		
				C					0.57	0.58					0.66	0.58	0.67		
				D					0.53	0.51					0.59	0.71	1.14		
				E						0.49		0.51			0.50	0.62	0.71		
	93	Calophyllum sp.	EW	A		0.24				0.31					0.50				
				B		0.41				0.17									
				C		0.23				0.26					0.31				
				D		0.21				0.24					0.40				
				E		0.21				0.40									
		Dryobalanops aromatica	EW	A		0.43				0.52					0.73				
				B		0.39				0.47									
				C		0.39				0.47					0.74				
				D		0.42				0.48									
				E		0.41				0.43					0.51				
		Endospermum malaccense	EW	A		0.51				0.50									
				B		0.64				0.61					1.09				
				C		0.56				0.56					0.89				
				D		0.56				0.67					1.45	1.85			
				E		0.50				0.55									
		Pentaspadon motleyi	EW	A		0.24				0.40					0.77				
				B		0.34				0.33									
				C		0.24				0.26									
				D		0.24				0.26					0.46	0.61			
				E		0.16				0.24					0.41				
		Pouteria malaccensis	EW	A		0.27				0.31									

Appendix S8 Growth of Mean Diameter

Site	Year	Species	Direction	Type	Month 1	2	3	4	5	6	7	8	9	10	12	18	24	30	36
				B		0.24				0.20									
				C		0.26				0.30					0.30				
				D		0.26				0.18									
				E		0.27				0.29					0.40				
		Scaphium macropodum	EW	A		0.35				0.45					0.48				
				B		0.33				0.40					0.30				
				C		0.39				0.39					0.37				
				D		0.35				0.40									
				E		0.35				0.38					0.46	0.51			
		Shorea acuminata	EW	A		0.42				0.47					0.58				
				B		0.45				0.50									
				C		0.45				0.50									
				D		0.38				0.46									
				E		0.44				0.43					0.76				
		Shorea bracteolata	EW	A		0.41				0.49					0.76				
				B		0.43				0.55					1.30				
				C		0.38				0.44					0.68				
				D		0.42				0.45					0.67	0.69			
				E		0.37				0.50					0.69				
X(Arboretum)	92	Dryobalanops aromatica	x	x				0.45		0.53					0.61	0.66			
		Durio sp.	x	x				0.97		0.98					1.14	1.09	1.41		
		Hevea brasiliensis	x	x				0.62		0.74					0.85	0.98	1.53		
		Hopea odorata	x	x				0.48		0.56					0.92	1.31	2.15		
		Hopea odorata-1	x	x							1.00		1.11		1.26	1.50	2.12	3.30	
		Intsia palembanica	x	x			0.79			0.84					0.86	0.94	1.20		
		Neobalanocarpus heimii	x	x				0.60		0.63					0.75	0.92	1.06		
		Parkia sp.	x	x			0.70			0.75					0.97	1.10	1.59		
		Pentaspadon motleyi	x	x				0.31		0.40					0.48	0.56			
		Scaphium macfopodum	x	x								0.75		0.80	0.77	0.72	0.73		
		Shorea acuminata	x	x				0.51		0.47					0.54	0.60			
		Shorea leprosula	x	x							0.65				0.66	0.56			
		Shorea ovalis	x	x				0.88		0.85					0.96	0.79	1.00		
		Shorea parvifolia	x	x	0.41					0.49					0.48				
		Swietenia macrophylla	x	x				0.98		1.08					1.23	1.30	1.65		
		Tectona grandis	x	x			0.59			0.82					1.20	1.60	2.21		
	93	Agathis borneensis	x	x		0.46				0.53					0.58				
		Alstonia sp.	x	x		0.54				0.72					0.93	1.74	2.17		
		Cinnamomum sp.	x	x		0.62				0.75					0.81	1.35	1.86		
		Dacryodes sp.	x	x		0.32				0.39					0.44				
		Dipterocarpus cornutus	x	x		0.68				0.65					0.53				
		Endospermum malaccense	x	x		0.53				0.65					0.74	1.11	1.45		
		Heritiera sp.	x	x		0.36				0.42					0.53				
		Hopea odorata-2	x	x				0.80		0.84					0.93		1.44		
		Hopea odorata-3	x	x		0.44				0.58					0.93				
		Koompassia malaccensis	x	x		0.13				0.30					0.30				
		Palaquium gutta	x	x		0.41				0.44					0.52				
		Shorea macroptera	x	x		0.33				0.75					1.19				
		Shorea multiflora	x	x		0.57				0.40					0.30				
		Shorea talura	x	x		0.50				0.58					0.75				
		Toona sureni	x	x		0.63				0.64					0.59	0.81	0.96		

Appendix S9 H/D Ratio

					Months after Planting														
Site	Year	Species	Direction	Type	1	2	3	4	5	6	7	8	9	10	12	18	24	30	36
Acacia	92	Neobalanocarpus heimii	EW	A								87			83	92	97	105	108
				B								89			84	91	98	110	
				C								81			78	90	94	95	100
				D								69			66	62	75	68	65
				E								73			72	71	77	85	92
			NS	A								84			83	87	95	103	100
				B								83			87	90	98	96	103
				C								73			80	81	88	91	92
				D								62			73	66	62	79	71
				E								75			73	77	85	85	82
		Shorea leprosula	EW	A								113			110	111	113	117	114
				B								126			111	110	105	106	111
				C								101			89	86	91	97	101
				D								91			84	81	82	83	82
				E								91			79	74	77	76	72
			NS	A								118			103	108	96	95	102
				B								111			100	95	78	89	94
				C								94			80	60	52	72	78
				D								100			86	77	73	82	80
				E								86			76	67	71	81	72
		Shorea parvifolia	EW	A								117			114	106	103	106	108
				B								126			119	113	108	109	132
				C								108			112	102	104	109	107
				D								105			88	88	101	102	92
				E								100			95	83	89	89	76
			NS	A								115			120	122	114	118	114
				B								112			114	117	106	107	102
				C								101			103	89	84	97	88
				D								98			95	89	98	95	77
				E								109			85	75	78	78	64
	93	Dryobalanops aromatica	EW	A	110					123					142	156			
				B	86					93					108	137			
				C	113					103					129	142			
				D	106					107					118	140			
				E	109					98					121	110			
			NS	A	114					117					150	154			
				B	140					134					170	172			
				C	112					119					141	162			
				D	114					111					118	140			
				E	104					113					105	102			
		Hopea odrata	EW	A	82					70					87	77			
				B	65					71					86	85			
				C	76					63					72	75			
				D	79					79					93	81			
				E	70					63					71	71			
		Palaquium gutta	EW	A	67					94					119	136			
				B	61					65					71	123			
				C	68					70					102	114			
				D	65					59					79	93			
				E	64					62					62	90			
		Parashorea densiflora	EW	A	91					93					122	108			
				B	95					93					101	109			
				C	98					88					96	107			
				D	83					70					77	90			
				E	59					65					75	102			
		Pentaspadon motleyi	EW	A	84					104					118	118			
				B	97					102					118	144			
				C	108					99					116	122			
				D	93					95					114	118			
				E	96					90					105	119			
			NS	A	160					127					137	125			
				B	139					124					200				

Appendix S9 H/D Ratio

					Months after Planting													
Site	Year	Species	Direction	Type	1	2	3	4	5	6	7	8	9	10	12	18	24	30	36
				C	126					91					126	131			
				D	107					104					117	115			
				E	149					122									
		Shorea acuminata	EW	A	99					107					124	133			
				B	121					108					124	131			
				C	128					119					114	107			
				D	114					92					104	122			
				E	96					99					98	116			
			NS	A	100					89					108	116			
				B	101					104					125	132			
				C	96					103					102	113			
				D	99					86					102	108			
				E	96					96					109	118			
		Shorea glauca	EW	A	76					77					105	96			
				C	97					100					114	108			
				D	89					75					79	83			
				E	100					80					89	104			
		Shorea macroptera	EW	A	69					79					105	113			
				B	81					84					98	113			
				C	81					80					86	124			
				D	59					81					78	121			
				E	100					94					105	117			
	94	Dipterocarpus cornutus	EW	A	63					72					85				
				B	62					67					84				
				C	50					65					73				
				D	51					66					85				
				E	56					70					90				
		Hopea pubescens	EW	A	110					83					115				
				B	101					92					106				
				C	83					71					111				
				D	89					97					124				
				E	88					101					111				
		Intsia palembanica	EW	A	69					75					78				
				B	75					84					86				
				C	64					68					78				
				D	64					64					68				
				E	73					70					77				
		Shorea assamica	EW	A	91					68					67				
				B	89					70					65				
				C	90					92					74				
				D	82					81					87				
				E	81					91					90				
		Shorea leprosula	EW	C						108					104				
		Shorea macroptera	EW	C						105					107				
		Shorea ovalis	EW	A	70					80					98				
				B	83					81					90				
				C	82					74					83				
				D	75					71					80				
				E	63					74					85				
		Shorea ovata	EW	A	100					100					105				
				B	91					88					109				
				C	122					75					83				
				D	97					83					98				
				E	74					76					80				
		Shorea pauciflora	EW	A	66					83					97				
				B	67					76					93				
				C	67					67					73				
				D	75					71					83				
				E	67					70					89				
Belukar	94	Dialium sp.	EW	F	53					58					71				
				G	60					67					75				
		Gonystylus sp.	EW	F	67					74					78				

Appendix S9 H/D Ratio

Site	Year	Species	Direction	Type	Months after Planting 1	2	3	4	5	6	7	8	9	10	12	18	24	30	36
				G	67					71					77				
		Neobalanocarpus heimii	EW	F	63					68					80				
				G	85					74					83				
				H	76					66					71				
		Shorea acuminata	EW	F	85					77					100				
				G	96					83					95				
		Shorea bracteolata	EW	F	72					67					59				
				G	72					58					53				
		Shorea gibbosa	EW	F	63					77					96				
				G	89					69					80				
		Shorea glauca	EW	F	106					106					124				
				G	109					93					93				
		Shorea leprosula	EW	F	81					79					87				
				G	95					74					75				
				H	88					68					81				
		Shorea multiflora	EW	F	85					78					86				
				G	86					78					94				
		Shorea ovalis	EW	F	72					73					96				
				G	86					65					78				
				H	80					71					78				
		Shorea ovata	EW	F	74					72					81				
				G	86					81					83				
				H	85					76					86				
		Shorea parvifolia	EW	F	76					78					104				
				G	90					76					96				
				H	68					68					88				
		Shorea pauciflora	EW	F	76					78					82				
				G	89					68					85				
				H	84					66					75				
		Shorea talura	EW	F	62					63					61				
				G	72					66					72				
		Sindora sp.	EW	F	58					54					55				
				G	70					64					55				
Open	92	Hopea odorata	EW	A			84			75					68	66	66		
				B			73			69					70	70	75		
				C			65			58					63	61	70		
				D			81			64					60	59	42		
				E			79			73					77	78	55		
		Neobalanocarpus heimii	EW	A				76		73					69	71	65	69	
				B				55		54					62	61	72	71	
				C				80		69					67	69	65	68	
				D				63		49					58	43	45	60	
				E							56			58	60	77	74	82	
		Shorea leprosula	EW	A				88		87					63	73			
				B				81		70					77	112			
				C				89		75					103	107	97		
				D				62		63					80	70			
				E						73		64			67	83	90		
		Shorea parvifolia	EW	A					77	67					86	105	80		
				B					83	81					70	92	57		
				C					74	79					64	54	79		
				D					99	98					72	84	91		
				E						76		73			72	81	90		
	93	Calophyllum sp.	EW	A		62				73					65				
				B		83				65									
				C		61				83					121				
				D		67				59					20				
				E		73				67									
		Dryobalanops aromatica	EW	A		107				93					110				
				B		134				87									
				C		124				104					81				
				D		111				108									

Appendix S9 H/D Ratio

Site	Year	Species	Direction	Type	Months after Planting 1	2	3	4	5	6	7	8	9	10	12	18	24	30	36
				E		110				113					108				
		Endospermum malaccense	EW	A		99				57									
				B		105				84					46				
				C		103				96					55				
				D		98				88					46	67			
				E		106				82									
		Pentaspadon motleyi	EW	A		91				90					76				
				B		108				90									
				C		87				107									
				D		94				102					128	126			
				E		110				97					81				
		Pouteria malaccensis	EW	A		60				57									
				B		70				25									
				C		59				84					53				
				D		65				103									
				E		63				66					63				
		Scaphium macropodum	EW	A		70				58					44				
				B		73				63					97				
				C		70				67					94				
				D		70				62									
				E		66				67					61	65			
		Shorea acuminata	EW	A		101				88					81				
				B		102				67									
				C		89				62									
				D		123				94									
				E		100				108					69				
		Shorea bracteolata	EW	A		65				68					55				
				B		73				61					50				
				C		69				68					55				
				D		66				67					50	64			
				E		96				76					56				
X(Arboretum)	92	Dryobalanops aromatica	x	x				89		78					87	73			
		Durio sp.	x	x				76		75					65	76	68		
		Hevea brasiliensis	x	x				68		49					55	57	82		
		Hopea odorata	x	x				65		61					67	61	53		
		Hopea odorata-1	x	x							66		60		55	61	61	61	
		Intsia palembanica	x	x			80			69					83	62	46		
		Neobalanocarpus heimii	x	x				86		73					67	61	59		
		Parkia sp.	x	x			57			52					62	54	84		
		Pentaspadon motleyi	x	x				67		60					91	96			
		Scaphium macfopodum	x	x								51		48	40	51	75		
		Shorea acuminata	x	x				108		112					100	90			
		Shorea leprosula	x	x							99				48	104			
		Shorea ovalis	x	x				76		71					56	65	40		
		Shorea parvifolia	x	x	107					85					94				
		Swietenia macrophylla	x	x				58		52					55	63	70		
		Tectona grandis	x	x			38			29					50	45	53		
	93	Agathis borneensis	x	x		63				75					83				
		Alstonia sp.	x	x		56				59					70	56	56		
		Cinnamomum sp.	x	x		90				85					86	56	57		
		Dacryodes sp.	x	x		39				37					45				
		Dipterocarpus cornutus	x	x		43				44					46				
		Endospermum malaccense	x	x		83				76					74	66	72		
		Heritiera sp.	x	x		62				52					57				
		Hopea odorata-2	x	x				84		78					72		51		
		Hopea odorata-3	x	x		63				49					44				
		Koompassia malaccensis	x	x		98				70					63				
		Palaquium gutta	x	x		57				55					61				
		Shorea macroptera	x	x		95				65					55				
		Shorea multiflora	x	x		82				53					70				
		Shorea talura	x	x		67				59					46				
		Toona sureni	x	x		83				63					76	55	71		

Appendix S10 BPU

					Months after Planting														
Site	Year	Species	Direction	Type	1	2	3	4	5	6	7	8	9	10	12	18	24	30	36
Acacia	92	Neobalanocarpus heimii	EW	A								0.22			0.37	0.76	1.04	1.86	2.89
				B								0.09			0.18	0.42	0.55	0.92	
				C								0.15			0.29	0.78	1.39	3.09	4.40
				D								0.14			0.18	0.29	0.42	0.58	1.01
				E								0.16			0.23	0.43	0.53	0.85	1.27
			NS	A								0.17			0.34	0.64	1.02	1.50	2.67
				B								0.23			0.41	1.16	1.91	3.61	6.34
				C								0.18			0.46	1.36	2.09	4.54	6.91
				D								0.13			0.29	0.87	1.18	2.69	4.59
				E								0.17			0.28	0.80	1.45	2.90	5.98
		Shorea leprosula	EW	A								0.89			2.66	12.41	30.33	64.71	127.26
				B								1.08			4.06	23.90	58.44	140.38	275.01
				C								0.97			3.14	18.10	46.78	130.16	242.03
				D								0.63			1.59	9.32	24.37	74.25	173.47
				E								0.46			1.07	6.75	11.09	35.16	93.19
			NS	A								0.83			3.11	13.97	34.94	85.61	169.33
				B								1.22			4.25	21.74	38.99	92.22	175.55
				C								0.89			2.72	7.34	11.20	28.68	54.12
				D								0.95			3.08	16.67	41.53	123.90	239.64
				E								0.33			0.75	2.11	4.05	12.19	27.84
		Shorea parvifolia	EW	A								0.57			1.49	6.23	13.71	30.11	52.62
				B								0.33			1.03	4.72	5.11	13.55	26.51
				C								0.36			0.76	3.41	8.12	23.21	54.95
				D								0.37			0.71	2.31	2.27	5.53	10.51
				E								0.17			0.35	1.51	1.73	4.79	10.24
			NS	A								0.48			1.10	5.42	11.43	27.23	49.00
				B								0.59			1.40	6.68	14.42	34.96	65.01
				C								0.44			1.23	6.66	13.38	32.40	69.20
				D								0.22			0.50	1.89	4.00	10.03	24.77
				E								0.22			0.61	2.17	4.04	9.89	24.73
	93	Dryobalanops aromatica	EW	A	0.09					0.11					0.30	0.87			
				B	0.06					0.05					0.08	0.13			
				C	0.07					0.07					0.25	0.65			
				D	0.08					0.07					0.17	0.72			
				E	0.15					0.18					0.11	0.20			
			NS	A	0.05					0.06					0.11	0.45			
				B	0.07					0.08					0.13	0.47			
				C	0.09					0.10					0.30	1.19			
				D	0.06					0.08					0.12	0.27			
				E	0.04					0.06					0.03	0.11			
		Hopea odrata	EW	A	0.07					0.23					1.60	7.97			
				B	0.13					0.29					1.42	5.77			
				C	0.14					0.54					4.32	21.19			
				D	0.39					0.49					1.52	3.74			
				E	0.09					0.22					1.76	9.44			
		Palaquium gutta	EW	A	0.03					0.04					0.10	0.26			
				B	0.01					0.01					0.03	0.07			
				C	0.01					0.01					0.03	0.09			
				D	0.01					0.01					0.02	0.04			
				E	0.12					0.09					0.03	0.01			
		Parashorea densiflora	EW	A	0.04					0.08					0.33	1.21			
				B	0.07					0.11					0.39	1.06			
				C	0.16					0.21					0.54	1.49			
				D	0.12					0.12					0.24	0.97			
				E	0.01					0.01					0.01	0.05			
		Pentaspadon motleyi	EW	A	0.04					0.07					0.24	1.13			
				B	0.05					0.10					0.57	3.26			
				C	0.01					0.14					0.86	4.03			
				D	0.03					0.05					0.27	1.54			
				E	0.01					0.01					0.03	0.18			
			NS	A	0.00					0.00					0.00	0.04			
				B	0.00					0.00					0.01				
				C	0.02					0.03					0.08	0.45			
				D	0.02					0.03					0.07	0.25			
				E	0.00					0.00									
		Shorea acuminata	EW	A	0.25					0.37					0.98	3.52			
				B	0.19					0.29					0.90	3.84			

Appendix S10 BPU

Site	Year	Species	Direction	Type	Months after Planting 1	2	3	4	5	6	7	8	9	10	12	18	24	30	36
				C	0.23					0.29					0.88	2.90			
				D	0.21					0.14					0.54	1.63			
				E	0.15					0.16					0.33	0.91			
			NS	A	0.07					0.11					0.05	0.15			
				B	0.08					0.15					0.11	0.57			
				C	0.09					0.12					0.32	1.03			
				D	0.04					0.05					0.13	0.42			
				E	0.05					0.06					0.15	0.55			
		Shorea glauca	EW	A	0.06					0.06					0.12	0.24			
				C	0.04					0.03					0.03	0.09			
				D	0.03					0.02					0.03	0.04			
				E	0.04					0.04					0.02	0.02			
		Shorea macroptera	EW	A	0.04					0.12					0.19	0.47			
				B	0.05					0.41					0.25	0.73			
				C	0.02					0.02					0.03	0.04			
				D	0.02					0.01					0.03	0.05			
				E	0.03					0.05					0.08	0.10			
	94	Dipterocarpus cornutus	EW	A	0.19					0.24					0.67				
				B	0.20					0.20					0.68				
				C	0.08					0.11					0.32				
				D	0.09					0.12					0.35				
				E	0.09					0.12					0.35				
		Hopea pubescens	EW	A	0.01					0.03					0.11				
				B	0.13					0.16					0.21				
				C	0.02					0.02					0.03				
				D	0.04					0.08					0.22				
				E	0.06					0.10					0.28				
		Intsia palembanica	EW	A	0.29					0.31					0.67				
				B	0.17					0.24					0.72				
				C	0.33					0.37					1.01				
				D	0.28					0.31					0.39				
				E	0.20					0.29					0.41				
		Shorea assamica	EW	A	0.11					0.30					0.73				
				B	0.15					0.26					0.66				
				C	0.09					0.21					0.80				
				D	0.15					0.21					0.84				
				E	0.20					0.23					0.37				
		Shorea leprosula	EW	C						0.58					4.03				
		Shorea macroptera	EW	C						0.43					1.22				
		Shorea ovalis	EW	A	0.07					0.20					1.01				
				B	0.07					0.27					1.30				
				C	0.04					0.19					0.75				
				D	0.07					0.19					1.08				
				E	0.11					0.17					0.89				
		Shorea ovata	EW	A	0.19					0.24					0.73				
				B	0.10					0.14					0.42				
				C	0.09					0.09					0.08				
				D	0.09					0.12					0.15				
				E	0.07					0.03					0.03				
		Shorea pauciflora	EW	A	0.13					0.21					0.55				
				B	0.15					0.30					1.08				
				C	0.10					0.18					0.59				
				D	0.08					0.09					0.15				
				E	0.08					0.15					0.38				
Belukar	94	Dialium sp.	EW	F	0.19					0.24					0.59				
				G	0.07					0.16					0.72				
		Gonystylus sp.	EW	F	0.23					0.37					1.01				
				G	0.15					0.23					0.63				
		Neobalanocarpus heimii	EW	F	0.25					0.36					0.96				
				G	0.30					0.36					0.68				
				H	0.37					0.53					1.11				
		Shorea acuminata	EW	F	0.12					0.16					0.41				
				G	0.05					0.08					0.22				
		Shorea bracteolata	EW	F	0.21					0.34					0.79				
				G	0.10					0.20					0.53				
		Shorea gibbosa	EW	F	0.06					0.11					0.49				
				G	0.03					0.11					0.58				

Appendix S10 BPU

Site	Year	Species	Direction	Type	Months after Planting 1	2	3	4	5	6	7	8	9	10	12	18	24	30	36
		Shorea glauca	EW	F	0.12					0.36					1.93				
				G	0.17					0.31					1.69				
		Shorea leprosula	EW	F	0.27					0.89					4.69				
				G	0.18					0.71					4.24				
				H	0.29					0.98					4.40				
		Shorea multiflora	EW	F	0.37					0.43					1.71				
				G	0.06					0.14					0.63				
		Shorea ovalis	EW	F	0.23					0.62					3.39				
				G	0.15					0.46					3.18				
				H	0.35					0.68					4.82				
		Shorea ovata	EW	F	0.18					0.22					0.49				
				G	0.16					0.16					0.34				
				H	0.11					0.16					0.13				
		Shorea parvifolia	EW	F	0.15					0.37					1.66				
				G	0.11					0.31					1.30				
				H	0.08					0.13					0.77				
		Shorea pauciflora	EW	F	0.25					0.78					2.62				
				G	0.21					0.65					1.76				
				H	0.10					0.37					1.84				
		Shorea talura	EW	F	0.32					0.67					4.55				
				G	0.18					0.80					6.97				
		Sindora sp.	EW	F	0.19					0.22					0.46				
				G	0.14					0.21					0.64				
Open	92	Hopea odorata	EW	A			0.17			0.18					0.48	0.92	2.13		
				B			0.21			0.22					0.40	0.82	2.28		
				C			0.14			0.21					1.00	1.98	6.46		
				D			0.14			0.19					0.26	0.30	1.19		
				E			0.26			0.30					0.68	1.21	3.40		
		Neobalanocarpus heimii	EW	A				0.09		0.07					0.07	0.06	0.05	0.08	
				B				0.04		0.03					0.02	0.03	0.04	0.07	
				C				0.06		0.07					0.04	0.02	0.02	0.04	
				D				0.06		0.08					0.04	0.03	0.02	0.03	
				E							0.06			0.06	0.06	0.09	0.10	0.14	
		Shorea leprosula	EW	A				0.07		0.04					0.01	0.01			
				B				0.05		0.02					0.01	0.01			
				C				0.05		0.05					0.10	0.14	0.46		
				D				0.02		0.01					0.00	0.00			
				E						0.04		0.02			0.02	0.02	0.08		
		Shorea parvifolia	EW	A					0.05	0.06					0.08	0.07	0.12		
				B					0.05	0.03					0.03	0.03	0.05		
				C					0.03	0.03					0.03	0.00	0.01		
				D					0.10	0.08					0.06	0.08	0.21		
				E						0.03		0.02			0.02	0.02	0.03		
	93	Calophyllum sp.	EW	A		0.01				0.00					0.00				
				B		0.06				0.00									
				C		0.01				0.00					0.00				
				D		0.01				0.00					0.00				
				E		0.00				0.00									
		Dryobalanops aromatica	EW	A		0.07				0.02					0.04				
				B		0.05				0.00									
				C		0.06				0.04					0.03				
				D		0.05				0.01									
				E		0.05				0.02					0.01				
		Endospermum malaccense	EW	A		0.09				0.00									
				B		0.28				0.03					0.09				
				C		0.15				0.02					0.03				
				D		0.16				0.11					0.49	1.34			
				E		0.03				0.01									
		Pentaspadon motleyi	EW	A		0.01				0.00					0.01				
				B		0.05				0.00									
				C		0.01				0.01									
				D		0.02				0.01					0.01	0.06			
				E		0.00				0.00					0.01				
		Pouteria malaccensis	EW	A		0.01				0.00									
				B		0.01													
				C		0.01				0.00					0.00				
				D		0.01				0.00									

Appendix S10 BPU

Site	Year	Species	Direction	Type	Months after Planting 1	2	3	4	5	6	7	8	9	10	12	18	24	30	36
				E		0.00				0.00					0.00				
		Scaphium macropodum	EW	A		0.02				0.01					0.00				
				B		0.02				0.01					0.00				
				C		0.03				0.01					0.00				
				D		0.02				0.00									
				E		0.02				0.02					0.01	0.01			
		Shorea acuminata	EW	A		0.07				0.02					0.02				
				B		0.04				0.00									
				C		0.01				0.00									
				D		0.04				0.01									
				E		0.06				0.02					0.03				
		Shorea bracteolata	EW	A		0.04				0.03					0.02				
				B		0.05				0.05					0.02				
				C		0.03				0.02					0.04				
				D		0.03				0.03					0.05	0.04			
				E		0.04				0.03					0.05				
X(Arboretum)	92	Dryobalanops aromatica	x	x				0.04		0.05					0.03	0.02			
		Durio sp.	x	x				0.52		0.50					0.57	0.29	0.46		
		Hevea brasiliensis	x	x				0.06		0.07					0.05	0.09	0.37		
		Hopea odorata	x	x				0.07		0.11					0.79	2.32	4.70		
		Hopea odorata-1	x	x							0.67		0.66		1.27	2.44	6.78	25.55	
		Intsia palembanica	x	x			0.26			0.22					0.11	0.07	0.05		
		Neobalanocarpus heimii	x	x				0.13		0.13					0.16	0.14	0.12		
		Parkia sp.	x	x			0.14			0.09					0.17	0.22	0.76		
		Pentaspadon motleyi	x	x				0.01		0.01					0.01	0.02			
		Scaphium macfopodum	x	x								0.12		0.11	0.07	0.03	0.01		
		Shorea acuminata	x	x				0.06		0.03					0.02	0.00			
		Shorea leprosula	x	x							0.04				0.02	0.01			
		Shorea ovalis	x	x				0.28		0.19					0.10	0.03	0.00		
		Shorea parvifolia	x	x	0.08					0.04					0.01				
		Swietenia macrophylla	x	x				0.26		0.27					0.25	0.28	0.29		
		Tectona grandis	x	x			0.09			0.29					1.99	5.51	15.60		
	93	Agathis borneensis	x	x		0.07				0.01					0.01				
		Alstonia sp.	x	x		0.09				0.27					0.59	3.13	6.45		
		Cinnamomum sp.	x	x		0.22				0.38					0.40	1.22	3.41		
		Dacryodes sp.	x	x		0.01				0.00					0.00				
		Dipterocarpus cornutus	x	x		0.14				0.04					0.00				
		Endospermum malaccense	x	x		0.13				0.17					0.10	0.29	0.84		
		Heritiera sp.	x	x		0.03				0.01					0.02				
		Hopea odorata-2	x	x				0.27		0.26					0.24		0.14		
		Hopea odorata-3	x	x		0.05				0.06					0.19				
		Koompassia malaccensis	x	x		0.00				0.00					0.00				
		Palaquium gutta	x	x		0.03				0.00					0.01				
		Shorea macroptera	x	x		0.03				0.16					0.46				
		Shorea multiflora	x	x		0.11				0.00					0.00				
		Shorea talura	x	x		0.10				0.10					0.18				
		Toona sureni	x	x		0.22				0.17					0.06	0.04	0.05		

Appendix 1

Result of cost analysis of Multi-Storied Forests Management (D-type model at Chikus project site Block-B)

1st year Operation

1.Establishment:*A.mangium* planting(Seedlings planted:896 trees/ha)

32 rows×28 rows=896 trees/ha

RM1,250/ha*1

2.Annual Balance:△RM1,250/ha

3.Total Balance:△RM1,250/ha

2nd year Operation

1.Treatment 1(Slashing and first pruning)

:RM170/ha*1×1/2×2(estimated double of normal operation)=RM170/ha

2. Road maintenance:RM50/ha*1

3. General administrative expenses(10% of direct expenses):RM22/ha

4. Annual Balance:△RM242/ha

5.Total Balance:△RM1,492/ha

3rd year Operation

1.Road maintenance:RM50/ha× 1 year=RM50/ha

2. General administrative expenses:RM5/ha

3. Annual Balance:△RM55/ha

4.Total Balance:△RM1,640/ha

4th year Operation

1.Establishment of Multi-Storied Forest

(1) *A.mangium*(3-year old) felling

Seedlings planted:896 trees/ha

Retaining trees:762 trees/ha

Trees felled:381 trees/ha

Felling costs:381 trees×RM3.5/tree=RM1,334/ha

Skidding costs:381 trees×RM2.5/tree=RM953/ha

Sub total:RM2,287/ha*1

(2) *Shorea* spp. planting(448 trees/ha)

Site preparation:448 trees/ha×RM1.0/tree=RM448/ha

Seedling costs:448 trees/ha×RM2.2/tree=RM986/ha

Seedling loading and transportation:448trees/ha×RM1.0/tree=RM448/ha

Planting costs:448 trees/ha×RM0.85/tree=RM381/ha

Weeding(Line weeding with 1m width):448trees/ha×RM0.4/tree×4 times/year=RM717/ha

Sub total:RM2,980/ha[*2]

(3) Road maintenance:RM50/ha× 1 year=RM50/ha

(4) General administrative expenses:RM532/ha

Total cost:RM5,849/ha

2.Annual Balance:△RM5,849/ha

3.Total Balance:△RM7,396/ha

5th year Operation

1. Treatment

(1) *Shorea* spp. Weeding:448 trees/ha×RM 0.4/tree×4 times/year=RM717/ha

(2) Road maintenance:RM50/ha× 1 year=RM50/ha

(3) General administrative expenses:RM77/ha

Total costs:RM844/ha

2. Annual balance:△RM844/ha

3. Total balance:△RM8,240/ha

Notes: 1. △ indicates deficit.

2. Source: [*1]:Forest Plantation Unit, Forestry Department Peninsular Malaysia

3. Source: [*2]:"Interim Report, The Multi-Storied Forest Management Project in Peninsular Malaysia, Forestry Department Peninsular Malaysia/Perak State Forestry Department/JICA "

4. Precondition of establishment of multi-storied forest is shown in the Table-F14.

Appendix 2

Cost Analysis of Multi-Storied Forests Management Model (D-type model at Chikus project site Block-B)

1st year Operation

1.Establishment of *A.mangium* forest(seedlings planted:896trees/ha)

32rows×28rows=896trees/ha

RM1,250/ha[*1]

2.Annual Balance:△RM1,250/ha

3.Total Balance:△RM1,250/ha

2nd year Operation

1.Treatment 1(slashing and first pruning for *A.mangium* stand)

:RM170/ha[*1]×1/2×2(estimated double of normal operation)=RM170/ha

2. Road maintenance:RM50/ha[*1]

3. General administrative expenses(10% of direct expenses):RM22/ha

4. Annual Balance:△RM242/ha

5.Total Balance:△RM1,492/ha

3rd year Operation

1.Road maintenance:RM50/ha×1year=RM50/ha

2. General administrative expenses:RM5/ha

3. Annual Balance:△RM55/ha

4.Total Balance:△RM1,640/ha

4th year Operation

1.Establishment of multi-storied forest

(1) *A.mangium*(3-year old) felling

Seedlings planted:896trees/ha

Retaining trees:762trees/ha

Trees felled:381trees/ha

Felling costs:381trees×RM3.5=RM1,331/ha

Skidding costs:381trees×RM2.5=RM953/ha

Sub total:RM2,287/ha[*2]

(2) *Shorea* spp. planting(448trees/ha)

Site preparation:448trees/ha×RM1.0/tree=RM448/ha

Seedling costs:448trees/ha×RM2.2/tree=RM986/ha

Seedling loading and transportation:448trees/ha×RM1.0/tree=RM448/ha

Planting costs:448trees/ha×RM0.85/tree=RM381/ha

Weeding(Line weeding with 1m width):448trees/ha×RM0.4/tree×4times/year=RM717/ha

Sub total:RM2,980/ha[*2]

(3) Road maintenance:RM50/ha × 1year = RM50/ha

(4) General administrative expenses:RM532/ha

Total cost:RM5,849/ha

2.Annual Balance:△RM5,849/ha

3.Total Balance:△RM7,396/ha

5th year Operation

1. Treatment for *Shorea* spp. stand

(1) *Shorea* spp. Weeding:448trees/ha × RM0.4/tree × 4times/year = RM717/ha

2. Road maintenance:RM50/ha × 1year = RM50/ha

3. General administrative expenses:RM77/ha

Total costs:RM844/ha

4. Annual balance:△RM844/ha

5. Total balance:△RM8,240/ha

6th year Operation

1. Treatment for *A.mangium* stand

(1) *Acacia mangium* Thinning Ⅱ :RM270/ha[*1] × 1/2(half area) × 2.0(estimated double of normal operation) = RM270/ha

(2) Road maintenance:RM50/ha × 1year = RM50/ha

(3) General administrative expenses:RM32/ha

Total costs:RM352/ha

2. Expected income

(1) *A.mangium* selling as pulpwood

20m³/ha[*3] × 1/2(half area) = 10m³/ha

10m³/ha × RM46/m³(supposed) = RM460/ha

3. Annual balance:RM108/ha

4. Total balance:△RM8,132/ha

(7~9th year Operation)

1. Road maintenance:RM50/ha × 3years = RM150/ha

2. General administrative expenses:RM15/ha

3. Total balance:△RM8,297/ha

10th year Operation

1.Treatment for *A.mangium* stand

(1) *A.mangium* Final Thinning(Thinning Ⅲ)

RM310/ha[*1] × 1/2 × 2 = RM310/ha

(2) Road maintenance:RM50/ha × 1year = RM50/ha

(3) General administrative expenses:RM36/ha

Total costs:RM396/ha

2. Expected Income

(1) *A.mangium* selling as pulpwood

60m³/ha[*3] × 1/2 = 30m³/ha

30m³/ha × RM46 = RM1,380/ha

3. Annual balance:RM984/ha

4. Total balance:△RM7,313/ha

(11~15th year Operation)

1. Road maintenance:RM50/ha × 5years = RM250/ha

2. General administrative expenses:RM25/ha

3. Total balance:△RM7,588/ha

16th year Operation

1. Treatment for *A.mangium* stand

(1) *A.mangium*(15-year old) felling(Final felling)

180m³/ha[*3] × 1/2 = 90m³/ha

Felling costs:RM8.61/m³[*1] × 90m³/ha × 2 = RM1,532/ha

Skidding costs:RM9.10/m³[*1] × 90m³/ha × 2 = RM1,638/ha

Sub total:RM3,170/ha

(2) *A.mangium* planting

(RM1,250/ha − RM100/ha:Road construction[*1]) × 1/2 = RM575/ha

(3) Road maintenance:RM50/ha × 1yesr = RM50/ha

(4) General administrative expenses:RM380/ha

Total costs:RM4,175/ha

2. Expected Income

(1) *A.mangium* selling as general use timber

90m³/ha × RM100/m³(supposed) = RM9,000/ha

3. Annual balance:RM4,825/ha

4. Total balance:△RM2,763/ha

17th year Operation

1.Treatment 1(slashing and first pruning for *A.mangium* stand)

RM170/ha × 1/2 × 2 = RM170/ha

2. Road maintenance:RM50/ha × 1year = RM50/ha

3. General administrative expenses:RM22/ha

4. Annual balance:△RM242/ha

5.Total balance:△RM3,005/ha

18th year Operation

1. Road maintenance:RM50/ha × 1year = RM50/ha

2. General administrative expenses:RM5/ha

3. Annual balance:△RM55/ha

4.Total balance:△RM3,060/ha

19th year Operation

1.Treatment for *A.mangium* stand

(1) *Acacia mangium* Thinning I

RM 300/ha×1/2×2=RM 300/ha

2. Road maintenance:RM50/ha×1year=RM50/ha

3. General administrative expenses:RM35/ha

4. Annual balance:RM385/ha

5.Total balance:△RM3,445/ha

20th year Operation

1. Road maintenance:RM50/ha×1year=RM50/ha

2. General administrative expenses:RM5/ha

3. Annual balance:△RM55/ha

4. Total balance:△RM3,600/ha

21st year Operation

1. Treatment for *A.mangium* stand

(1) *Acacia mangium* Thinning II

RM270/ha×1/2×2.0=RM270/ha

(2) Road maintenance:RM50/ha×1year=RM50/ha

(3) General administrative expenses:RM32/ha

Total costs:RM352/ha

2. Expected Income(Pulpwood)

(1) *A.mangium* selling as pulpwood

$20m^3/ha \times 1/2 = 10m^3/ha \times 0.9 = 9m^3/ha$

$9m^3/ha \times RM46/m^3 = RM414/ha$

3.Annual balance:RM62/ha

4.Total balance:△RM3,438/ha

(22~24th year Operation)

1. Road maintenance:RM50/ha×3years=RM150/ha

2. General administrative expenses:RM15/ha

3. Total balance:△RM3,603/ha

25th year Operation

1.Treatment for *A.mangium* stand

(1) *A.mangium* Final Thinning(Thinning III)

RM310/ha×1/2×2=RM310/ha

(2) Road maintenance:RM50/ha×1year=RM50/ha

(3) General administrative expenses:RM36/ha

Total costs:RM396/ha

2. Expected Income

(1) *A.mangium* selling as pulpwood

60m³/ha×1/2=30m³/ha×0.9=27m³/ha

27m³/ha×RM46=RM1,242/ha

3. Annual balance:RM846/ha

4. Total balance:△RM2,767/ha

(26~30th year Operation)

1. Road maintenance:RM50/ha×5years=RM250/ha

2. General administrative expenses:RM25/ha

3. Total balance:△RM3,032/ha

31st year Operation

1. Establishment of multi-storied forest

(1) *A.mangium*(15-year old) felling(Final felling)

180m³/ha×1/2=90m³/ha×0.9=81m³/ha

Felling costs: RM8.51/m³×81m³/ha×2=RM1,379/ha

Skidding costs: RM9.10/m³×81m³/ha×2=RM1,474/ha

Sub total:RM2,853/ha

(2) *Shorea* spp.(27-year old) Thinning

8rows×28rows:73trees/ha

Felling·Extraction costs:73trees×0.82m³/tree×RM60/m³(assumed)=RM3,592/ha

(3) *Shorea* spp. planting

24rows×28rows=672trees/ha

Site preparation costs:672trees/ha×RM1.0/tree=RM672/ha

Seedling costs:672trees/ha×RM2.2/tree=RM1,478/ha

Seedling loading and transportation costs:672trees/ha×RM1.0/tree=RM672/ha

Planting costs:672trees/ha×RM0.85/tree=RM571/ha

Weeding costs(Line weeding with 1m width):672trees/ha×RM0.4/tree×4times/year=RM1,076/ha

Sub total:RM4,468/ha

(4) Road maintenance:RM50/ha

(5) General administrative expenses:RM1,096/ha

Total costs:RM12,059/ha

2. Expected Income

(1) *A.mangium* selling as general use timber

81m³/ha×RM100(supposed)=RM8,100/ha

(2) *Shorea* spp. selling as general use timber

73trees/ha×0.82m³/tree×RM517/ m³×1/2(estimated as half price of final felling timber)=RM15,474/ha

Total Income:RM23,574/ha

3. Annual balance:RM11,615/ha

4. Total balance:RM8,483/ha

32nd year Operation

1.Treatment for *Shorea* spp. stand

(1) *Shorea* spp. Weeding

672 trees/ha×RM 0.4/tree×4times/year=RM1,075/ha

2. Road maintenance:RM50/ha

3. General administrative expenses:RM113/ha

Total costs:RM1,238/ha

4. Annual balance:△RM1,238/ha

5. Total balance:RM7,245/ha

(33~53rd year Operation)

1. Road maintenance:RM50/ha×21years=RM1,050/ha

2. General administrative expenses:RM105/ha

3. Total balance:RM6,090/ha

54th year Operation

1.Establishment of multi-storied forest

(1) *Shorea* spp.(50-year old) Final felling

8rows×28rows:27trees/ha

Felling･Extraction costs:27trees×3.25m³/tree×RM60/m³=RM5,265/ha

(2) *Shorea* spp.(23-year old) Thinning

8rows×28rows:125trees/ha

Felling･Extraction costs:125trees×0.82m³/tree×RM60/ m³=RM6,150/ha

(3) *Shorea* spp. Planting

16rows×28rows=448trees/ha

(as same as 4th year Operation)

RM2,980/ha

(4) Road maintenance:RM50/ha

(5) General administrative expenses:RM1,445/ha

Total costs:RM15,890/ha

2.Expected Income

(1) *Shorea* spp. selling of final felling timber as general use timber

27trees/ha×3.25m³/tree×RM517/ m³=RM45,367/ha

(2) *Shorea* spp. selling of thinning timber as general use timber

125trees/ha×0.82m³/tree×RM517/ m³×1/2=RM26,496/ha

Total Income:RM71,863/ha

3. Annual balance:RM55,973/ha

4. Total balance:RM62,063/ha

55th year Operation

1.Treatment for *Shorea* spp. stand

(1) *Shorea* spp. Weeding:448trees/ha×RM0.4/tree×4times/year=RM717/ha

2. Road maintenance:RM50/ha

3. General administrative expenses:RM77/ha

Total costs:RM844/ha

2. Annual balance:△RM844/ha

3. Total balance:RM61,219/ha

(56~80th year Operation)

1. Road maintenance :RM50/ha×25years=RM1,250/ha

2. General administrative expenses:RM125/ha

3. Total balance:RM59,844/ha

81st year Operation

1.Establishment of multi-storied forest

(1) *Shorea* spp.(50-year old) Final felling (General use timber)

16rows×28rows:73trees/ha

Felling·Extraction costs:73trees×3.25m³/tree×RM60/m³=RM14,235/ha

(2) *Shorea* spp. Planting

16rows×28rows=448trees/ha

(as same as 4th year Operation)

RM2,980/ha

(3) Road maintenance:RM50/ha

(4) General administrative expenses:RM1,727/ha

Total costs:RM18,992/ha

2.Expected Income

(1) *Shorea* spp. selling of final felling timber as general use timber

73trees/ha×3.25m³/tree×RM517/ m³=RM122,658/ha

Total Income:RM122,658/ha

3. Annual balance:RM103,666/ha

4. Total balance:RM163,510/ha

82nd year Operation

1.Treatment for *Shorea* spp. stand

(1) *Shorea* spp. Weeding:448trees/ha×RM0.4/tree×4times/year=RM717/ha

2. Road maintenance:RM50/ha

3. General administrative expenses:RM77/ha

Total costs:RM844/ha

4. Annual balance:△RM844/ha

5. Total balance:RM162,666/ha

(83~103rd year Operation)

1. Road maintenance:RM50/ha×21years=RM1,050/ha

2. General administrative expenses:RM105/ha

3. Total balance:RM161,511/ha

104th year Operation

1. Establishment of multi-storied forest

(1) *Shorea* spp.(50-year old) Final felling(General use timber)

16rows×28rows:72trees/ha

Felling･Extraction costs:72trees×3.25m³/tree×RM60/m³=RM14,040/ha

(2) Road maintenance:RM50/ha

(3) General administrative expenses:RM1,409/ha

Total costs:RM15,499/ha

2. Expected Income

(1) *Shorea* spp. selling of final felling timber as general use timber

72trees/ha×3.25m³×RM517=RM120,978/ha

Total Income:RM120,978/ha

3. Annual balance:RM105,479/ha

4. Total balance:RM266,990/ha

Notes:1. △ indicates deficit.

2. Source:[*1]: Forest Plantation Unit,Forestry Department Peninsular Malaysia

3. Source :[*2]:"Interim Report, The Multi-Storied Forest Management Project in Peninsular Malaysia, Forestry Department Peninsular Malaysia/Perak State Forestry Department/JICA"

4. Source:[*3]:Forest Plantation Unit,Forestry Department Peninsular Malaysia

5. Yield prediction for thinnings and final felling timber of *Shorea* spp. are based on empirical yield table produced in 1995 by JICA Short-Term Expert.

Appendix 3

Result of Cost Analysis of Multi-Storied Forest Management Model(H-type model at Chikus project site Block-A)

1st year Operaion

1.Establishment

(1) Secondary forest felling / *Shorea* spp. planting

15rows×20rows=300trees/ha

Site preparation:RM3,000/ha×0.4ha(40m×100m×1row)=RM1,200/ha

Seedling costs:300trees/ha×RM2.2/seedling=RM660/ha

Seedling loading and transportation:300trees/ha×RM0.3/seedling=RM90/ha

Planting costs:300trees/ha×RM1.0/seedling=RM300/ha

Weeding:300trees×RM0.65/seedling×4times per 1year=RM780/ha

Sub total:RM3,030/ha (Based on contract works of the project)

(2) Road construction and maintenance:RM50/ha*1

(3) General administrative expenses:RM313/ha

Total cost:RM3,443/ha

2. Annual balance

△RM3,443/ha

3. Total balance

△RM3,443/ha

2nd year Operation

1.Treatment for *Shorea* spp. stand

(1) *Shorea* spp. Weeding

300trees/ha×RM0.65/tree×2times per 1year=RM390/ha

2. *Road maintenance*:RM50/ha

3. General administrative expenses:RM44/ha

Total cost:RM484/ha

4. Annual balance

△RM484/ha

5. Total balance

△RM3,927/ha

Notes:1. △indicates deficit.

2. Source: *1:Forest Plantation Unit, Forestry Department Peninsular Malaysia

Appendix 4

Cost Analysis of Multi-Storied Forest Management Model(H-type model at Chikus project site Block-A)

1st year Operaion

1.Establishment

(1) Secondary forest felling / *Shorea* spp. planting

15rows×20rows=300trees/ha

Site preparation:RM3,000/ha×0.4ha(40m×100m×1row)=RM1,200/ha

Seedling costs:300trees/ha×RM2.2/seedling=RM660/ha

Seedling loading and transportation:300trees/ha×RM0.3/seedling=RM90/ha

Planting costs:300trees/ha×RM1.0/seedling=RM300/ha

Weeding:300trees×RM0.65/seedling×4times per 1year=RM780/ha

Sub total:RM3,030/ha (Based on contract works of the project)

(2) Road construction and maintenance:RM50/ha*1

(3) General administrative expenses:RM313/ha

Total cost:RM3,443/ha

2. Annual balance

△RM3,443/ha

3. Total balance

△RM3,443/ha

2nd year Operation

1.Treatment for *Shorea* spp. stand

(1) *Shorea* spp. Weeding

300trees/ha×RM0.65/tree×2times per 1year=RM390/ha

2. Road maintenance:RM50/ha

3. General administrative expenses:RM44/ha

Total cost:RM484/ha

4. Annual balance

△RM484/ha

5. Total balance

△RM3,927/ha

(3~25th year Operation)

1. Road maintenance:RM50/ha×23years=RM1,150/ha

2. General administrative expenses:RM115/ha

2. Total balance

△RM5,192/ha

26th year Operation

1. Establishment of multi-storied forest

(1) Secondary forest felling / *Shorea* spp. planting

22rows×20rows=440trees/ha

Site preparation:RM3,000/ha×0.6ha((40m+20m)×100m×1row)×1.2=RM 2,160/ha

Seedling costs:440trees/ha×RM2.2/seedling=RM968/ha

Seedling loading and transportation:440trees/ha×RM0.3/seedling=RM132/ha

Planting costs:440trees/ha×RM1.0/seedling=RM440/ha

Weeding:440trees/ha×RM0.65/seedling×4times per 1year=RM1,144/ha

Sub total:RM4,844

(2) *Shorea* spp. (25-year old) Thnning

7rows×20rows:79trees/ha

Felling·Extraction costs:79trees/ha×0.82m³/tree×RM60/m³=RM3,887/ha

(3) *Shorea* spp. Planting (at the strips of *Shorea* spp. thinning)

7rows×20rows=140trees/ha

Site preparation:140trees/ha×RM1.0/seedling=RM140/ha

Seedling costs:140trees/ha×RM2.2/seedling=RM308/ha

Seedling loading and transportation:140trees/ha×RM0.3/seedling=RM42/ha

Planting costs:140trees/ha×RM1.0/seedling=RM140/ha

Weeding:140trees/ha×RM0.65/seedling×4times per 1year=RM364/ha

Sub total:RM994/ha

(4) Road maintenance:RM50/ha

(5) General administrative expenses:RM978/ha

Total cost:RM10,763/ha

2. Expected Income

(1) *Shorea* spp. (25-year old) selling

7rows×20rows:79trees/ha

79trees/ha×0.82m³×RM517/m³×1/2(estimated as half price of final felling timber)=RM16,746/ha

Total Income:RM16,746/ha

3. Annual balance

RM5,993/ha

4. Total balance

RM801/ha

27th year Operation

1. *Treatment for Shorea spp. stand*

(1) *Shorea* spp. Weeding

440trees(22rows×20rows)/ha×RM0.65/tree×4times per 1year=RM1,144/ha

(at the strips of secondary forest felling)

140trees(7rows×20rows)/ha×RM0.65×2times per 1year=RM182/ha

(at the strips of *Shorea* spp. thinning)

Sub total:RM1,326/ha

2. Road maintenance:RM50/ha

3. General administrative expenses:RM138/ha

Total cost:RM1,514/ha

4. Annual balance

△RM1,514/ha

5. Total balance

△RM713/ha

(28~50th year Operation)

1. Road maintenance:RM50/ha×23years=RM1,150/ha

2. General administrative expenses:RM115/ha

3. Total balance

△RM1,978/ha

51st year Operation

1. Establishment of multi-storied forest

(1) *Shorea* spp. (50-year old) final felling

8rows×20rows:26trees/ha

Felling·Extraction costs:26trees/ha×3.25m³/tree×RM60/m³=RM5,070/ha

(2) *Shorea* spp. (25-year old) thinning

17rows×20rows:192trees/ha

Felling·Extraction costs:192trees/ha×0.82m³/tree×RM60/m³=RM9,446/ha

(3) *Shorea* spp. planting

25rows×20rows=500trees/ha

Site preparation:500trees/ha×RM1.0/seedling=RM500/ha

Seedling costs:500trees/ha×RM2.2/seedling=RM1,100/ha

Seedling loading and transportation:500trees/ha×RM0.3/seedling=RM150/ha

Planting costs:500trees/ha×RM1.0/seedling=RM500/ha

Weeding:500trees/ha×RM0.65/seedling×4times per 1year=RM1,300/ha

Sub total:RM3,550/ha

(4) Road maintenance:RM50/ha

(5) General administrative expenses:RM1,812/ha

Total cost:RM19,928/ha

2. Expected Income

(1) *Shorea* spp. selling of final felling

26trees/ha×3.25m³/tree×RM517/m³=RM13,687/ha

(2) *Shorea* spp. selling of thinning

192trees/ha×0.82m³/tree×RM517×1/2=RM40,698/ha

Total Income:RM84,385/ha

3. Annual balance

RM64,457/ha

4. Total balance

RM62,479/ha

52nd year Operation

1. Treatment for *Shorea* spp. stand

(1) *Shorea* spp. Weeding

300trees(15rows×20rows)/ha×RM0.65/tree×4times per 1year=RM780/ha

200trees(10rows×20rows)/ha×RM0.65/tree×2times per 1year=RM260/ha

Sub total:RM1,040/ha

2. Road maintenance:RM50/ha

3. General administrative expenses:RM109/ha

Total costs:RM1,199/ha

4. Annual balance

△RM1,199/ha

5. Total balance

RM61,280/ha

(53~75th year Operation)

1. Road maintenance:RM50/ha×23years=RM1,150/ha

2. General administrative expenses:RM115/ha

3. Total balance

RM 60,015/ha

76th year Operation

1. Establishment of multi-storied forest

(1) *Shorea* spp. (50-year old) final felling

12rows×20rows:39trees/ha

Felling·Extraction costs:39trees/ha×3.25m³/tree×RM60/ m³=RM7,605/ha

(2) *Shorea* spp. (25-year old) thinning

17rows×20rows:192trees/ha

Felling·Extraction costs:192trees/ha×0.82m³/tree×RM60/ m³=RM9,446/ha

(3) *Shorea* spp. planting

29rows×20rows=580rows/ha

Site preparation:580trees/ha×RM1.0/seedling=RM580/ha

Seedling costs:580trees/ha×RM2.2/seedling=RM1,276/ha

Seedling loading and transportation:580trees/ha×RM0.3/seedling=RM174/ha

Planting costs:580trees/ha×RM1.0/seedling=RM580/ha

Weeding:580trees/ha×RM0.65/seedling×4times per 1year=RM1,508/ha

Sub total:RM4,118/ha

(4) Road maintenance:RM50/ha

(5) General administrative expenses:RM2,122/ha

Total costs:RM23,341/ha

2. Expected Income

(1) *Shorea* spp. selling of final felling timber

39trees/ha×3.25m³/tree×RM517/m³=RM65,530/ha

(2) *Shorea* spp. selling of thinning timber

192trees/ha×0.82m³/tree×RM517/m³×1/2=RM40,698/ha

Total Income:RM106,228/ha

3. Annual balance

RM82,887/ha

4. Total balance

RM142,902/ha

77th year Operation

1. Treatment for *Shorea* spp. stand

(1) *Shorea* spp. Weeding

410trees(22rows×20rows)/ha×RM0.65/seedling×4times per 1year=RM1,144/ha

140trees(7rows×20rows)/ha×RM0.65/seedling×2times per 1year=RM182/ha

Sub total:RM1,326/ha

2. Road maintenance:RM50/ha

3. General administrative expenses:RM138/ha

Total costs:RM1,514/ha

4. Annual balance

△RM1,514/ha

5. Total balance

RM141,388/ha

(78~100th year Operation)

1. Road maintenance:RM50/ha×23years=RM1,150/ha

2. General administrative expenses:RM115/ha

3. Total balance

RM 140,123/ha

101st year Operation

1. Establishment of multi-storied forest

(1) *Shorea* spp. (50-year old) final felling

8rows×20rows:30trees/ha

Felling·Extraction costs:30trees/ha×3.25m³/tree×RM60/ m³=RM5,850/ha

(2) *Shorea* spp. (25-year old) thinning

17rows×20rows:192trees/ha

Felling・Extraction costs:192trees/ha×0.82m³/tree×RM60/ m³=RM9,446/ha

(3) Road maintenance:RM50/ha

(4) General administrative expenses:RM1,535/ha

Total costs:RM16,881/ha

2. Expected Income

(1) *Shorea* spp. selling of final felling timber

30trees/ha×3.25m³/tree×RM517/m³=RM50,408/ha

(2) *Shorea* spp. selling of thinning timber

192trees/ha×0.82m³/tree×RM517/m³×1/2=RM40,698/ha

Total Income:RM91,106/ha

3. Annual balance

RM74,225/ha

4. Total balance

RM 214,348/ha

Notes:1. △indicates deficit.

2. Source: *1:Forest Plantation Unit,Forestry Department Peninsular Malaysia

3. Yield prediction for thinnings and final felling timber of *Shorea* spp. are based on empirical yield table produced in 1995 by JICA Short-Term Expert.

Appendix 5

Cost Analysis of Multi-Storied Forests Management Model(Subtype of D-type model at Chikus projrct site Block-B)

1st year Operation

1.Establishment of *A.mangium* forest(seedlings planted:896trees/ha)

32rows×28rows=896trees/ha

RM 1,250/ha*1

2 Annual Balance:△RM1,250/ha

3.Total Balance:△RM1,250/ha

2nd year Operation

1.Treatment 1(slashing and first pruning for *A.mangium* stand)

:RM 170/ha*1×1/2×2(estimated double of normal operation)=RM170/ha

2. Road maintenance:RM 50/ha*1

3. General administrative expenses(10% of direct expenses):RM22/ha

4. Annual Balance:△RM242/ha

5.Total Balance:△RM1,492/ha

3rd year Operation

1.Road maintenance:RM50/ha×1year=RM50/ha

2. General administrative expenses:RM5/ha

3. Annual Balance:△RM55/ha

4.Total Balance:△RM1,547/ha

4th year Operation

1. Treatment for *A.mangium* stand

(1) *Acacia mangium* Thinnig I

RM300/ha*1×1/2×2=RM300/ha

2. Road maintenance:RM50/ha×1year=RM50/ha

3. General administrative expenses:RM35/ha

4. Annual balance:△RM385/ha

5.Total Balance:△RM1,932/ha

(5~9th year Operation)

1. Road maintenance:RM50/ha×5year=RM250/ha

2. General administrative expenses:RM25/ha

3. Total balance:△RM2,207/ha

10th year Operation

1. Establishment of multi-storied forest

(1) *A.mangium*(9-year old) felling

Seedlings planted:896 trees/ha

Retaining trees:896 trees/ha×68%(survival rate)=609trees/ha

Trees felled:305trees/ha(thinning rate:50%)

Felling and skidding costs:305trees/ha×RM6.0/tree×1.5(9-year old stand is about one and a half times as large as 3-year old stand.)=RM2,745/ha

Sub total:RM2,745/ha*2

(2) *Shorea* spp. planting(448trees/ha)

Site preparation:448trees/ha×RM1.0/tree=RM448/ha

Seedling costs:448trees/ha×RM2.2/tree=RM986/ha

Seedling loading and transportation:448trees/ha×RM1.0/tree=RM448/ha

Planting costs:448trees/ha×RM0.85/tree=RM381/ha

Weeding(Line weeding with 1m width):448trees/ha×RM0.4/tree×4times/year=RM717/ha

Sub total:RM 2,980/ha*2

(3) Road maintenance:RM50/ha×1year=RM50/ha

(4) General administrative expenses:RM578/ha

Total cost:RM6,353/ha

2. Expected Income

(1) *A.mangium* selling as general use timber

305 trees/ha×0.33m³/tree=101m³/ha

101m³/ha×70%(utilization percentage)×RM90/m³=RM6,363/ha

3. Annual balance:RM10/ha

4. Total balance:△RM2,197/ha

11th year Operation

1.Treatment for *Shorea* spp. stand

(1)*Shorea* spp. Weeding:448trees/ha×RM0.4/tree×4times/year=RM717/ha

2. Road maintenance:RM50/ha× 1 year=RM50/ha

3. General administrative expenses:RM77/ha

4. Annual balance:△RM844/ha

5.Total balance:△RM3,041/ha

(12~15th year Operation)

1. Road maintenance:RM50/ha×4years=RM200/ha

2. General administrative expenses:RM20/ha

3. Total balance:△RM3,261/ha

16th year Operation

1. Establishment of *A.mangium* forest

(1) *A.mangium*(15-year old) felling(Final felling)

305trees/ha×97%=296trees/ha

Felling and skidding costs:296trees/ha×RM6.0/tree×2.0(15-year old stand is about two times as large as 3-year old stand.)=RM3,552/ha

Sub total:RM3,552/ha

(2) *A.mangium* planting(448trees/ha)

(RM1,250/ha－RM100/ha:Road construction*1)×1/2＝RM575/ha

(3) Road maintenance:RM50/ha×1 year＝RM50/ha

(4) General administrative expenses:RM418/ha

Total costs:RM4,595/ha

2. Expected Income

(1) *A.mangium* selling as general use timber

296trees/ha×0.43m³/tree＝127m³/ha

127m³/ha×70%(utilization percentage)×RM100/m³(supposed)＝RM8,890/ha

3. Annual balance:RM 4,295/ha

4. Total balance:RM1,034/ha

17th year Operation

1.Treatment 1(Slashing and first pruning for *A.mangium* stand)

RM170/ha×1/2×2＝RM170/ha

2. Road maintenance:RM50/ha×1year＝RM50/ha

3. General administrative expenses:RM22/ha

4. Annual balance:RM242/ha

5.Total balance:RM792/ha

18th year Operation

1. Road maintenance:RM50/ha×1year＝RM50/ha

2. General administrative expenses:RM5/ha

3. Annual balance:△RM55/ha

4.Total balance:RM737/ha

19th year Operation

1.Treatment for *A.mangium* stand

(1) *Acacia mangium* Thinnig I (thinning rate:30%,448trees/ha×81%(survival rate)×70%=254trees/ha)

RM300/ha×1/2×2＝RM300/ha

2. Road maintenance:RM50/ha×1year＝RM50/ha

3. General administrative expenses:RM35/ha

4. Annual balance:△RM385/ha

5.Total balance:RM352/ha

(20~24th year Operation)

1. Road maintenance:RM50/ha×5year＝RM250/ha

2. General administrative expenses:RM25/ha

3. Total balance:RM77/ha

25th year Operation

1.Treatment for *A.mangium* stand

(1) *A.mangium* Final Thinning(Thinning Ⅱ・Ⅲ)

254trees/ha×84%(survival rate)×60%(thinning rate)=107trees/ha

Felling and skidding costs:107trees/ha×RM6.0/tree×1.5(9-year old stand is about one and a half times as large as 3-year old stand.)=RM963/ha

Sub total:RM963/ha

(2) Road maintenance:RM 50/ha×1 year=RM50/ha

(3)General administrative expenses:RM101/ha

Total costs:RM1,114/ha

2. Expected Income

(1) *A.mangium* selling as general use timber

107trees/ha×0.33m³/tree×0.9(growth retardation by continuous cropping)=32m³/ha

32m³/ha×70%(utilization percentage)×RM90=RM2,016/ha

3. Annual balance:RM902/ha

4. Total balance:RM979/ha

(26~30th year Operation)

1. Road maintenance:RM50/ha×5 year=RM250/ha

2. General administrative expenses:RM25/ha

3. Total balance:RM704/ha

31st year Operation

1. Establishment of multi-storied forest

(1) *A.mangium*(15-year old) felling(Final felling)

107trees/ha×97%(survival rate)=104trees/ha

Felling and skidding costs:107trees/ha×RM6.0/tree×2.0(15-year old stand is about two times as large as 3-year old stand.)=RM1,248/ha

Sub total:RM1,248/ha

(2) *Shorea* spp.(21-year old) Thinning

8rows×28rows:101trees/ha

Felling・Extruction costs:101trees×0.48m³/tree×RM60/m³(assumed)=RM2,909/ha

(3) *Shorea* spp. planting

24rows×28rows=672trees/ha

Site preparation costs:672trees/ha×RM1.0/tree=RM672/ha

Seedling costs:672trees/ha×RM2.2/tree=RM1,478/ha

Seedling loading and transportation costs:672trees/ha×RM1.0/tree=RM672/ha

Planting costs:672trees/ha×RM0.85/tree=RM571/ha

Weeding costs(1line weeding with 1m.width):672trees/ha×RM0.4/tree×4times/year=RM1,076/ha

Sub total:RM4,468/ha

(4) Road maintenance:RM50/ha

(5) General administrative expenses:RM868/ha

Total costs:RM9,543/ha

2. Expected Income

(1) *A. mangium* selling as general use timber

104trees/ha×0.43m³/tree×0.9(growth retardation by continuous cropping)=40m³/ha

40m³/ha×70%(utilization percentage)×RM100/m³(supposed)=RM2,800/ha

(2) *Shorea* spp. selling as general use timber

101trees/ha×0.48m³/tree×RM517/m³×1/2(estimated as half price of final felling timber)=RM12,532/ha

Total Income:RM15,332/ha

3. Annual balance:RM5,789/ha

4. Total balance:RM6,493/ha

32nd year Operation

1.Treatment for *Shorea* spp. stand

(1) *Shorea* spp. Weeding

672 trees/ha×RM 0.4/tree×4times/year=RM1,075/ha

2. Road maintenance:RM50/ha

3. General administrative expenses:RM113/ha

Total costs:RM1,238/ha

4. Annual balance:△RM1,238/ha

5. Total balance:RM5,255/ha

(33~53rd year Operation)

1. Road maintenance:RM50/ha×21years=RM1,050/ha

2. General administrative expenses:RM105/ha

3. Total balance:RM4,100/ha

54th year Operation

1.Establishment of multi-storied forest

(1) *Shorea* spp.(44-year old) Final felling

8rows×28rows:30trees/ha

Felling·Extraction costs:30trees×2.72m³/tree×RM60/m³=RM4,896/ha

(2) *Shorea* spp.(23-year old) Thinning

8rows×28rows:125trees/ha

Felling·Extraction costs:125trees×0.82m³/tree×RM60/ m³=RM6,150/ha

(3) *Shorea* spp. Planting

16rows×28rows=448trees/ha

(as same as 4th year Operation)

RM2,980/ha

(4) Road maintenance:RM50/ha

(5) General administrative expenses:RM1,408/ha

Total costs:RM15,484/ha

2.Expected Income

(1) *Shorea* spp. selling of final felling timber as general use timber

30trees/ha×2.72m³/tree×RM517/ m³=RM42,187/ha

(2) *Shorea* spp. selling of thinning timber as general use timber

125trees/ha×0.82m³/tree×RM517/ m³×1/2=RM26,496/ha

Total Income:RM68,683/ha

3. Annual balance:RM53,199/ha

4. Total balance:RM57,299/ha

55th year Operation

1.Treatment for *Shorea* spp. stand

(1) *Shorea* spp. Weeding:448trees/ha×RM0.4/tree×4times/year=RM717/ha

2. Road maintenance:RM50/ha

3. General administrative expenses:RM77/ha

Total costs:RM844/ha

2. Annual balance:△RM844/ha

3. Total balance:RM56,455/ha

(56~80th year Operation)

1. Road maintenance :RM50/ha×25years=RM1,250/ha

2. General administrative expenses:RM125/ha

3. Total balance:RM55,080/ha

81st year Operation

1.Establishment of multi-storied forest

(1) *Shorea* spp.(50-year old) Final felling (General use timber)

16rows×28rows:73trees/ha

Felling·Extraction costs:73trees×3.25m³/tree×RM60/m³=RM14,235/ha

(2) *Shorea* spp. Planting

16rows×28rows=448trees/ha

(as same as 4th year Operation)

RM2,980/ha

(3) Road maintenance:RM50/ha

(4) General administrative expenses:RM1,727/ha

Total costs:RM18,992/ha

2.Expected Income

(1) *Shorea* spp. selling of final felling timber as general use timber

73trees/ha×3.25m³/tree×RM517/ m³=RM122,658/ha

Total Income:RM122,658/ha

3. Annual balance:RM103,666/ha

4. Total balance:RM158,746/ha

82nd year Operation

1.Treatment for *Shorea* spp. stand

(1) *Shorea* spp. Weeding:448trees/ha×RM0.4/tree×4times/year=RM717/ha

2. Road maintenance:RM50/ha

3. General administrative expenses:RM77/ha

Total costs:RM844/ha

4. Annual balance:△RM844/ha

5. Total balance:RM157,902/ha

(83~103rd year Operation)

1. Road maintenance:RM50/ha×21years=RM1,050/ha

2. General administrative expenses:RM105/ha

3. Total balance:RM156,747/ha

104th year Operation

1. Establishment of multi-storied forest

(1) *Shorea* spp.(50-year old) Final felling(General use timber)

16rows×28rows:72trees/ha

Felling･Extraction costs:72trees×3.25m³/tree×RM60/m³=RM14,040/ha

(2) Road maintenance:RM50/ha

(3) General administrative expenses:RM1,409/ha

Total costs:RM15,499/ha

2. Expected Income

(1) *Shorea* spp. selling of final felling timber as general use timber

72trees/ha×3.25m³×RM517=RM120,978/ha

Total Income:RM120,978/ha

3. Annual balance:RM105,479/ha

4. Total balance:RM262,226/ha

Notes:1. △ indicates deficit.

2. Source:[*1]: Forest Plantation Unit,Forestry Department Peninsular Malaysia

3. Source :[*2]:"Interim Report, The Multi-Storied Forest Management Project in Peninsular Malaysia, Forestry Department Peninsular Malaysia/Perak State Forestry Department/JICA"

4. Yield prediction for thinnings and final felling timber of *Shorea* spp. are based on empirical yield table produced in 1995 by JICA Short-Term Expert.

Appendix 6

D-tpye management plan

Year	Cost /ha	Income /ha	Annual Balance /ha	Total Balance /ha	Cost /500ha	Income /500ha	Annual Balance /500ha	Total Balance /500ha
1	1,250	0	-1,250	-1,250	625,000	0	-625,000	-625,000
2	242	0	-242	-1,492	121,000	0	-121,000	-746,000
3	55	0	-55	-1,547	27,500	0	-27,500	-773,500
4	5,849	0	-5,849	-7,396	2,924,500	0	-2,924,500	-3,698,000
5	844	0	-844	-8,240	422,000	0	-422,000	-4,120,000
6	352	460	108	-8,132	176,000	230,000	54,000	-4,066,000
7	55	0	-55	-8,187	27,500	0	-27,500	-4,093,500
8	55	0	-55	-8,242	27,500	0	-27,500	-4,121,000
9	55	0	-55	-8,297	27,500	0	-27,500	-4,148,500
10	396	1,380	984	-7,313	198,000	690,000	492,000	-3,656,500
11	55	0	-55	-7,368	27,500	0	-27,500	-3,684,000
12	55	0	-55	-7,423	27,500	0	-27,500	-3,711,500
13	55	0	-55	-7,478	27,500	0	-27,500	-3,739,000
14	55	0	-55	-7,533	27,500	0	-27,500	-3,766,500
15	55	0	-55	-7,588	27,500	0	-27,500	-3,794,000
16	4,175	9,000	4,825	-2,763	2,087,500	4,500,000	2,412,500	-1,381,500
17	242	0	-242	-3,005	121,000	0	-121,000	-1,502,500
18	55	0	-55	-3,060	27,500	0	-27,500	-1,530,000
19	385	0	-385	-3,445	192,500	0	-192,500	-1,722,500
20	55	0	-55	-3,500	27,500	0	-27,500	-1,750,000
21	352	414	62	-3,438	176,000	207,000	31,000	-1,719,000
22	55	0	-55	-3,493	27,500	0	-27,500	-1,746,500
23	55	0	-55	-3,548	27,500	0	-27,500	-1,774,000
24	55	0	-55	-3,603	27,500	0	-27,500	-1,801,500
25	396	1,242	846	-2,757	198,000	621,000	423,000	-1,378,500
26	55	0	-55	-2,812	27,500	0	-27,500	-1,406,000
27	55	0	-55	-2,867	27,500	0	-27,500	-1,433,500
28	55	0	-55	-2,922	27,500	0	-27,500	-1,461,000
29	55	0	-55	-2,977	27,500	0	-27,500	-1,488,500
30	55	0	-55	-3,032	27,500	0	-27,500	-1,516,000
31	12,059	23,574	11,515	8,483	6,029,500	11,787,000	5,757,500	4,241,500
32	1,238	0	-1,238	7,245	619,000	0	-619,000	3,622,500
33	55	0	-55	7,190	27,500	0	-27,500	3,595,000
34	55	0	-55	7,135	27,500	0	-27,500	3,567,500
35	55	0	-55	7,080	27,500	0	-27,500	3,540,000
36	55	0	-55	7,025	27,500	0	-27,500	3,512,500
37	55	0	-55	6,970	27,500	0	-27,500	3,485,000
38	55	0	-55	6,915	27,500	0	-27,500	3,457,500
39	55	0	-55	6,860	27,500	0	-27,500	3,430,000
40	55	0	-55	6,805	27,500	0	-27,500	3,402,500
41	55	0	-55	6,750	27,500	0	-27,500	3,375,000
42	55	0	-55	6,695	27,500	0	-27,500	3,347,500
43	55	0	-55	6,640	27,500	0	-27,500	3,320,000
44	55	0	-55	6,585	27,500	0	-27,500	3,292,500
45	55	0	-55	6,530	27,500	0	-27,500	3,265,000
46	55	0	-55	6,475	27,500	0	-27,500	3,237,500
47	55	0	-55	6,420	27,500	0	-27,500	3,210,000
48	55	0	-55	6,365	27,500	0	-27,500	3,182,500
49	55	0	-55	6,310	27,500	0	-27,500	3,155,000
50	55	0	-55	6,255	27,500	0	-27,500	3,127,500

51	55	0	-55	6,200	27,500	0	-27,500	3,100,000
52	55	0	-55	6,145	27,500	0	-27,500	3,072,500
53	55	0	-55	6,090	27,500	0	-27,500	3,045,000
54	15,890	71,863	55,973	62,063	7,945,000	35,931,500	27,986,500	31,031,500
55	844	0	-844	61,219	422,000	0	-422,000	30,609,500
56	55	0	-55	61,164	27,500	0	-27,500	30,582,000
57	55	0	-55	61,109	27,500	0	-27,500	30,554,500
58	55	0	-55	61,054	27,500	0	-27,500	30,527,000
59	55	0	-55	60,999	27,500	0	-27,500	30,499,500
60	55	0	-55	60,944	27,500	0	-27,500	30,472,000
61	55	0	-55	60,889	27,500	0	-27,500	30,444,500
62	55	0	-55	60,834	27,500	0	-27,500	30,417,000
63	55	0	-55	60,779	27,500	0	-27,500	30,389,500
64	55	0	-55	60,724	27,500	0	-27,500	30,362,000
65	55	0	-55	60,669	27,500	0	-27,500	30,334,500
66	55	0	-55	60,614	27,500	0	-27,500	30,307,000
67	55	0	-55	60,559	27,500	0	-27,500	30,279,500
68	55	0	-55	60,504	27,500	0	-27,500	30,252,000
69	55	0	-55	60,449	27,500	0	-27,500	30,224,500
70	55	0	-55	60,394	27,500	0	-27,500	30,197,000
71	55	0	-55	60,339	27,500	0	-27,500	30,169,500
72	55	0	-55	60,284	27,500	0	-27,500	30,142,000
73	55	0	-55	60,229	27,500	0	-27,500	30,114,500
74	55	0	-55	60,174	27,500	0	-27,500	30,087,000
75	55	0	-55	60,119	27,500	0	-27,500	30,059,500
76	55	0	-55	60,064	27,500	0	-27,500	30,032,000
77	55	0	-55	60,009	27,500	0	-27,500	30,004,500
78	55	0	-55	59,954	27,500	0	-27,500	29,977,000
79	55	0	-55	59,899	27,500	0	-27,500	29,949,500
80	55	0	-55	59,844	27,500	0	-27,500	29,922,000
81	18,992	122,658	103,666	163,510	9,496,000	61,329,000	51,833,000	81,755,000
82	844	0	-844	162,666	422,000	0	-422,000	81,333,000
83	55	0	-55	162,611	27,500	0	-27,500	81,305,500
84	55	0	-55	162,556	27,500	0	-27,500	81,278,000
85	55	0	-55	162,501	27,500	0	-27,500	81,250,500
86	55	0	-55	162,446	27,500	0	-27,500	81,223,000
87	55	0	-55	162,391	27,500	0	-27,500	81,195,500
88	55	0	-55	162,336	27,500	0	-27,500	81,168,000
89	55	0	-55	162,281	27,500	0	-27,500	81,140,500
90	55	0	-55	162,226	27,500	0	-27,500	81,113,000
91	55	0	-55	162,171	27,500	0	-27,500	81,085,500
92	55	0	-55	162,116	27,500	0	-27,500	81,058,000
93	55	0	-55	162,061	27,500	0	-27,500	81,030,500
94	55	0	-55	162,006	27,500	0	-27,500	81,003,000
95	55	0	-55	161,951	27,500	0	-27,500	80,975,500
96	55	0	-55	161,896	27,500	0	-27,500	80,948,000
97	55	0	-55	161,841	27,500	0	-27,500	80,920,500
98	55	0	-55	161,786	27,500	0	-27,500	80,893,000
99	55	0	-55	161,731	27,500	0	-27,500	80,865,500
100	55	0	-55	161,676	27,500	0	-27,500	80,838,000
101	55	0	-55	161,621	27,500	0	-27,500	80,810,500
102	55	0	-55	161,566	27,500	0	-27,500	80,783,000
103	55	0	-55	161,511	27,500	0	-27,500	80,755,500
104	15,499	120,978	105,479	266,990	7,749,500	60,489,000	52,739,500	133,495,000
Total	84,579	351,569	266,990	533,980	42,289,500	175,784,500	133,495,000	133,495,000

Appendix 7

H-type management plan

Year	Cost /ha	Income /ha	Annual Balance /ha	Total Balance /ha	Cost /500ha	Income /500ha	Annual Balance /500ha	Total Balance /500ha
1	3,443	0	-3,443	-3,443	1,721,500	0	-1,721,500	-1,721,500
2	484	0	-484	-3,927	242,000	0	-242,000	-1,963,500
3	55	0	-55	-3,982	27,500	0	-27,500	-1,991,000
4	55	0	-55	-4,037	27,500	0	-27,500	-2,018,500
5	55	0	-55	-4,092	27,500	0	-27,500	-2,046,000
6	55	0	-55	-4,147	27,500	0	-27,500	-2,073,500
7	55	0	-55	-4,202	27,500	0	-27,500	-2,101,000
8	55	0	-55	-4,257	27,500	0	-27,500	-2,128,500
9	55	0	-55	-4,312	27,500	0	-27,500	-2,156,000
10	55	0	-55	-4,367	27,500	0	-27,500	-2,183,500
11	55	0	-55	-4,422	27,500	0	-27,500	-2,211,000
12	55	0	-55	-4,477	27,500	0	-27,500	-2,238,500
13	55	0	-55	-4,532	27,500	0	-27,500	-2,266,000
14	55	0	-55	-4,587	27,500	0	-27,500	-2,293,500
15	55	0	-55	-4,642	27,500	0	-27,500	-2,321,000
16	55	0	-55	-4,697	27,500	0	-27,500	-2,348,500
17	55	0	-55	-4,752	27,500	0	-27,500	-2,376,000
18	55	0	-55	-4,807	27,500	0	-27,500	-2,403,500
19	55	0	-55	-4,862	27,500	0	-27,500	-2,431,000
20	55	0	-55	-4,917	27,500	0	-27,500	-2,458,500
21	55	0	-55	-4,972	27,500	0	-27,500	-2,486,000
22	55	0	-55	-5,027	27,500	0	-27,500	-2,513,500
23	55	0	-55	-5,082	27,500	0	-27,500	-2,541,000
24	55	0	-55	-5,137	27,500	0	-27,500	-2,568,500
25	55	0	-55	-5,192	27,500	0	-27,500	-2,596,000
26	10,753	16,746	5,993	801	5,376,500	8,373,000	2,996,500	400,500
27	1,514	0	-1,514	-713	757,000	0	-757,000	-356,500
28	55	0	-55	-768	27,500	0	-27,500	-384,000
29	55	0	-55	-823	27,500	0	-27,500	-411,500
30	55	0	-55	-878	27,500	0	-27,500	-439,000
31	55	0	-55	-933	27,500	0	-27,500	-466,500
32	55	0	-55	-988	27,500	0	-27,500	-494,000
33	55	0	-55	-1,043	27,500	0	-27,500	-521,500
34	55	0	-55	-1,098	27,500	0	-27,500	-549,000
35	55	0	-55	-1,153	27,500	0	-27,500	-576,500
36	55	0	-55	-1,208	27,500	0	-27,500	-604,000
37	55	0	-55	-1,263	27,500	0	-27,500	-631,500
38	55	0	-55	-1,318	27,500	0	-27,500	-659,000
39	55	0	-55	-1,373	27,500	0	-27,500	-686,500
40	55	0	-55	-1,428	27,500	0	-27,500	-714,000
41	55	0	-55	-1,483	27,500	0	-27,500	-741,500
42	55	0	-55	-1,538	27,500	0	-27,500	-769,000
43	55	0	-55	-1,593	27,500	0	-27,500	-796,500
44	55	0	-55	-1,648	27,500	0	-27,500	-824,000
45	55	0	-55	-1,703	27,500	0	-27,500	-851,500
46	55	0	-55	-1,758	27,500	0	-27,500	-879,000
47	55	0	-55	-1,813	27,500	0	-27,500	-906,500
48	55	0	-55	-1,868	27,500	0	-27,500	-934,000
49	55	0	-55	-1,923	27,500	0	-27,500	-961,500
50	55	0	-55	-1,978	27,500	0	-27,500	-989,000

51	19,928	84,385	64,457	62,479	9,964,000	42,192,500	32,228,500	31,239,500
52	1,199	0	-1,199	61,280	599,500	0	-599,500	30,640,000
53	55	0	-55	61,225	27,500	0	-27,500	30,612,500
54	55	0	-55	61,170	27,500	0	-27,500	30,585,000
55	55	0	-55	61,115	27,500	0	-27,500	30,557,500
56	55	0	-55	61,060	27,500	0	-27,500	30,530,000
57	55	0	-55	61,005	27,500	0	-27,500	30,502,500
58	55	0	-55	60,950	27,500	0	-27,500	30,475,000
59	55	0	-55	60,895	27,500	0	-27,500	30,447,500
60	55	0	-55	60,840	27,500	0	-27,500	30,420,000
61	55	0	-55	60,785	27,500	0	-27,500	30,392,500
62	55	0	-55	60,730	27,500	0	-27,500	30,365,000
63	55	0	-55	60,675	27,500	0	-27,500	30,337,500
64	55	0	-55	60,620	27,500	0	-27,500	30,310,000
65	55	0	-55	60,565	27,500	0	-27,500	30,282,500
66	55	0	-55	60,510	27,500	0	-27,500	30,255,000
67	55	0	-55	60,455	27,500	0	-27,500	30,227,500
68	55	0	-55	60,400	27,500	0	-27,500	30,200,000
69	55	0	-55	60,345	27,500	0	-27,500	30,172,500
70	55	0	-55	60,290	27,500	0	-27,500	30,145,000
71	55	0	-55	60,235	27,500	0	-27,500	30,117,500
72	55	0	-55	60,180	27,500	0	-27,500	30,090,000
73	55	0	-55	60,125	27,500	0	-27,500	30,062,500
74	55	0	-55	60,070	27,500	0	-27,500	30,035,000
75	55	0	-55	60,015	27,500	0	-27,500	30,007,500
76	23,341	106,228	82,887	142,902	11,670,500	53,114,000	41,443,500	71,451,000
77	1,514	0	-1,514	141,388	757,000	0	-757,000	70,694,000
78	55	0	-55	141,333	27,500	0	-27,500	70,666,500
79	55	0	-55	141,278	27,500	0	-27,500	70,639,000
80	55	0	-55	141,223	27,500	0	-27,500	70,611,500
81	55	0	-55	141,168	27,500	0	-27,500	70,584,000
82	55	0	-55	141,113	27,500	0	-27,500	70,556,500
83	55	0	-55	141,058	27,500	0	-27,500	70,529,000
84	55	0	-55	141,003	27,500	0	-27,500	70,501,500
85	55	0	-55	140,948	27,500	0	-27,500	70,474,000
86	55	0	-55	140,893	27,500	0	-27,500	70,446,500
87	55	0	-55	140,838	27,500	0	-27,500	70,419,000
88	55	0	-55	140,783	27,500	0	-27,500	70,391,500
89	55	0	-55	140,728	27,500	0	-27,500	70,364,000
90	55	0	-55	140,673	27,500	0	-27,500	70,336,500
91	55	0	-55	140,618	27,500	0	-27,500	70,309,000
92	55	0	-55	140,563	27,500	0	-27,500	70,281,500
93	55	0	-55	140,508	27,500	0	-27,500	70,254,000
94	55	0	-55	140,453	27,500	0	-27,500	70,226,500
95	55	0	-55	140,398	27,500	0	-27,500	70,199,000
96	55	0	-55	140,343	27,500	0	-27,500	70,171,500
97	55	0	-55	140,288	27,500	0	-27,500	70,144,000
98	55	0	-55	140,233	27,500	0	-27,500	70,116,500
99	55	0	-55	140,178	27,500	0	-27,500	70,089,000
100	55	0	-55	140,123	27,500	0	-27,500	70,061,500
101	16,881	91,106	74,225	214,348	8,440,500	45,553,000	37,112,500	107,174,000
Total	84,117	298,465	214,348	428,696	42,058,500	149,232,500	107,174,000	214,348,000

Annex 3

Details on

FOREST MANAGEMENT AND OTHERS

CONTENTS

1.1 FOREST MANAGEMENT

1.1.1 Introduction

The objective of forest management field in this project is to formulate effective Multi-Storied Forest Management Models in the tropics based on tree growth prediction, cost analysis and simulation. The management models that are assumed reforestation by the private sector are produced as trial in this report. Acacia mangium plantation, logged-over forest and openland are supposed as sites of reforestation in Peninsular Malaysia.

Strip planting method that is progressing in Chikus project site Block-B, consisting of Acacia mangium trees as upper trees and high quality timber species such as dipterocarp species as lower trees will be applied to Acacia mangium plantation.

Gap planting method that is progressing in Bukit Kinta project site, filling a gap after logging in natural forest with high quality timber species such as dipterocarp species will be applied to logged-over forest.

Strip planting method that is progressing in Chikus project site Block-A, means planting Acacia mangium trees as upper trees before planting high quality timber species such as dipterocarp species as lower trees without planting in strips for lower trees will be applied to openland in the initial stage.

Furthermore another strip planting method that is progressing in natural secondary forest in Chikus project site Block-A, means using secondary forest as shade trees, planting high quality timber species such as dipterocarp species as lower trees will be applied to natural secondary forest changed from openland.

At first the forest management models were produced as trial for each site of reforestation and then were analyzed by its costs and income. According to the results of cost analysis, strip planting with wider width of felling is expected to get maximum income and recover costs earlier than strip planting with narrower width of felling. It will be expected to recover investment at the 31st year after establishment at RM8,500 per 1 hectare and evaluated income at RM267,000 per 1 hectare at the 104th year after establishment in Acacia mangium plantation.

Establishment cost of gap planting method was calculated in initial stage in logged-over forest. Reforestation by the private sector is considered as not suitable in logged-over forest without concession for logging.

As multi-storied forest by using strip planting method in openland in Chikus project site Block-A has not been established at present, the management model is not formulated.

Strip planting with wider width of felling of secondary forest is expected to get

maximum income than strip planting with narrower width of felling of secondary forest in natural secondary forest. It will be expected to recover investment at the 51st year after establishment at RM62,000 per 1 hectare with an estimated income of RM214,000 per 1 hectare at 101st year after establishment in secondary forest.

The forest management plans were produced as trial for each site of reforestation. If the multi-storied forest is established in whole area, it would take more than 30 years to recover investment in Acacia mangium plantation and secondary forest. However the possibility will be expected to recover investment earlier depending on reconsidering forest management models mentioned above. Therefore we continue to formulate the effective forest management models.

1.1.2 Management Policy

1.1.2.1 Background and objectives

The objective of forest management field in this project is to formulate effective Multi-Storied Forest Management Models in the tropics based on tree growth prediction, cost analysis and simulation so that the private sector could use it.

Multi-Storied Forest Management - the planting of different species of trees with in the same area in order to create a mixed forest of complex structure - lacks the shortcomings of single-species reforestation and results in forest that are effective in environmental conservation, resistant to pests and diseases, and conducive to diversified timber production.

1.1.2.2 Site of Reforestation

Sites assumed as site of reforestation are introduced. At the multi-storied forest experimental site at Chikus project site Block-B, high quality timber species such as dipterocarp species are planted in the strips in existing Acacia mangium plantation. The gaps are cut in five different patterns(1:1(one row cut, one row left) namely A-type, 2:2(two rows cut, two rows left) namely B-type, 4:4(four rows cut, four rows left) namely C-type, 8:8(eight rows cut, eight rows left) namely D-type and 16:16(sixteen rows cut, sixteen rows left) namely E-type). High quality timber species are planted at the strips as lower trees. Acacia mangium plantation is assumed as site of reforestation with this strip planting method. Total area of plantation forest by state are shown in Table-F1.

At Bukit Kinta project site, multi-storied forests are established through the gap planting of high quality timber species in gaps in logged-over natural forest. Logged-over forests of Permanent Forest Estate are assumed as site of reforestation with this gap planting method . The forests are shown by state in Table-F1.

At the multi-storied forest experimental site at Chikus project site Block-A(an openland produced by clear cutting), two types of planting method for multi-storied forest are progressing.

One is a strip planting method which is planting Acacia mangium trees as upper trees before planting high quality timber species such as dipterocarp species as lower trees without planting in the strips for lower trees at initial stage. This planting method will be applied to openland. Concretely speaking, this planting method will be applied to the forests after clear cutting Acacia mangium plantation and Stateland.

The other is a strip planting method which uses secondary forest as shade trees. High quality timber species such as dipterocarp species are planted as lower trees

between a strip and another strip of secondary forest. Secondary forest means forest which is naturally regenerated after clear cutting of natural forest. This planting method will be applied to secondary forest in openland. Concretely speaking, the planting method will be applied to the forests after clear cutting Acacia mangium plantation and Stateland.

1.1.2.2.1 Acacia mangium plantation

Commercial establishment of Acacia mangium plantations have been mainly planted under the Compensatory Forest Plantation Project in Peninsular Malaysia (hereinafter referred to as "CFPP". At present, the plantation was established about 60 thousand hectares in Peninsular Malaysia. The total area planted and age classes of CFPP species(including another CFPP species) are shown in Table-F2. The locations are shown in Figure-F1. The plantation area by state in Peninsular Malaysia are appropriated in Table-F3 on the 7th Malaysian Plan.

1.1.2.2.2 Logged-over forest

Area of Permanent Forest Estate by state in Peninsular Malaysia are shown in Table-F1. Forest area for logging by state in Peninsular Malaysia are appropriated in Table-F4 on the 7th Malaysian Plan.

1.1.2.2.3 Openland

Stateland and Acacia mangium plantation after clear cutting forest are assumed as openland in this report. Stateland means the land which is diverted from Permanent Forest Estate as mainly agriculture land. Total area of Stateland by state in Peninsular Malaysia are shown in Table-F1. Acacia mangium plantations are shown in the head of 1.1.2.2.1.

Table-F1 Forest area in Peninsular Malaysia(ha)

State	Forest land					
	Permanent forest estate				Stateland	Wildlife reserve
	Production forest			Protection forest		
	Virgin forest	Logged-over forest	Plantation forest			
Johor	90,100	233,684	19,956	63,138	110,397	48,795
Kedah	132,308	210,409	2,035	97,565	1,686	--
Kelantan	181,053	445,319	6,770	264,655	159,116	108,783
Melaka	96	7,213	--	2,604	1,200	--
N.Sembilan	22,410	148,149	5,914	58,202	9,256	--
Pahang	792,203	602,788	21,298	--	202,324	361,130
Perak	502,960	493,601	3,281	7,320	64,959	7,413
Perlis	714	10,454	431	--	1,078	68
P.Pinang	5,273	1,133	--	6,426	848	--
Selangor	15,056	233,614	9,657	88,195	--	7,644
Terengganu	248,297	316,020	3,817	130,204	38,000	77,507
Wilayan Persekutuan	5	56	--	61	--	--
Total	1,990,475	2,702,440	73,159	718,370	588,864	611,340

Notes:1. These are the figures as of ,1995.

2. Source:Forestry Department, Perak

Table-F2 Area planted and age classes of Compensatory Forest Plantation species(ha)

Year / Age / State	1983 year 13	1984 year 12	1985 year 11	1986 year 10	1987 year 9	1988 year 8	1989 year 7	1990 year 6	1991 year 5	1992 year 4	1993 year 3	1994 year 2	1995 year 1	Total planted area
Johor	236	250	1,350	1,956	2,008	6,470	3,368	947	1,333	477	221	0	0	18,322
Pahang	0	0	2,175	1,222	2,760	5,451	1,600	330	1,028	2,282	1,331	741	106	18,998
N.Sembilan	178	15	354	212	361	215	321	000	463	710	302	0	0	4,151
Selangor	0	212	511	1,100	622	3,110	1,100	0	657	980	567	0	61	9,012
Perak	0	0	0	0	0	0	0	89	1,497	402	222	0	121	2,330
Kelantan	0	0	0	0	0	0	0	0	270	0	167	321	0	761
Terengganu	0	0	0	0	0	0	0	100	100	0	89	100	443	832
Total	473	477	4,390	4,000	5,751	15,245	6,417	2,392	5,348	4,881	2,982	1,165	791	51,406

Notes:1. These are the figure as of January, 1996.

2. Source:Forest Plantation Unit, Forestry Department Headquaters

Figure - F1

LOCATION OF FOREST PLANTATION IN PENINSULAR MALAYSIA

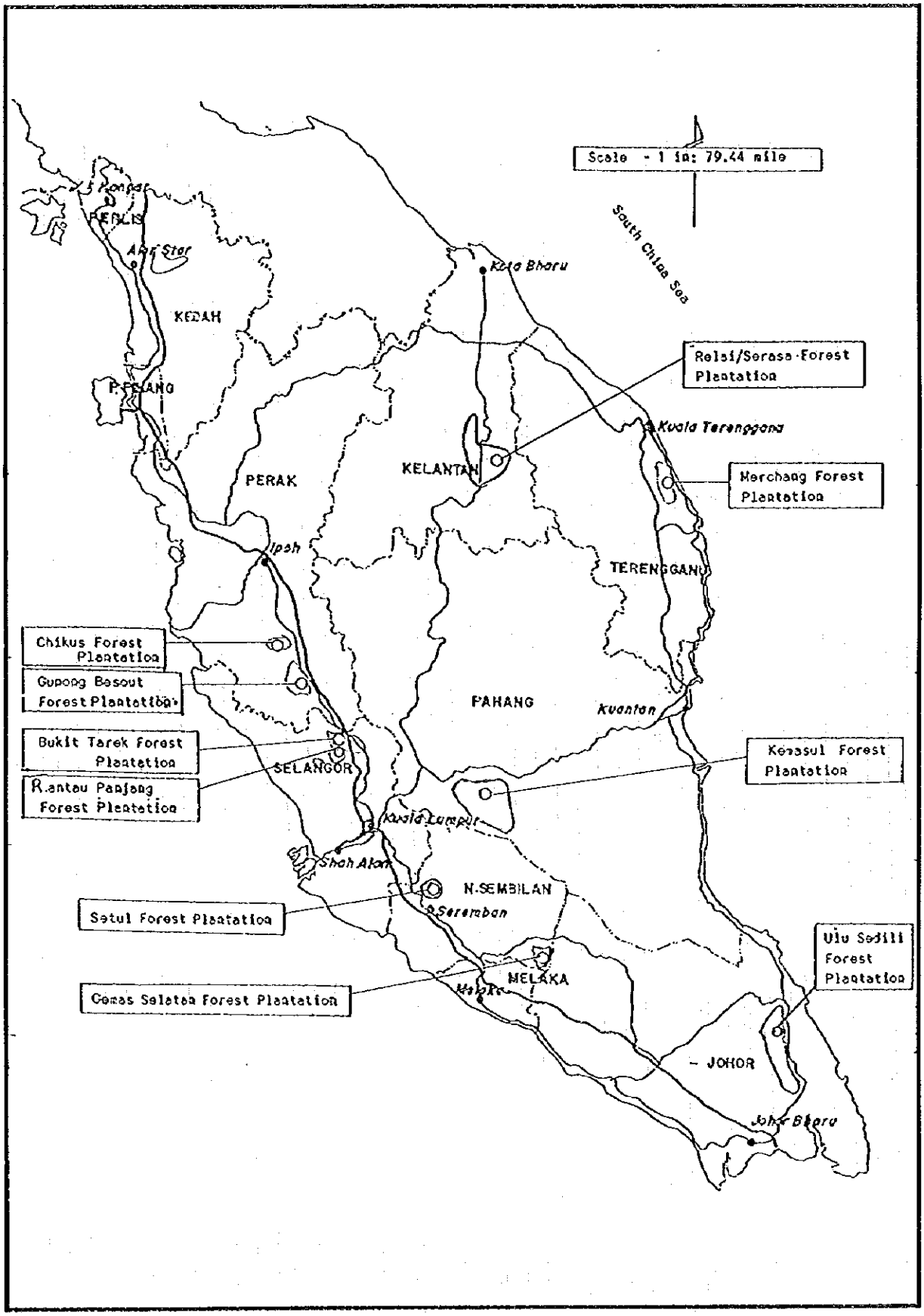


Table-F3 Area of Compensatory Forest Plantation on the 7th Malaysian Plan(ha)

Year / State	1996	1997	1998	1999	2000	Total
Johor	–	–	–	–	–	–
Kedah+	220	300	300	380	300	1,500
Kelantan	–	–	–	–	–	–
Melaka	–	–	–	–	–	–
N.Sembilan*	400	190	–	–	–	590
Pahang*	700	850	–	–	–	1,550
Perak	–	–	–	–	–	–
P.Pinang	–	–	–	–	–	–
Selangor	–	–	–	–	–	–
Terengganu*	400	360	–	–	–	760
Wilayan Persekutuan	–	–	–	–	–	–
Total	1,720	1,700	300	380	300	4,400

Notes:1. +Main species:Tectona grandis

2. *Main species:Acacia mangium

3. Source:Forest Plantation unit, Forestry Department Headquaters

Table-F4 Area of Permanent Forest Estate for logging on the 7th Malaysian Plan(ha)

Year / State	1996	1997	1998	1999	2000	Total
Johor	2,705	2,705	2,705	2,705	2,705	13,525
Kedah	2,860	2,860	2,860	2,860	2,860	14,300
Kelantan	6,885	6,885	6,885	6,885	6,885	34,425
Melaka	–	–	–	–	–	–
N.Sembilan	2,435	2,435	2,435	2,435	2,435	12,175
Pahang	12,240	12,240	12,240	12,240	12,240	61,200
Perak	8,300	8,300	8,300	8,300	8,300	41,500
P.Pinang	–	–	–	–	–	–
Selangor	1,795	1,795	1,795	1,795	1,795	8,975
Terengganu	8,820	8,820	8,820	8,820	8,820	44,100
Wilayan Persekutuan	–	–	–	–	–	–
Total	46,040	46,040	46,040	46,040	46,040	230,200

Notes:1. Source:Forestry Department, Perak

1.1.3 Management Model

1.1.3.1 Management model in site of reforestation

The management models with 1 hectare as a unit were developed for each site of reforestation in order to formulate proper style of forest management plan in commercial base. All costs in the case study were based on written contract which consist of nursery work, silviculture work and construction and maintenance of forest road. Land cost and scale of enterprise were not considered.

1.1.3.1.1 Management model in Acacia mangium plantation

The management model at Chikus project site Block-B were applied to Acacia mangium plantation. The management model which consisted of Acacia mangium trees as upper trees and dipterocarp species trees as lower trees were produced experimentally.

The management model produced experimentally were B-type model(two rows cut, two rows left), C-type model(four rows cut, four rows left) and D-type model(eight rows cut, eight rows left). A-type model(one row cut, one row left) and E-type model(sixteen rows cut, sixteen rows left) were not produced. Establishment cost was calculated with the actual project cost. The establishment(between first year operation to fifth year operation) cost is shown in Table-F5. Basis of the estimate is shown in Appendix 1.

Establishment costs were estimated at RM8,240 per 1 hectare. Based on the actual project costs, ten types of the management models were produced experimentally. Copmarison of the management models are shown in Table-F6. According to the result of cost and income analysis in this case study, D-type model was expected to get maximum income and recover investment at earliest stage. D-type model was estimated most proper model of the others as commercial management model.

Hence, by using D-type model, forest management model in this case study is introduced(refer to Case study-1). Basis of the estimate is shown in Appendix 2. According to the result of the case study, it will be expected to recover investment at the 31st year operation. Total balance was estimated at RM8,483 per 1 hectare at the year. Total balance was estimated at RM266,990 per 1 hectare finally. Estimated yield volume and price of felled timber are explained in the head of "1.1.4 Income and cost analysis".

The management model developed is tentative based on the project to date.

Other models are not excluded by this. Therefore, the management model will leave much room for improvement.

1.1.3.1.2 Management model in logged-over forest

The management model at Bukit Kinta project site was applied to logged-over forest. At the Bukit Kinta multi-storied forest project site, multi-storied forests are progressing to establish through the gap planting of high quality timber species in gaps in logged-over natural forest. The initial establishment cost was estimated per 1 hectare based on the actual establishment costs of Block-D of this project.

Establishment costs(between first year operation to fifth year operation) were estimated at RM17,516 per 1 hectare. The result is shown in Table-F7. However, the establishment which was estimated except forest road construction and maintenance means planted costs in the case of the whole area planted. In actual planting operation, gaps for planting exist partly in the site of reforestation(logged-over forest). Therefore, establishment costs estimated will be estimated to reduce in actual planting operation.

1.1.3.1.3 Management model in openland

At the multi-storied forest experimental site of Chikus project site Block-A, two types of establishment methods are progressing.

One is a strip planting method which is planting Acacia mangium trees as upper trees before planting high quality timber species as lower trees without planting in the strips for lower trees at initial stage(hereinafter referred to as "pre-planting method of fast growing species"). As multi-storied forest by using pre-planting method of fast growing species has not been established, the management model is not formulated.

The other is a strip planting method which used secondary forests as shade trees. High quality timber species are planted as lower trees between a strip of a secondary forest and another one. The management models which was used natural secondary forest as shade trees, planted high quality timber species(supposed Shorea leprosula) were produced experimentally. The management models produced experimentally were F-type(10m width cut, 10m width left), G-type(20m width cut, 20m width left) and H-type(40m width cut, 40m width left).

Establishment costs were calculated with the actual project costs. The costs from first year operation to second year operation are shown in Table-F8. Establishment costs were estimated at RM3,927 per 1 hectare. Basis of the estimate is shown in

Appendix 3. Based on the result, three types of the management models were produced experimentally. Comparison of the management models are shown in Table-F9. According to the results of cost and income analysis, H-type model was expected to get maximum income and recover investment at earliest stage. H-type model was estimated a more proper commercial management model than others.

Hence, by using H-type model, forest management model in this case study is introduced(refer to Case study-2). Basis of the estimate is shown in Appendix 4. According to the result of the case study, it will be expected to recover investment at the 51st year operation. Total balance was estimated at RM62,479 per 1 hectare at the year. Total balance was estimated at RM214,348 per 1 hectare finally. Estimated yield volume and price of felled timber are explained in the head of "1.1.4 Income and cost analysis".

The management model developed is tentative based on the project to date. Other models are not excluded by this. Therefore, the management model will leave much room for improvement.

1.1.3.1.4 Discussion and recommendation

The outlook for commercial reforestation is spoken generally whether it takes less than 20 years or not to recover investment. It was estimated to take 30 years for recovering investment of D-type. Among the management models of Chikus project site Block-B, D-type model was estimated to be better than the others. In the operation more than 30 years, total balance got into the black. There was no problem to keep multi-storied forest management stably. Therefore, a problem which confronts us is to reduce the initial establishment costs.

Multi-storied forests are established experimentally at few forest reserves in Peninsular Malaysia. Estimated establishment costs were compared at three multi-storied forests at Chikus project site. Gunung Besout Forest Reserve in Perak and Rantau Panjang Forest Reserve in Selangor. Comparison of preconditions at establishment are shown in Table-F10. Comparison of estimated establishment costs are shown in Table-F11.

Establishment costs of Chikus project site and Gunung Besout Forest Reserve are based on written contract. Establishment costs of Rantau Panjang Forest Reserve are based on interview study at the site. According to the comparison of the unit price, there were no great differences among each establishment costs except upper tree

felling cost. How to reduce cost of upper tree felling at establishment operation is an important matter.

For the time being, the most effective method of the cost reduction is as follows. To operate thinning for income and establish multi-storied forest at the same time by felling upper trees with income of thinning. This method was done at establishment of multi-storied forest at Rantau Panjang Forest Reserve in Selangor. If the operation of thinning II and thinning III are combined and multi-storied forest is established at the year(at 9th or 10th year operation), the income of thinning would recover the establishment costs. The management model is shown in Case study-3. Basis of the estimate is shown in Appendix 5. According to the estimated result, the establishment cost of multi-storied forest is recovered at the 16th year of operation and the model of multi-storied forest management is kept stable through two rotations of Acacia mangium management in the multi-storied forest management. In the simulation model, the selling price of thinning timber(RM90/m^3) was interviewed at Rantau Panjang Forest Reserve.

However, expected timber volume of Acacia mangium was not clear in this case. And when multi-storied forest is established at 9th or 10th year operation, it is unknown whether planted seedlings as lower trees can survive or not. Therefore, the studies for these subjects are required through the study at another plantation site in the Follow-up phase.

Gross profit is greatly influenced by yield volume and timber price of Shorea species in the whole management period in this case study. Expected yield volume of Shorea species is greatly influenced by damage rate to Shorea species as lower trees at the upper tree felling of Acacia mangium.

In this case study, the damage rate to Shorea species was supposed through the experimental study of upper-story tree felling by Short-term Expert in 1995. Therefore, upper-story tree felling study is required and actual damage rate to lower-story tree, Shorea species, have to be measured in the Follow-up phase. At the same time, cost analysis of the operation is required through the study.

At the Bukit Kinta project site, establishment costs of initial stage were estimated at RM16,744 per 1 hectare. In actual operation these estimated costs are reduced, because actual planting area exists partly in logged-over forest.

However, this estimated costs can not be recovered except from income by felling of reserved trees or final felling of planted seedlings. It also turned out expensive to construct and maintain forest road at hill forest such as Bukit Kinta project site. Therefore it can not be expected to reduce establishment costs of multi-storied forest at

initial stage in hill forest under the present forest management system.

Establishment of multi-storied forest immediately after felling is suggested as the solution to the problem. That is to say, planting gaps are easy to access by using logging roads and skidding roads. Immediately after felling and seedlings should be planted at that time. And a lot of yield volume will be expected in the future by planting seedlings in skidding roads.

At the multi-storied experimental plot with pre-planting method of fast growing species of Chikus project site Block-A, production of the management model is required. And cost analysis is required at establishment of multi-storied forest in the Follow-up phase.

In the produced multi-storied forest management model with secondary forest as shade trees at Chikus project site Block-A, remaining secondary forest strips were left as they were until the 26th year operation. However, in actual forest management seedlings should be planted early in strips of remaining secondary forest. To secure the interim revenue that will be needed before dipterocarps can be harvested needs to be examined.

Table-F5 Result of establishment costs of D-type management model at Chikus project site Block-B(Balance Sheet)

year	Cost (RM/ha)	Income (RM/ha)	Annual balance (RM/ha)	Total balance (RM/ha)
1	*A.mangium* planting : 1,250	–	△ 1,250	△ 1,250
2	Treatment 1 (slashing and form pruning):170 Road maintenance:50 General administrative expenses: 22 Sub total:242	–	△ 242	△ 1,492
3	Road maintenance:50 General administrative expenses:5 Sub total:55	–	△ 65	△ 1,547
4	*A.mangium* felling:2,287 *Shorea* spp. planting:2,980 Road maintenance:50 General administrative expenses:532 Sub total:5,849	–	△ 5,849	△ 7,396
5	*Shorea* spp. weeding:717 Road maintenance:50 General administrative expenses:77 Sub total:844	–	△ 844	△ 8,240
Total	8,240	–	△ 8240	△ 8,240

Note : 1. △ indicates deficit.

2. Precondition of establishment of multi-storied forest is shown in Table-F14.

Table-F6 Comparison of the management models at Chikus project site Block-B

Type	Production goal of Acacia mangium	Use of heavy machine at upper-story felling(times used/times upper-story felled)	Year recovered investment (year)	Total balance at the final management year (RM/ha)
B1	T:Pulpwood F:General use timber	—	31st	241,773
B2	T:Pulpwood F:General use timber	3/8	54th	265,420
B3	T:Pulpwood F:General use timber	7/8	54th	264,174
C	T:Pulpwood F:General use timber	—	31st	260,340
D	T:Pulpwood F:General use timber	—	31st	266,990
B1p	T and F:Pulpwood	—	54th	229,508
B2p	T and F:Pulpwood	2/5	54th	253,801
B3p	T and F:Pulpwood	4/5	54th	254,669
Cp	T and F:Pulpwood	—	54th	247,954
Dp	T and F:Pulpwood	—	54th	254,724

Notes:1. T:Thinnings

2. F:Final felling timber

3. Total management period:104th year

4. Upper-story tree:Acacia mangium

5. Lower-story tree:Shorea leprosula or Shorea parvifolia

Case Study-1 D-type management model at Chikus project site Block-B

1 Target forest

Multi-storied forest(2 storied forest)

Ultimately, estimated multi-storied forest will be predominated by dipterocarps(supposed *Shorea* species in this case study)

2 Planting species

upper-story tree in initial stage:*Acacia mangium*

lower-story tree in initial stage:*Shorea* species

Fast growing *Acacia mangium* will be used to establish *Shorea* species forests.

Acacia mangium are used to achieve the following:

① To serve as nurse trees that provide *Shorea* species with the shade which they require at the initial growth stage.

②To secure the interim revenue that will be needed before dipterocarps can be harvested.

3 Production goal

Acacia mangium final felled trees as general use timber,thinnings as pulpchip

Shorea species: final felled trees and thinnings as general use timber

4 Site of reforestation

Acacia mangium plantation

5 Spacing

3.7m×3.0m(896trees/ha)

6 Initial planting width of high quality timber species(hereinafter referred to as "HQTS":8rows(33.3m)

7 Initial retaining width of fast growing timber species(hereinafter referred to as "FGTS":8rows(33.3m)

8 Felling of HQTS in whole management period(104years)

① Thinning

a) Times : 2 times

b) Year after first operation:31st year, 56th year

c) Cutting period:25 years

② Final felling

a) Times : 3 times

b) Year after first operation:56th year, 81st year, 106th year

c) Cutting period:50 years

9 Felling of FGTS

①Thinning

a) Times : 6 times

b) Year after first operation:4th, 6th, 10th, 19th, 21st, 25th

c) Cutting period:Thinning Ⅰ:3 to 4 years, Thinning Ⅱ:5 years, Thinning Ⅲ:9

②Final felling

a) Times : 2 times

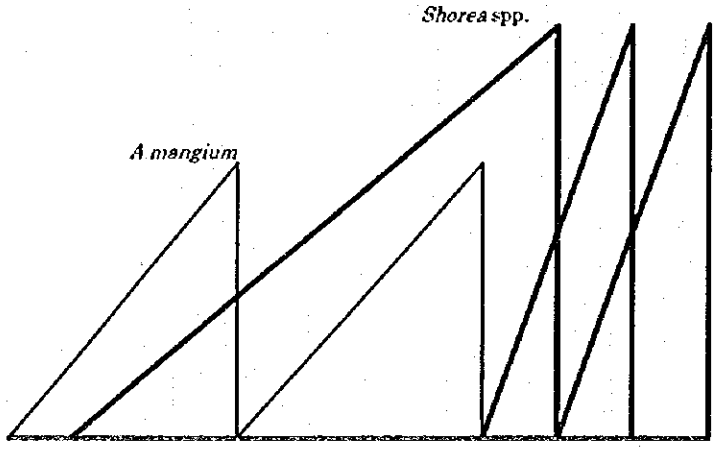
b) Year after first operation:16th, 31st year

c) Cutting period:15

10 Final felling year

:104th year

The planned whole management period is supposed 104th year.



	1	4	6	10	16	19	21	25	31	51	81	101(year)
A.mangium planting(row)	32				16							
(trees/ha)	896				448							
A.mangium thinning(row)		16										
(trees/ha)		381										
(yield volume : m³/ha)		4	10	30		4	9	27				
A.mangium final felling(row)					16				16			
(trees/ha)												
(yield volume : m³/ha)					90				81			
Shorea spp. planting(row)		16							24	16	16	16
(trees/ha)		448							672	448	448	448
Shorea spp. thinning(row)									8	8		
(trees/ha)									73	125		
(yield volume : m³/ha)									60	103		
Shorea spp. final felling(row)										8	16	16
(trees/ha)										27	73	72
(yield volume : m³/ha)										88	237	234

Figure:Multi-storied Forest Management Model,D-type at Chikus project site Block-B

Notes:1. Planting spacing : 3.7m×3.0m (32rows×28rows=896trees/ha)

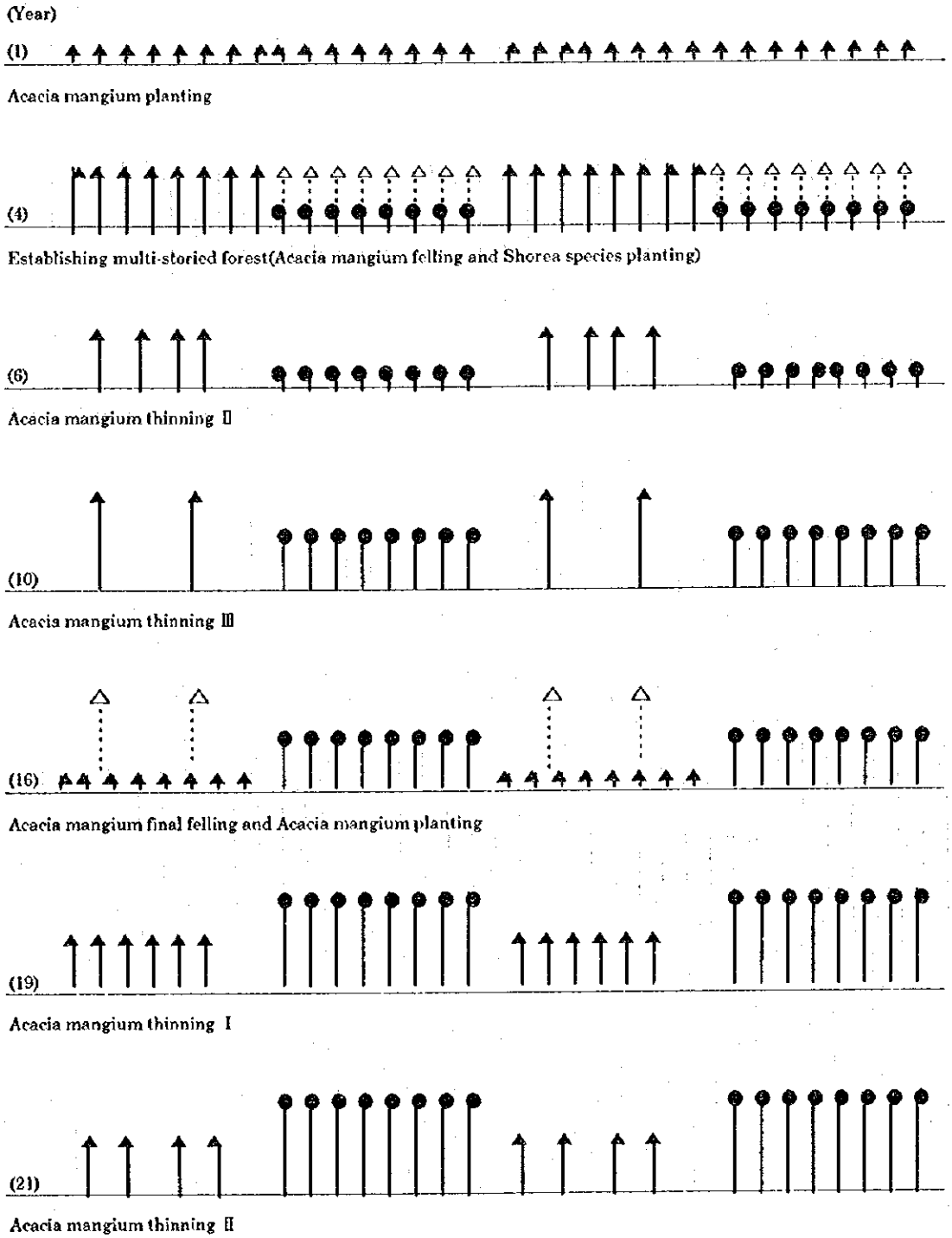
2. Final felling of *A mangium* : 2 times(16th year, 31st year)

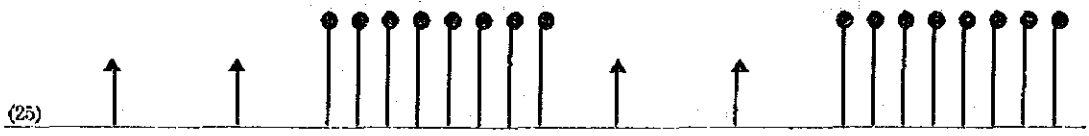
Final felling of *Shorea* spp. : 3 times(56th year, 81st year, 106th year)

3. Final felling age of *A mangium* : 15th year

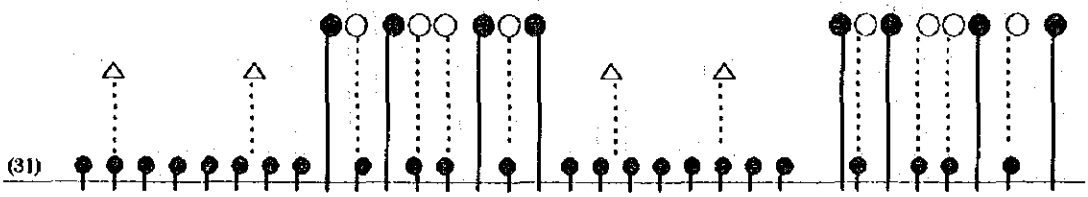
Final felling age of *Shorea* spp. : 50th year

Planting pattern of D-type management model

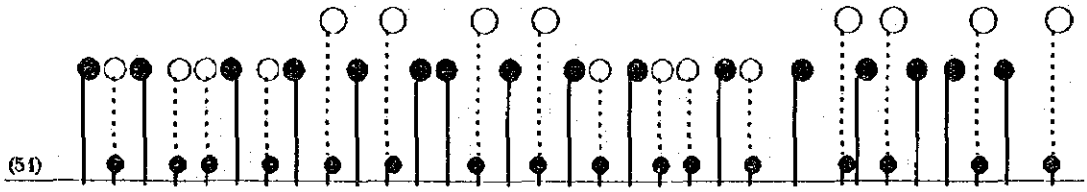




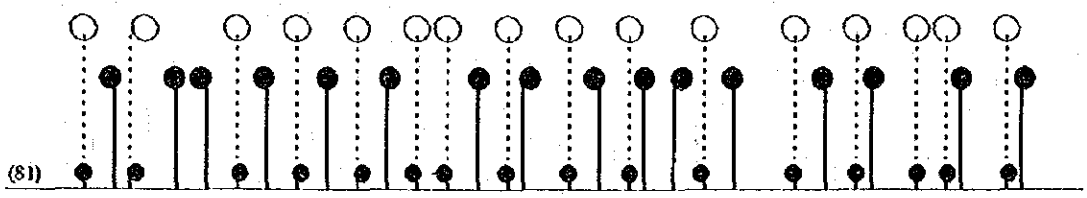
Acacia mangium thinning Ⅲ



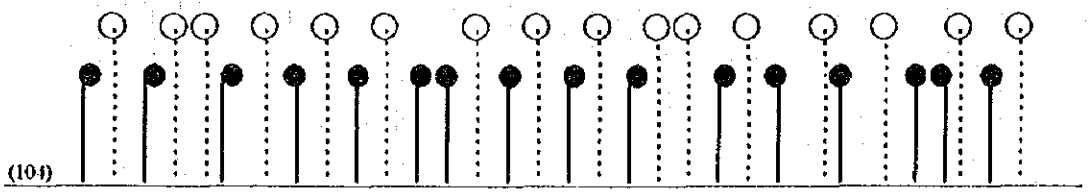
Establishing multi-storied forest(Acacia mangium final felling, Shorea species thinning and planting)



Shorea species final felling, thinning and planting



Shorea species final felling and planting



Shorea species final felling

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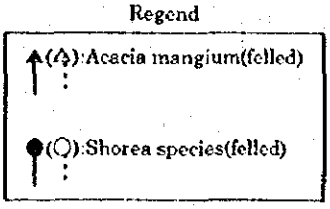


Table : Balance Sheet (Case study)

year	Cost (RM/ha)	Income (RM/ha)	Annual balance (RM/ha)	Total balance (RM/ha)
1	*A.mangium* planting : 1,250		△ 1,250	△ 1,250
2	Treatment 1 (slashing and form pruning):170 Road maintenance:50 General administrative expenses: 22 Sub total:242		△ 242	△ 1,492
3	Road maintenance:50 General administrative expenses:5 Sub total:55		△ 55	△ 1,547
4	*A.mangium* felling:2,287 *Shorea* spp. planting:2,980 Road maintenance:50 General administrative expenses:532 Sub total:5,849		△ 5,849	△ 7,396
5	*Shorea* spp. weeding:717 Road maintenance:50 General administrative expenses:77 Sub total:844		△ 844	△ 8,240
6	*A.mangium* thinning Ⅱ:270 Road maintenance:50 General administrative expenses:32 Sub total:352	Pulpwood:460 Sub total:460	108	△ 8,132
7~9	Road maintenance:150 General administrative expenses:15 Sub total:165		△ 165	△ 8,297
10	*A.mangium* thinning Ⅲ:310 Road maintenance:50 General administrative expenses:36 Sub total:396	Pulpwood:1,380 Sub total:1,380	984	△ 7,313
11 ~15	Road maintenance:250 General administrative expenses:25 Sub total:275		△ 275	△ 7,588

year	Cost (RM/ha)	Income (RM/ha)	Annual balance (RM/ha)	Total balance (RM/ha)
16	*A.mangium* final felling:3,170 *A.mangium* planting:575 Road maintenance:50 General administrative expenses:380 Sub total:4,175	General use timber:9,000 Sub total:9,000	4,825	△ 2,763
17	*A.mangium* Treatment 1:170 Road maintenance:50 General administrative expenses:22 Sub total:242		△ 242	△ 3,005
18	Road maintenance:50 General administrative expenses:5 Sub total:55		△ 55	△ 3,060
19	*A.mangium* thinning Ⅰ:300 Road maintenance:50 General administrative expenses:35 Sub total:385		△ 385	△ 3,445
20	Road maintenance:50 General administrative expenses:5 Sub total:55		△ 55	△ 3,500
21	*A.mangium* thinning Ⅱ:270 Road maintenance:50 General administrative expenses:32 Sub total:352	Pulpwood:414 Sub total:414	62	△ 3,438
22~24	Road maintenance:150 General administrative expenses:15 Sub total:165		△ 165	△ 3,603
25	*A.mangium* thinning Ⅲ:310 Road maintenance:50 General administrative expenses:36 Sub total:396	Pulpwood:1,242 Sub total:1,242	846	△ 2,757
26~30	Road maintenance:250 General administrative expenses:25 Sub total:275		△ 275	△ 3,032

year	Cost (RM/ha)	Income (RM/ha)	Annual balance (RM/ha)	Total balance (RM/ha)
31	*A.mangium* final felling:2,853	General use timber:8,100		
	Shorea spp. thinning:3,592	General use timber : 15,474		
	Shorea spp. planting:4,468			
	Road maintenance:50			
	General administrative expenses:1,096			
	Sub total:12,059	Subtotal:23,574	11,515	8,483
32	*Shorea* spp. weeding:1,075			
	Road maintenance:50			
	General administrative expenses:113			
	Sub total:1,238		△ 1,238	7,245
33	Road maintenance:1,050			
~53	General administrative expenses:105			
	Sub total:1,155		△ 1,155	6,090
54	*Shorea* spp. final felling:5,265	General use timber:45,367		
	Shorea spp. thinning:6,150	General use timber:26,496		
	Shorea spp. planting:2,980			
	Road maintenance:50			
	General administrative expenses:1,445			
	Sub total:15,890	Subtotal:71,863	55,973	62,063
55	*Shorea* spp. weeding:717			
	Road maintenance:50			
	General administrative expenses:77			
	Sub total:844		△ 844	61,219
56~80	Road maintenance:1,250			
	General administrative expenses:125			
	Sub total:1,375		△ 1,375	59,844
81	*Shorea* spp. final felling:14,235	General use timber:122,658		
	Shorea spp. planting:2,980			
	Road maintenance:50			
	General administrative expenses:1,727	Sub total		
	Sub total:18,992	:122,658	103,666	163,510

year	Cost (RM/ha)	Income (RM/ha)	Annual balance (RM/ha)	Total balance (RM/ha)
82	*Shorea* spp. weeding:717 Road maintenance:50 General administrative expenses:77 Sub total:844		△ 844	162,666
83~ 103	Road maintenance:1,050 General administrative expenses:105 Sub total:1,155		△ 1,155	161,511
104	*Shorea* spp. final felling:14,040 Road maintenance:50 General administrative expenses:1,409 Sub total:15,499	General use timber:120,978 Sub total :120,978	105,479	266,990
Total	84,579	351,569	266,990	266,990

Note : 1. △ indicates deficit.

Table-F7 Result of establishment cost of Block-D at Bukit Kinta project site

Actual area:1.03ha
Planted seedlings:Shorea parvifolia
Planted number of seedlings:800seedlings/1.03ha

1st year operation		[Basis of estimate]
1. Establishment		
a)Site preparation (Slashing and clearing wild banana and fern)	7,000RM/1.03ha	
b)To carry seedlings (JICA Nursery→B.Kinta F.R.)	800RM/1.03ha	[RM1.0/seedling]
c)Planting of Shorea parvifolia	680RM/1.03ha	[RM1.0/seedling]
d)Seedlings(supposed to buy at private nursery)	1,760RM/1.03ha	[RM2.2/seedling]
e)Treatment(Spot weeding included climber cutting)	2,472RM/1.03ha	[RM600/ha*4times/year]
f)General administrative expense (10% of direct expenses)	1,271RM/1.03ha	
Sub total	13,983RM/1.03ha(RM13,576/ha)	
2. Forest road construction and maintenance		
a)Construction:RM206,507/300ha*(RM688/ha) (included bridge construction costs)		
Grand total	14,264/ha	

2nd year operation		[Basis of estimate]
1. Silviculture work		
a)Treatment(Spot weeding included climber cutting)	1,236RM/1.03ha	[RM600/ha*2times/year]
b)General administrative expense (10% of direct expenses)	124RM/1.03ha	
Sub total	1,360RM/1.03ha(RM1,320/ha)	
2. Forest road maintenance		
a)Maintenance:RM73,535/300ha*(RM245/ha) (included bridge maintenance and restoration costs)		
Grand total	1,565/ha	

3rd year operation	
1. Forest road maintenance	
a)Maintenance:RM506,241/300ha*(RM1,687/ha)	

Total costs of 1st year to 3rd year operation:RM17,516/ha

Note:*:Area of access region for the forest road(ha)

Table-F8 Result of establishment costs of H-type management model at Chikus project site Block-A(Balance Sheet)

year	Cost (RM/ha)	Income (RM/ha)	Annual balance (RM/ha)	Total balance (RM/ha)
1	Secondary forest felling/ *Shorea* spp.planting:3,030 Road construction:100 General administrative expenses:313 Sub total:3,443		△3,443	△3,443
2	*Shorea* spp. weeding:390 Road maintenance50 General administrative expenses:44 Sub total:484		△484	△3,927
Total	3,927	–	△3,927	△3,927

Notes: △ indicates deficit.

Table-F9 Comparison of the management models at Chikus project site Block-A

Type	Production goal of planted trees	Year recovered investment (year)	Total balance at the final management year(RM/ha)
F	General use timber	51st	187,960
G	General use timber	51st	193,638
H	General use timber	51st	214,348

Notes:1.Total management period:101st year

2.Upper-story tree(Shade tree):Secondary forest

3.Lower-story tree:Shorea lepurosula or Shorea parvifolia

Case Study-2 H-type management model at Chikus project site Block-A

1. Target forest

Multi-storied forest(2 storied forest)

Ultimately, estimated multi-storied forest will be predominated by dipterocarps(supposed *Shorea* species in this case study)

2. Planting species

lower-story tree in initial stage:*Shorea* species,High Quality Timber Species(hereinafter referred to as"HQTS")

upper-story tree in initial stage:Secondary forest(multi-storied forest management model in Secondary forest)

Secondary forest will be used to establish *Shorea* species forests.

Secondary forest are used to serve as nurse trees that provide *Shorea* species with the shade which they require at the initial growth stage.

3. Production goal

Shorea species:final felled trees and thinnings as general use timber

4. Site of reforestation

Acacia mangium forest plantation and Stateland

5. Spacing

2.5m×5.0m(600trees/ha)

6. Initial planting width of HQTS:40m(15rows)

7. Initial retaining width of Secondary forest:40m

8. Felling of HQTS in whole management period(101years)

(1)Thinning

a)Times:4times

b)Year after 1st year operation:31st, 56th year

c)Cutting period:25years

(2)Final felling

a) Times:3times

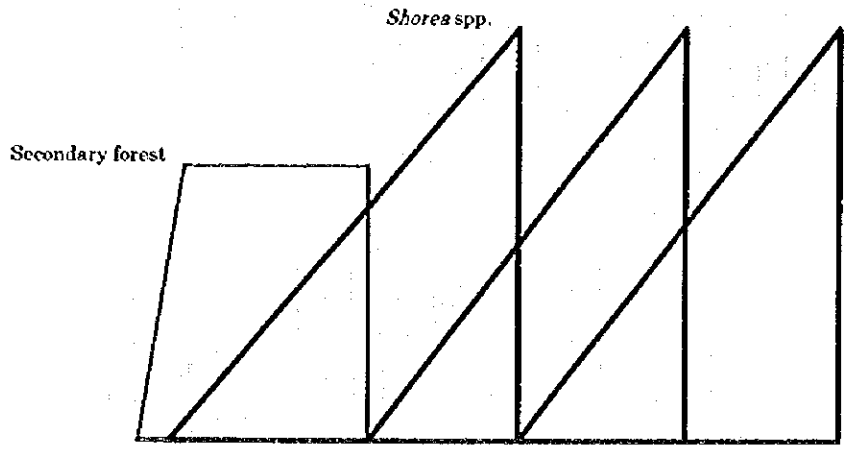
b) Year after 1st year operation:51st, 76th, 101st year

c) Cutting period:50years

9. Final felling year

:101year

The planned whole management period is supposed 101year.



	1	26	51	76	101 (year)
Shorea spp. planting(row)	15	29	25	29	
(trees/ha)	300	580	500	580	
Shorea spp. thinning(row)		7	17	17	17
(trees/ha)		79	192	192	192
(yield volume : m^3/ha)		65	157	157	139
Shorea spp. final felling(row)			8	12	8
(trees/ha)			26	39	30
(yeild volume : m^3/ha)			85	127	98

Figure:Multi-Storied Forest Management Model,H-type at Chikus project site Block-A

Notes:1. Planting spacing:2.5m×6.0m(30rows×20rows=600trees/ha)

2. Final felling of *Shorea* spp.:3times(51, 76, 101yr)

3. Final felling age of *Shorea* spp.:50year

Planting pattern of H-type management model

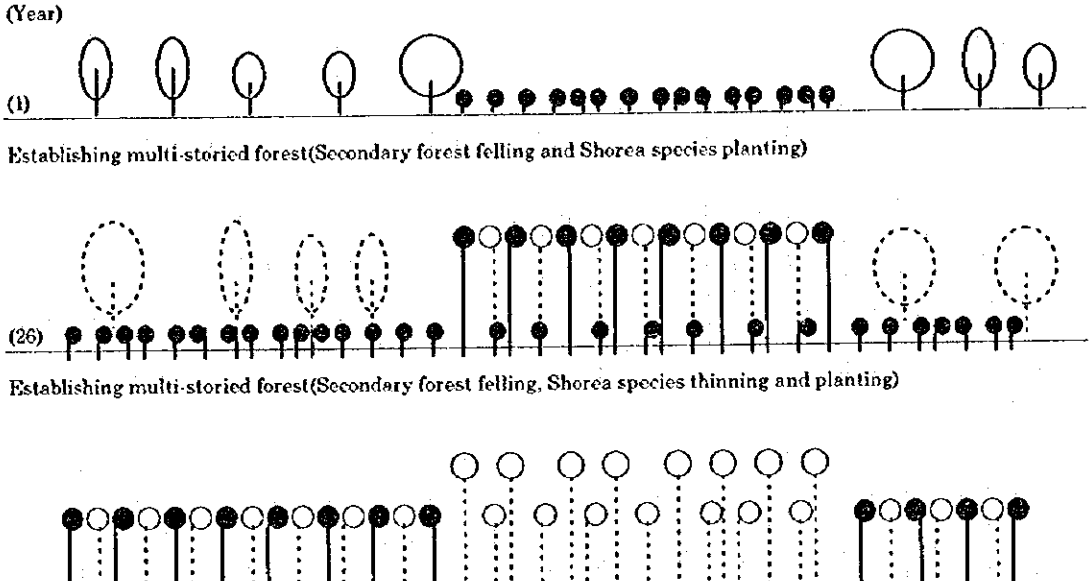


Table : Balance Sheet (Case study)

year	Cost (RM/ha)	Income (RM/ha)	Annual balance (RM/ha)	Total balance (RM/ha)
1	Secondary forest felling/ *Shorea* spp.planting:3,030 Road construction:100 General administrative expenses:313 Sub total:3,443		△3,443	△3,443
2	*Shorea* spp. weeding:390 Road maintenance50 General administrative expenses:44 Sub total:484		△484	△3,927
3~25	Road construction 1,150 General administrative expenses:115 Sub total:1,265		△1,265	△5,192
26	Secondary forest felling/ *Shorea* spp. planting:5,838 *Shorea* spp. thinning:3,887 Road maintenance:50 General administrative expenses:978 Sub total:10,735	General use timber:16,746 Sub total :16,746	5,993	801
27	*Shorea* spp. weeding:1,326 Road maintenance:50 General administrative expenses:138 Sub total:1,514		△1,514	△713
28~50	Road maintenance:1,150 General administrative expenses:115 Sub total:1,265		△1,265	△1,978
51	*Shorea* spp. final felling:5,070 *Shorea* spp. thinning:9,446 *Shorea* spp. planting:3,550 Road maintenance50 General administrative expenses:1,812 Sub total:19,928	General use timber:43,687 General use timber:40,698 Sub total :84,385	64,457	62,479

year	Cost (RM/ha)	Income (RM/ha)	Annual balance (RM/ha)	Total balance (RM/ha)
52	*Shorea* spp. weeding:1,040 Road maintenance:50 General administrative expenses:109 Sub total:1,199		△1,199	61,280
53~75	Road maintenance:1,150 General administrative expenses:115 Sub total:1,265		△1,265	60,015
76	*Shorea* spp. final felling:7,605 *Shorea* spp.thinning:9,446 *Shorea* spp. planting:4,118 Road maintenance:50 General administrative expenses:2,122 Sub total:23,341	General use timber:65,530 General use timber40,698 Sub total :106,228	82,887	142,902
77	*Shorea* spp. weeding:1,326 Road maintenance:50 General administrative expenses:138 Sub total:1,514		△1,514	141,388
78 ~100	Road maintenance:1,150 General administrative expenses:115 Sub total:1,265		△1,265	140,123
101	*Shorea* spp. final felling:5,850 *Shorea* spp. thinning:9,446 Road maintenance:50 General administrative expenses:1,535 Sub total:16,881	General use timber:50,408 General use timber:40,698 Sub total :91,106	74,225	214,348
Total	84,117	298,465	214,348	214,348

Notes : 1. △ indicates deficit.

Table-F10 Comparison of precondition at establishment of multi-storied forest

Item	Chikus F.R.	Gunung Besout F.R.	Rantau Panjang F.R.
1.Species of upper-story tree	Acacia mangium 3-year old stand (DBH:14cm,H:13m)	Acacia mangium 3-year old stand	Acacia mangium 9-year old stand*
a)Seedlings planted (seedlings/ha)	a)900	a)900	a)900
b)Remaining trees (trees/ha)	b)765	b)Unkown	b)Unkown
2.Upper-story tree felled	381trees/ha(D-type)	2rows felled, 6rows left mainly	a)2rows felled, 2rows left b)4rows felled, 2rows left
3.Tree length skidding distance(m)	200	–	Unkown
4.Site preparation	448seedlings/ha (spot weeding,1m diameter)	Line weeding	Line weeding
5.Seedlings of lower-story tree planted (seedlings/ha)	448	225(on the average)	176(on the average)
6.Treatment	Line weeding with 1m.width	Line weeding with 1m.width	Line weeding

Note:1. *Thinning(thinning Ⅰ) was carried out between 3rd to 4th year after planting.
2. F.R.:Forest Reseave

Table-F11 Comparison of establishment cost of multi-storied forest(RM/ha)

Operation	Chikus F.R. [Basis of estimate]	Gunung Besout F.R. [Basis of estimate]	Rantau Panjang F.R. [Basis of estimate]
Site preparation	2,735 [Felling and hauling of upper-story tree :RM6.0/tree, Clearing planting site :RM1.0/seedlings]	563 [To carry and felling upper-story tree :RM2.0/tree, To clean planting line :RM0.5/seedling]	0 [−]
Seedlings	986^ [RM2.2/seedling]	450 [RM2.0/seedling]	264 [RM1.5/seedling]
Planting	381 [RM0.85/seedling]	113 [RM0.5/seedling]	448 [RM2.77/seedling]
Treatment	717 [RM0.4/seedling *4times/year]	90 [RM0.4/seedling]	200 [RM1.13/seedling]
Seedling loading and transportation	448 [RM1.0/seedling]	225 [RM1.0/seedling]	− [−]
Total	5,267	1,150	912

Notes:1. ^:Seedlings brought at private nursery

2. F.R.:Forest Reserve

Case Study-3 Subtype of D-type

Table : Balance Sheet

year	Cost (RM/ha)	Income (RM/ha)	Annual balance (RM/ha)	Total balance (RM/ha)
1	*A.mangium* planting : 1,250		△ 1,250	△ 1,250
2	Treatment 1 (slashing and form pruning):170 Road maintenance:50 General administrative expenses: 22 Sub total:242		△ 242	△ 1,492
3	Road maintenance:50 General administrative expenses:5 Sub total:55		△ 55	△ 1,547
4	*A.mangium* thinning I :300 Road maintenance:50 General administrative expenses:35 Sub total:385		△ 385	△ 1,932
5~9	Road maintenance:250 General administrative expenses:25 Sub total:275		△275	△2,207
10	*A.mangium* felling:2,745 *Shorea* spp. planting:2,980 Road maintenance:50 General administrative expenses:578 Sub total:6,353	General use timber:6,363 Sub total:6,363	10	△2,197
11	*Shorea* spp. weeding:717 Road maintenance:50 General administrative expenses:77 Sub total:844		△844	△3,041
12 ~15	Road maintenance:200 General administrative expenses:20 Sub total:220		△220	△3,261
16	*A.mangium* final felling:3,552 *A.mangium* planting:575 Road maintenance:50 General administrative expenses:418 Sub total:4,595	General use timber:8,890 Sub total:8,890	4,295	1,034

year	Cost (RM/ha)	Income (RM/ha)	Annual balance (RM/ha)	Total balance (RM/ha)
17	*A.mangium* Treatment I:170 Road maintenance:50 General administrative expenses:22 Sub total:242		△242	792
18	Road maintenance:50 General administrative expenses:5 Sub total:55		△55	737
19	*A.mangium* thinning Ⅰ:300 Road maintenance:50 General administrative expenses:35 Sub total:385		△385	352
20 ~24	Road maintenance:250 General administrative expenses:25 Sub total:275		△275	77
25	*A.mangium* thinning Ⅱ・Ⅲ:963 Road maintenance:50 General administrative expenses:101 Sub total:1,114	General use timber:2,016 Sub total:2,016	902	979
26 ~30	Road maintenance:250 General administrative expenses:25 Sub total:275		△275	704
31	*A.mangium* final felling:1,248 *Shorea* spp. thinning:2,909 *Shorea* spp. planting:4,468 Road maintenance:50 General administrative expenses:868 Sub total:9,543	General use timber:2,800 General use timber:12,532 Sub total :15,332	5,789	6,493
32	*Shorea* spp. weeding:1,075 Road maintenance:50 General administrative expenses:113 Sub total:1,238		△1,238	5,255
33 ~53	Road maintenance:1,050 General administrative expenses:105 Sub total:1,155		△1,155	4,100

year	Cost (RM/ha)	Income (RM/ha)	Annual balance (RM/ha)	Total balance (RM/ha)
54	*Shorea* spp. final felling:4,896 *Shorea* spp. thinning:6,150 *Shorea* spp. planting:2,930 Road maintenance:50 General administrative expenses:1,408 Sub total:15,484	General use timber:42,187 General use timber:26,496 Subtotal:68,683	53,199	57,299
55	*Shorea* spp. weeding:717 Road maintenance:50 General administrative expenses:77 Sub total:844		△844	56,455
56 ~80	Road maintenance:1,250 General administrative expenses:125 Sub total:1,375		△1,375	55,080
81	*Shorea* spp. final felling:14,235 *Shorea* spp. planting:2,930 Road maintenance:50 General administrative expenses:1,727 Sub total:18,992	General use timber:122,658 Sub total :122,658	103,666	158,746
82	*Shorea* spp. weeding:717 Road maintenance:50 General administrative expenses:77 Sub total:844		△844	157,902
83 ~103	Road maintenance:1,050 General administrative expenses:105 Sub total:1,155		△1,155	156,747
101	*Shorea* spp. final felling:14,040 Road maintenance:50 General administrative expenses:1,409 Sub total:15,499	General use timber:120,978 Sub total :120,978		262,226
Total	82,694	344,920	262,226	262,226

Note:1.△indicates deficit.

2.Condition of operation follows D-type management model.

1.1.3.2 Management plan in site of reforestation

Production of the forest management plan is required based on the effective forest management model for each site of reforestation finally. At that time, production of planning fund procurement and planning cost and benefit are required.

Planning fund procurement is for calculating the actual balance between revenues from the sales of wood chips as well as borrowed money and expenditures for repayment, interest, operating and general administrative expenses, including planting, tending, timber production and the operation of the mill, and other necessary expenses per year.

In planning cost and benefit, sales of logs and chips less the above-mentioned operating and depreciation costs will be operating profits. Moreover, the deduction of interest and taxes from the profits will result in profits for the term. The advisability of investment is substantially affected when profits for the term occur or when cumulative loss disappears.

Effective management plans for commercial reforestation for each site can not be produced based on the produced management models. Reason being that it takes more than 30 years to recover investment in the produced management models. Rough estimates of income and cost for each site were introduced based on the produced management models in this report. Therefore, production of planning fund procurement and planning cost and benefit are required finally.

1.1.3.2.1 Management plan in Acacia mangium plantation

At present, multi-storied forests are established experimentally at Acacia mangium plantation and openland at Chikus project site with total area of 500 hectare. Scale of management plan was supposed to be 500 hectare at the management model, D-type management model, for Acacia mangium plantation.

Summary of the income and cost are shown in Table-F12 in the case study. The detailed estimation is shown in Appendix 6. After this, production of planning fund procurement and planning cost and benefit are required based on the effective forest management model.

1.1.3.2.2 Management plan in logged-over forest

Establishment costs of multi-storied forest at Bukit Kinta project site was mentioned in the head of "1.1.3.1.2 Management model in logged-over forest". After this,

management plan is required based on the effective forest management model.

1.1.3.2.3 Management plan in openland

Scale of the management plan was supposed to be 500 hectares at the management model, H-type management model, with secondary forest as shade trees.

Summary of the income and cost are shown in Table-F13 in the case study. The detailed estimation is shown in Appendix 7. After this, production of planning fund procurement and planning cost and benefit are required based on the effective forest management model.

1.1.3.2.4 Discusssion and recommendation

Effective management plans including planning fund procurement and planning cost and benefit for commercial reforestation can not be produced based on the produced management models. For the reason that it takes more than 30 years to recover investment in the produced management models and is not applicable for commercial reforestation.

As it was mentioned in the head of "1.1.3.1.4 Discussion and recommedation", the possibility of recovering investment earlier is expected by reconsidering forest management model especially in the management model for Chikus project site Block-B. Consequently, the management plans produced in this reprot are tentative. After this, production of the management plans are required based on the effective management models.

Table-F12 Summary of the cost and income of D-type management plan

Year	Cost (RM/500ha)	Income (RM/500ha)	Annual balance (RM/500ha)	Total balance (RM/500ha)
1st	625,000	0	△625,000	△625,000
11th	27,500	0	△27,500	△3,684,000
21st	176,000	207,000	31,000	△1,719,000
31st	6,029,500	11,787,000	5,757,500	4,241,500
41st	27,500	0	△27,500	3,375,000
51st	27,500	0	△27,500	3,100,000
61st	27,500	0	△27,500	30,444,500
71st	27,500	0	△27,500	30,169,500
81st	9,496,000	61,329,000	51,833,000	81,755,000
91st	27,500	0	△27,500	81,085,500
101st	27,500	0	△27,500	80,810,500
104th	7,749,500	60,489,000	52,739,500	133,495,000
Total	42,289,500	175,784,500	133,495,000	133,495,000

Note:1. △ indicates deficit.

Table-F13 Summary of the cost and income of H-type management plan

Year	Cost (RM/500ha)	Income (RM/500ha)	Annual balance (RM/500ha)	Total balance (RM/500ha)
1st	1,721,500	0	△1,721,500	△1,721,500
11th	27,500	0	△27,500	△2,211,000
21st	27,500	0	△27,500	△2,486,000
31st	27,500	0	△27,500	△466,500
41st	27,500	0	△27,500	△741,500
51st	9,964,000	42,192,500	32,228,500	31,239,500
61st	27,500	0	△27,500	30,392,500
71st	27,500	0	△27,500	30,117,500
81st	27,500	0	△27,500	70,584,000
91st	27,500	0	△27,500	70,309,000
101st	8,440,500	45,553,000	37,112,500	107,174,000
Total	42,058,500	149,232,500	107,174,000	107,174,000

Note:1. △ indicates deficit.

1.1.4 Income and cost analysis

1.1.4.1 Cost analysis

Cost analysis was mainly carried out based on written contract and experimental study for process analysis of the project. However, cost analysis of each type of the management models such as A-type, B-type, C-type and D-type at Chikus project site Block-B could not be carried out sufficiently. After this, application of each cost analysis is required to the management models and the management plans.

1.1.4.1.1 Seedlings cost analysis

Seedlings cost analysis is mentioned in the field of "Nursery". It is required to refer to Nursery field.

1.1.4.1.2 Silviculture work cost analysis

Silviculture work cost of each forest management model is shown in Table-F14 to Table-F17. These costs are based on written contracts of actual works of the project.

Experimental studies for process analysis were carried out in the field of upper-story tree felling, hauling techniques and planting seedlings. Data obtained was not applied to the management models produced.

Experimental study of upper-story tree felling and haulimg techniques were conducted by Short-term Expert, Dr.SAWAGUCHI.

The survey was carried out to fulfill two objectives:1)To determine the amount of damage upper-story tree felling and hauling does to lower trees; and 2)To analyze labor productivity and the cost of initial felling and hauling in the development of multi-storied forests. A total of four plots were selected to conduct the survey. One plot was selected from among the felling areas in the multi-storied forest for the first objective, while three plots were selected from model felling areas for the second. The felling area chosen for the first objective was the Chikus Forest Reserve:Block-B. This plot is composed of Acacia mangium, the upper-story tree planted 1989, and Shorea leprosula, the lower-story tree planted in 1992. The other three plots consist of Acacia mangium woods adjacent to the first plot.

Acacia mangium trees that were surveyed have grown vigorously reaching 20cm in DBH, 19m in height, and 233m^3/ha in growing stock. This stand was used to survey the damage felling upper trees may cause to lower trees on one hand, and to analyze

the process and cost of felling, bucking and skidding by time study on the other(refer to phtograph-F1~F3).

The results of the trial upper-story tree felling in the survey clearly proved that *upper-story tree felling would be technically possible in the future. That is to say,* damage to lower trees is expected to be small as long as a backhoe is used in felling upper trees and logs are hauled by tractor running on a skidding trail, with the exception that the 1 row cut, 1 row left method is employed for multi-storied forest A-type(The result is shown in Figure-F2.). However, damage to lower trees varies to some degree with the felling pattern. When felling upper-story trees on a commercial basis, damage may increase unless the following technical conditions are cleared. Any commercial project undertaken should be carried out carefully.

a)Topographical conditions: This survey was carried out at a topographically favorable site with little inclination, where heavy machines could easily be used. Felling may be very difficult at a topographically severe site where a skidding trail cannot be freely constructed.

b)Size of upper-story tree: The larger the upper-story tree, the greater damage to the lower-story tree.

c)Technical level of the logging contractor: Because a backhoe is indispensable for controlling the direction of fall, the contractor is required to have the appropriate operating skill and high expertise in determining the direction of the center of gravity for every felled tree.

Data obtained from the survey's cost analysis on felling and hauling will contribute towards estimating felling and hauling costs necesary for the development of future multi-storied forests. The values for labor productivity on initial felling and hauling in the development of such forests were estimated at 2.24m^3/person·day, and 2.85m^3/ person·day, and 3.86m^3/ person·day for the two-, four-, and eight-row felling areas, respectively. The eight-row area was 1.7 times higher than the two-row area. However, these values must be discounted to some degree because the skidding distance in the two-row area was twice the distance of the eight-row area. Nevertheless, if it is taken into account that the waiting time per felling or hauling, observed in a time series, for the two-row area was around twice as long as the eight-row area, it can be judged that differences in the number of rows have a great effect on labor productivity, unless the skidding distance is extremely long.

The cost of felling and hauling in the survey was estimated at RM120.97/m^3 in total. Of this amount, the cost of fellling, trimming and bucking was RM30.17/m^3, yarding RM18.20/m^3(RM53/m^3 estimated at 200m diatance), and transportation

RM71.60/m³. Consequently, log transportation alone accounted for 60% of the total. In this situation, manual loading increased personnel cost. If loading is mechanized, the cost will decrease. The results of this analysis was almost similar to the estimates presented by the logging contractor.

Experimental study of planting seedlings was carried out from 26th Decmber 1995 to 30th December 1995 by time study at Chikus project site. The survey was carried out to fulfill the objective of analysis of labor productivity of initial planting seedlings at A-type, B-type, C-type and D-type of multi-storied forest in Acacia mangium plantation. The results of the study are shown in Table-F18(refer to photograph-F4). According to the result, labor productivity on the planting operation were estimated at 14.09Hr/ha, 10.66Hr/ha, 10.13Hr/ha and 11.33Hr/ha for A-tpye, B-type, C-type and D-type.

1.1.4.1.3 Discussion and recommendation

The result of the trial upper-story tree felling and hauling techniques were mentioned in the head of "1.1.4.1.2 Cost analysis in silviculture work". Not only have the technical conditions to be cleared(mentioned in the head of "1.1.4.1.2"), but also the techniques is costly. Therefore, these techniques will not be used on a commercial basis of the felling. Upper-story tree felling is recommended without using a heavy machine such as a backhoe, with using chain-saw only.

When upper-story tree felling is carried out with chian-saw only, the felling methods are the points to be specially considered. That is to say, it is important which row of upper-story tree will be felled first. If we fell the middle of rows at first and then the edge of rows last, damage rate to the lower trees are assumued less serious at C-type and D-type at Chikus project site Block-B. At that time, cost analysis of the felling method is required.

Data obtained by the study of planting seedlings has a tendency, that is, the wider planting strip is, the better the labor productivity(output per day). After this, output per day of other silviculture work, weeding, climber cutting, pruning(if necessary) and upper-story felling on large scale should be surveyed.

1.1.4.2 Income analysis

1.1.4.2.1 Yield prediction

Yield volume of final felling and thinning were estimated on the management models based on produced empirical yield table experimentally and supposed damage rate to lower trees at upper-story tree felling. Empirical yield table of Shorea species and Acacia mangium were produced experimentally by Short-term Expert, Dr.MATSUMURA. Some estimations for yield prediction model were obtained through the existing data and our investigation data.

Materials for definition of the growth function are shown in Table-F19. Based on the estimations, the basic yield tables for Acacia mangium and Shorea species were constructed. The yield tables are shown in Table-F20 and Table-F21. The volume was calculated by using expressions as follows:-

-for Acacia mangium,

V=0.000315*D^1.54738*HB^0.80931(m^3)(by Wan Razali Wan Mohd.1989)

-for Shorea species,

V=0.000109*D^1.87642*HB^0.943107(m^3)(by T.M.B.Abell 1989)

The yield table for Acacia mangium shown in Table-F20 was produced by Dr. MATSUMURA at September of 1996. However the cost/income for establishment of MSF in this report were estimated by using the yield table shown in Table-F22 which was produced in 1995.

1.1.4.2.2 Timber price prediction

Shorea leprosula and Shorea parvifolia are assumed as planting species in the produced management models. These species belong to classification of the Light Red Meranti. Trend of average domestic price of log from December 1992 to April 1996, delivered at the mill, RM per m^3, in Peninsular Malaysia are shown in Figure-F3. This average price(RM517/m^3) was supposed as timber price in the produced management models. Timber price of thinnings was supposed at half of final felling timber.

Acaia mangium timber was estimated to cover the range of uses of local species, the Light Red Meranti, which is the most important general-utility timber in Peninsular Malaysia.*(*source:"Brief Notes on the Compensatory Forest Plantation Project in Peninsular Malaysia") However, heart rot probem of Acacia mangium is not solved clearly and accordingly timber price(RM100/m^3) was supposed at half of the Other Light Hardwood.

1.1.4.2.3 Discussion and recommendation

Prediction of growth volume of Acacia mangium and Shorea species were tried in 1995. The use of this empirical yield table have made possible easy predictions for yield volume of final felling and thinning. However, it is assumed that the volume of Acacia mangium are underestimated, the volume of Shorea species are overestimated, because effective data are not enough. Therefore, further investigations should be required. Especially, data from more than 10-year old stand of Acacia mangium should be required.

Profit of the management models is greatly influenced by timber price of planted high quality timber species such as Shorea species and Acacia mangium. Especially, Acacia mangium is expected to be not only shade tree but also interim revenue. At presnt, the market price of Acacia mangium timber does not exist clearly. Because Acacia mangium stands in Peninsular Malaysia are still at a young stage. Market price of Acacia mangium timber should be surveyed at Acacia mangium plantations in Peninsular Malaysia during the Follow-up phase.

Table-F14 Establishment cost of multi-storied forest at 3-year old Acacia mangium plantation at Chikus project site Block-B

Precondition	Unit cost(RM)
Species of upper-story felled:Acacia magium 3-year old (DBH14cm.,H13m.) Seedlings planted:900seedlings/ha Remaining trees:765trees/ha	
Upper-story trees felled:382trees/ha	3.5/tree
Tree length skidding distance:200m	2.5/tree
Site preparation(spot weeding):1m diameter(382seedlings/ha)	1.0/seedling
Seedling cost(Species:Shorea leprosula)	2.2/seedling
Seedling loading and transportion(from JICA Chikus nursery to Block-B)	1.0/seedling
Planting	0.85/seedling
Weeding:Line weeding with 1m width	0.4/seedling

Notes:1. The estimated unit cost is based on 1992 plantation contracts.
2. These costs are applicable to the management models(B-type,C-type and D-type) at Chikus project site Block-B.

Table-F15 Establishment cost of Acacia mangium plantation

Items	Estimated cost
A)Establishment	
1)Site preparation	RM700/ha
2)Seedlings	RM160/ha
3)Planting	RM180/ha
4)First treatment(slashing and form pruning)	RM110/ha
5)Road construction and maintenance	RM100/ha
B)Silviculture	
1)Treatment 1 (slashing and first pruning)	RM170/ha
2) Treatment 2 (slashing,high pruning and first thinning)	RM300/ha
3) Treatment 3 (Second thinning)	RM270/ha
4) Treatment 4 (Final thinning)	RM310/ha
C)Felling and Extraction	
1) Felling and bucking	RM8.61/m^3
2)Hauling	RM9.10/ m^3
3)Transporting	RM5.90/m^3

Notes:1. Source:Forest plantation Unit, Forestry Department Peninsular Malaysia
2. These costs are applicable to the management models(B-type,C-type and D-type) at Chikus project site Block-B.

Table-F16 Establishment cost of multi-storied forest at logged-over forest at Bukit Kinta project site

Actual area of Block-D:1.03ha
Planted seedlings:Shorea parvifolia
Planted number of seedlings:800seedlings/1.03ha

Operation	Estimated cost	Basis of estimate
Site preparation (Slashing and clearing wild banana and fern)	7,000RM/1.03ha	
To carry seedlings (JICA Nursery→B.Kinta F.R.)	800RM/1.03ha	RM1.0/seedling
Planting	680RM/1.03ha	RM1.0/seedling
Seedlings (supposed to buy at private nursery)	1,760RM/1.03ha	RM2.2/seedling
Treatment (Spot weeding included climber cutting)	2,472RM/1.03ha	RM600/ha*4times/year

Notes:1. The estimated unit cost is based on 1994 plantation contracts.
2. These costs are applicable to the result of establishment costs of Block-D at Bkuit Kinta project site.

Table-F17 Establishment cost of multi-storied forest at secondary forest at Chikus project site Block-A

Operation	Unit cost
A)Site preparation	
1)Cutting and slashing	RM1,500/ha
2)To clean the planting sites	RM1,500/ha
B)Planting	
1)To transport seedlings (JICA Nursery→Chikus Block-A)	RM0.3/seedling
2)To plant seedlings	RM1.0/seedling
C)Seedlings(supposed to buy Shorea spp. at private nursery)	RM2.2/seedling
D)Treatment:Line weeding with 1m width	RM0.4/seedling

Notes:1. The estimated unit cost is based on 1994 plantation contracts.
2. These costs are applicable to the management models(F-type,G-type and H-type) at Chikus project site Block-A.

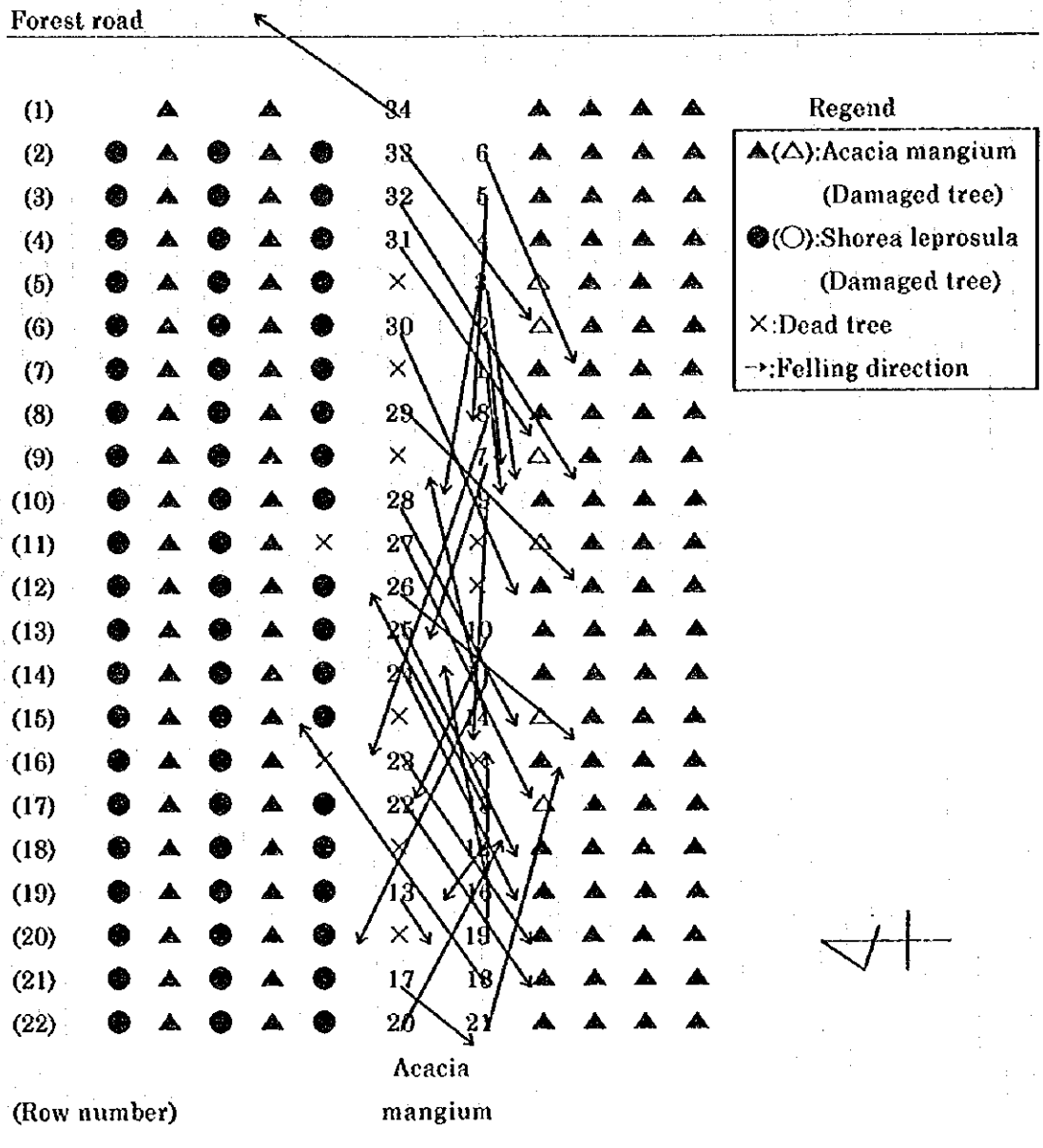
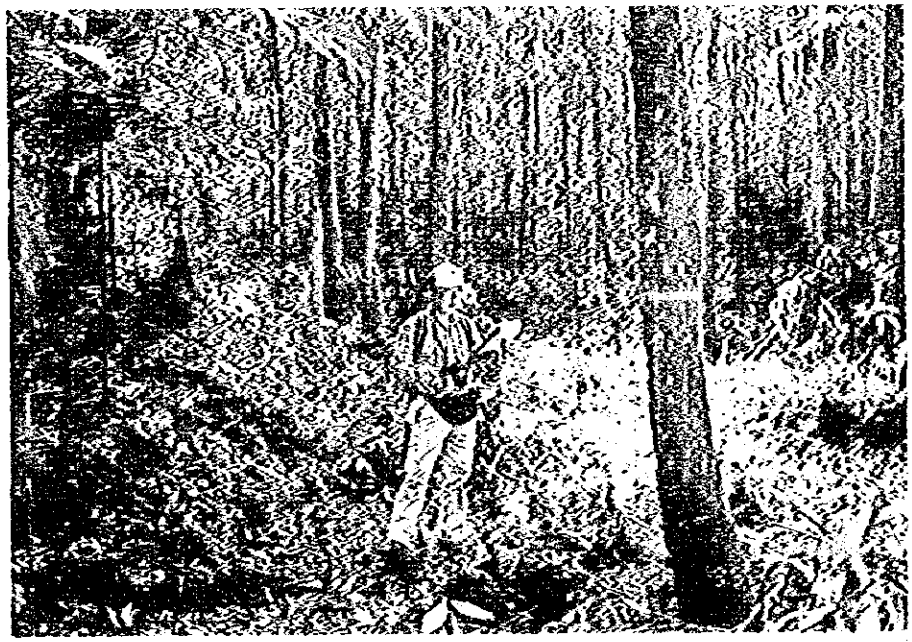


Figure-F2 Tree location in experimental plot(Chikus site Block-B,1992 plot A-type, Upper-story tree:Acacia mangium planted in November,1992 Lower-story tree:Shorea leprosula planted in October,1992)

Note:Number of Acacia mangium means numerical values of felling order.

Photograph-F1:Felling upper-story tree (Acacia mangium)by heavy machine

Photograph-F2:The whole view of the operation



Photograph-F3:Process analysis by time study

Table-F18 Labor productivity of planting seedlings at Chikus project site

Operation	A-type	B-type	C-type	D-type
Planting hole digging	3.41Hr/ha RM17.05/ha	2.93Hr/ha RM14.65/ha	3.85Hr/ha RM19.25/ha	2.65Hr/ha RM13.25/ha
Planting	3.18Hr/ha RM15.90/ha	2.49Hr/ha RM12.45/ha	3.00Hr/ha RM15.00/ha	2.04Hr/ha RM10.20/ha
Seedling distribution	7.50Hr/ha RM37.50/ha	5.24Hr/ha RM26.20/ha	3.28Hr/ha RM16.40/ha	6.64Hr/ha RM33.20/ha
Total	14.09Hr/ha RM70.45/ha	10.66Hr/ha RM53.30/ha	10.13Hr/ha RM50.65/ha	11.33/ha RM56.65/ha

Notes: 1. The estimated cost is based on worker's wage only.

2. Worker's wage is based on interview at the experimental site.

3. Height of seedling was 47.14cm on the average.

4. Weight of seedling pot was 1.0kg on the average.

Photograph-F4:Experimantal study for process analysis in the field of planting seedlings by time study

Table-F19 Material for definition of the growth function

Species	Used data for parameter estimation of growth function	Referenced data for model validation
Acacia mangium	1.Kemasul F.R./Pahang (Ahmad Zuhaidi Yahya 1990) 2.Kemasul F.R./Pahang (B.K.Paudyal 1990) 3.Ulu Sedili F.R./Johor (E.Panitz 1992) 4.Kemasul F.R./Pahang (Ahmad Zuhaidi Yahya 1993) 5.Chikus F.R./Perak (JICA 1994)	1.SAFODA/Sabah (M.Inose 1991) 2.Benakat/Sumatra/INDONESIA (S.Sakurai 1994)
Shorea species	1.Bukit Tapah F.R./Perak (H.T.Tang 1980) 2.Bukit Tapah F.R./Perak (Azman Hassan 1990) 3.Sungai Buloh F.R./Selangor (L.H.Ang 1991) 4.Bukit Tapah F.R./Perak (S.Appanah 1993) 5.FRIM/KL (S.Appanah 1993) 6.Bukit Lagong F.R./Selangor (Ahmad Zuhaidi Yahya 1994)	1.Bogor/Java/INDONESIA (S.Sakurai 1992) 2.Maquiling/PHILIPPINES (S.Sakurai 1994) 3.Keledang Saiong F.R./Perak (JICA 1995)

Note:1. SAFODA:Sabah Forestry Development Authority

2. F.R.:Forest Reserve

Table-F20 Merchantable volume of Acacia mangium

Age (years)	H (m)	HB (m)	DBH (cm)	N (/ha)	GF (m^2/ha)	V (m^3/ha)	Sr (%)
1	4.2	2.3	7.1	814	3	10	83.5
2	9.0	4.9	9.6	736	5	28	41.0
3	12.7	9.4	12.0	666	8	60	30.5
4	15.6	10.5	14.2	603	10	77	26.1
5	17.9	11.3	16.2	545	11	91	23.9
6	19.7	11.9	18.1	493	13	102	22.9
7	21.1	12.4	19.8	446	14	109	22.4
8	22.2	12.8	21.4	403	14	114	22.4
9	23.0	13.1	22.9	365	15	117	22.8
10	23.7	13.3	24.2	330	15	117	23.2
11	24.2	13.5	25.5	299	15	116	23.9
12	24.6	13.6	26.7	270	15	113	24.7
13	24.9	13.8	27.8	244	15	110	25.7
14	25.2	13.9	28.8	221	14	106	26.7
15	25.3	13.9	29.7	200	14	101	27.9
16	25.5	14.0	30.5	181	13	96	29.1
17	25.6	14.0	31.3	164	13	90	30.5
18	25.7	14.0	32.1	148	12	85	32.0
19	25.8	14.1	32.7	134	11	79	33.5
20	25.8	14.1	33.4	121	11	74	35.2

Notes:H:Tree Height

HB:Clear bole height

DBH:Diameter at breast height

N:Number of stems per hectare

GF:Basal area per hectare

V:Merchantable volume per hectare

Sr:Spacing index=100/sqr(N)/H

Table-F21 Merchantable volume of Shorea species

Age (years)	H (m)	HB (m)	DBH (cm)	N (/ha)	GF (m^2/ha)	V (m^3/ha)	Sr (%)
5	3.4	1.8	5.6	450	1.1	2	138.65
10	11.2	6.2	12.4	450	5.4	31	42.09
15	17.5	9.7	18.6	450	12.2	101	26.94
20	22.6	12.6	24.5	352	16.6	169	23.58
25	26.8	14.9	29.9	254	17.8	208	23.41
30	30.2	16.8	35.0	197	19.0	243	23.59
35	32.9	18.3	39.7	160	19.8	271	24.03
40	35.2	19.6	44.1	135	20.6	297	24.45
45	37.0	20.6	48.2	117	21.3	318	24.99
50	38.4	21.4	52.0	103	21.9	335	25.66
55	39.6	22.1	55.6	93	22.6	353	26.19
60	40.6	22.6	58.9	84	22.9	363	26.87
65	41.4	23.1	62.0	78	23.5	379	27.35
70	42.0	23.4	64.9	72	23.8	386	28.06
75	42.5	23.7	67.6	67	24.0	392	28.75
80	42.9	23.9	70.1	63	24.3	398	29.37

Notes:H:Tree Height

HB:Clear bole height

DBH:Diameter at breast height

N:Number of stems per hectare

GF:Basal area per hectare

V:Merchantable volume per hectare

Sr:Spacing index=100/sqr(N)/H

Table-F22 Merchantable volume of Acacia mangium

Age (years)	H (m)	HB (m)	DBH (cm)	N (/ha)	GF (m^2/ha)	V (m^3/ha)	Sr (%)
1	2.8	1.5	5.5	1,306	3.1	8	98.83
2	7.4	4.0	8.8	1,142	6.9	32	39.99
3	11.3	6.2	11.5	1,058	11.0	64	27.21
4	14.7	8.1	13.8	1,005	15.0	100	21.46
5	17.6	9.8	15.7	968	18.7	137	18.26
6	20.1	11.2	17.3	942	22.1	173	16.21
7	22.3	12.4	18.7	921	25.3	207	14.78
8	24.2	13.4	19.8	906	27.9	237	13.73
9	25.8	14.3	20.7	895	30.1	264	12.96
10	27.2	15.1	21.5	885	32.1	289	12.36
11	28.4	15.8	22.2	877	33.9	312	11.89
12	29.5	16.4	22.7	872	35.3	331	11.48
13	30.4	16.9	23.2	866	36.6	349	11.18
14	31.1	17.3	23.6	862	37.7	363	10.95
15	31.8	17.7	23.9	859	38.5	376	10.73
16	32.4	18.0	24.2	856	39.4	387	10.55
17	32.9	18.3	24.4	854	39.9	397	10.40
18	33.3	18.5	24.6	852	40.5	404	10.29
19	33.7	18.8	24.7	851	40.8	412	10.17
20	34.0	18.9	24.9	849	41.3	418	10.09

Notes:H:Tree Height

HB:Clear bole height

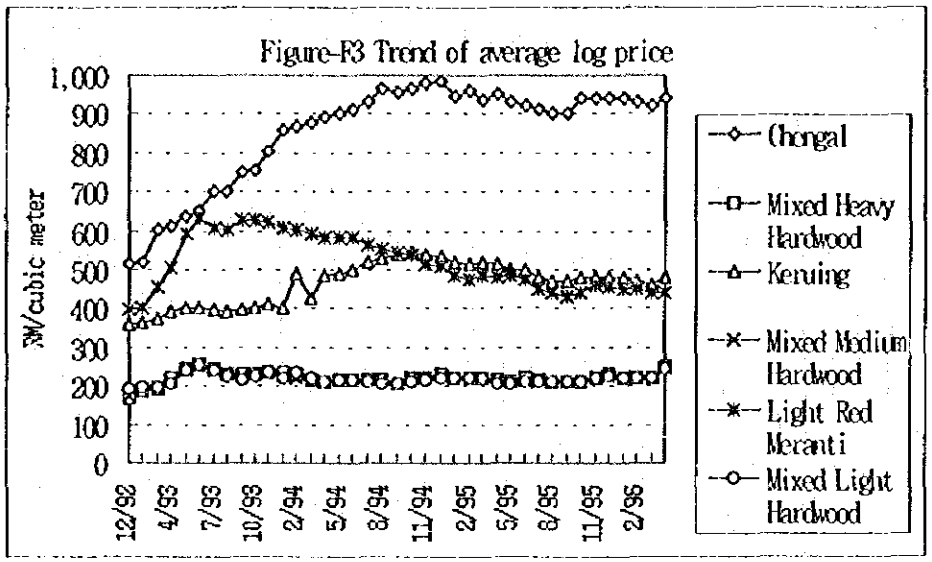
DBH:Diameter at breast height

N:Number of stems per hectare

GF:Basal area per hectare

V:Merchantable volume per hectare

Sr:Spacing index=100/sqr(N)/H



Note:Average log price of Light Red Meranti:RM517/m³

1.2 Others

1.2.1 Forest Road

It was planned to convert pre-existing roads in the Chikus and Bukit Kinta areas into all-weather roads. Most work roads and firebreak had to be newly constructed. Although it was initially planned to directly supervise the construction roads, partly because of requests from the Malaysian government, however, it was decided to contract out the construction work except for gravelling and simple repairs.

Construction and maintenance of roads have been carried out in order to contribute silviculture and nursery work. Therefore, cost analysis for roads is not applied directly to the case studies of the multi-storied management models. Result of construction and maintenance of forest road and operation road are shown in Table-F23. Table-F24 shows summary of costs for road construction in the initial stage of the project(refer to photograph-F5~F6).

1.2.2 Forest Machinery

Maintenance of machinery have been carried out in order to contribute silviculture, nursery work and road maintenance. Although it was initially planned to directly supervise the construction roads and silviculture work, partly because of requests from the Malaysian government, however, it was decided to contract out the construction work and silviculture work except for gravelling and simple repairs of roads. Therefore, cost analysis for forest machinery is not applied to the case studies of the multi-storied forest management models.

The maintenance of machinery is supervised by experts at the locations of delivery. Local staffs who use the vehicles most frequently have been appointed as the main operators of their respective vehicles, and are directly carrying out the maintenance of vehicles under the guideline(refer to Table-F25) and supervision of the appropriate experts. To use machineries effectively and maintained well. Table-F26 shows the operation record of vehicles and machinery.

Table-F23 Result of Construction and Maintenance of Forest Road and Firebreak

Place	Items	Year	1992	1993	1994	1995	1996	Total
Chikus	Trunk road	(m)	8,050	–	–	–	–	8,050
		(RM)	135,305.00	–	–	–	–	135,305.00
	Operation road	(m)	–	–	8,489	–	–	8,489
		(RM)	–	–	337,854.00	–	–	337,854.00
	Firebreak	(m)	10,852	–	13,900	–	3,800	28,552
		(RM)	89,530.00	–	12,510.00	–	7,045.00	109,085.00
	Bridge	(m)	18	–	–	–	–	18
		(RM)	76,570.00	–	–	–	–	76,570.00
	Maintenance of road	(m)	–	2,635	6,990	10,450	–	20,075
						(6,000)		(6,000)
		(RM)	–	37,654.24	86,584.00	134,044.74	–	258,282.98
						(55,458.74)		(55,458.74)
Bukit Kinta	Trunk road	(m)	2,646	–	–	–	–	2,646
		(RM)	88,180.00	–	–	–	–	88,180.00
	Operation road	(m)	–	–	1,000	–	–	1,000
		(RM)	–	–	81,238.00	–	–	81,238.00
	Firebreak	(m)	–	–	–	–	–	–
		(RM)	–	–	–	–	–	–
	Bridge	(m)	14	–	–	–	–	14
		(RM)	47,460.00	–	–	–	–	47,460.00
	Maintenance of road	(m)	–	1,150	12,600	11,028	–	24,778
		(RM)	–	19,973.20	396,003.40	115,570.66	–	531,547.26
					(74,303.40)	(42,710.66)	–	(117,014.06)
	Maintenance of bridge	(m)	13	(13)	14	14	–	54
								(13)
		(RM)	70,867.00	(53,562.15)	29,000.00	21,117.46	–	174,546.61
								(53,562.15)
Total		(RM)	507,912.00	111,189.59	943,189.40	270,732.86	7,045.00	1,840,068.85
				(53,562.15)	(74,303.40)	(98,169.40)		(226,034.95)

Note: 1. The result of the construction and maintenance works were completed by the local contractors.

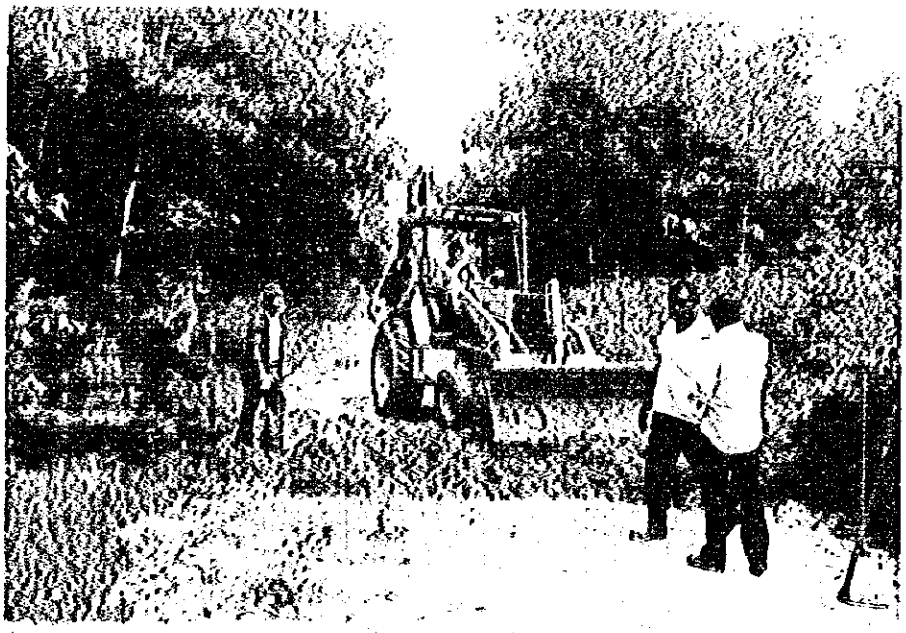
2. ( ) indicates expenditures by State Forestry Department Perak..

3. Total cost includes expenditures by State Forestry Department Perak.

Table-F24 Summary of Costs for Forest road Construction

Work	Unit cost (RM)	Chikus(Block-A,B)		Chikus Block-A Firebreak		Bukit Kinta		Total (RM)
		Quantity	Amount (RM)	Quantity	Amount (RM)	Quantity	Amount (RM)	
Earth Work 1	6.90	8,050 m	55,545.00					55,545.00
Earth Work 2	13.00					1,660 m	21,580.00	21,580.00
Ditch(Digging)	1.50	7,200 m	10,800.00			1,000 m	1,500.00	12,300.00
(Concrete)	25.00	500 m	12,500.00					12,500.00
Total		7,700 m	23,300.00			1,000 m	1,500.00	24,800.00
Culvert(¢0.60)	1,300.00	7 places	9,100.00	6 places	7,800.00	6 places	7,800.00	24,700.00
(¢0.45)	900.00	4 places	3,600.00	4 places	3,600.00	5 places	4,500.00	11,700.00
Total		11 places	12,700.00	10 places	11,400.00	11 places	12,300.00	36,400.00
Turfing	3.20	8,050 m	25,760.00			1,500 m	4,800.00	30,560.00
Bridge	Set					14 m	47,460.00	47460.00
Gravelling	60.00	300 m	18,000.00			800 m	48,000.00	66,000.00
Firebreak	7.20			10,851.50 m	78,130.00			78,130.00
Total(direct costs)			135,305.00		89,530.00		135,640.00	360,475.00

Note:1. The cost is based on 1992 construction contracts.



Photograph-F5:Forest road maintenance by JICA staffs

Photograph-F6:Forest road maintenance by a contractor

Table-F25 Changing Chart for Oil and Filtres

Items	Distance(km)
Engine oil	Every 5,000
Engine oil filter	Every 20,000
Fuel filter	Every 25,000
Transmission gear oil	Every 50,000
Differantial gear oil	Every 50,000

Table-F26 Operation record of Vehicle and Machinery

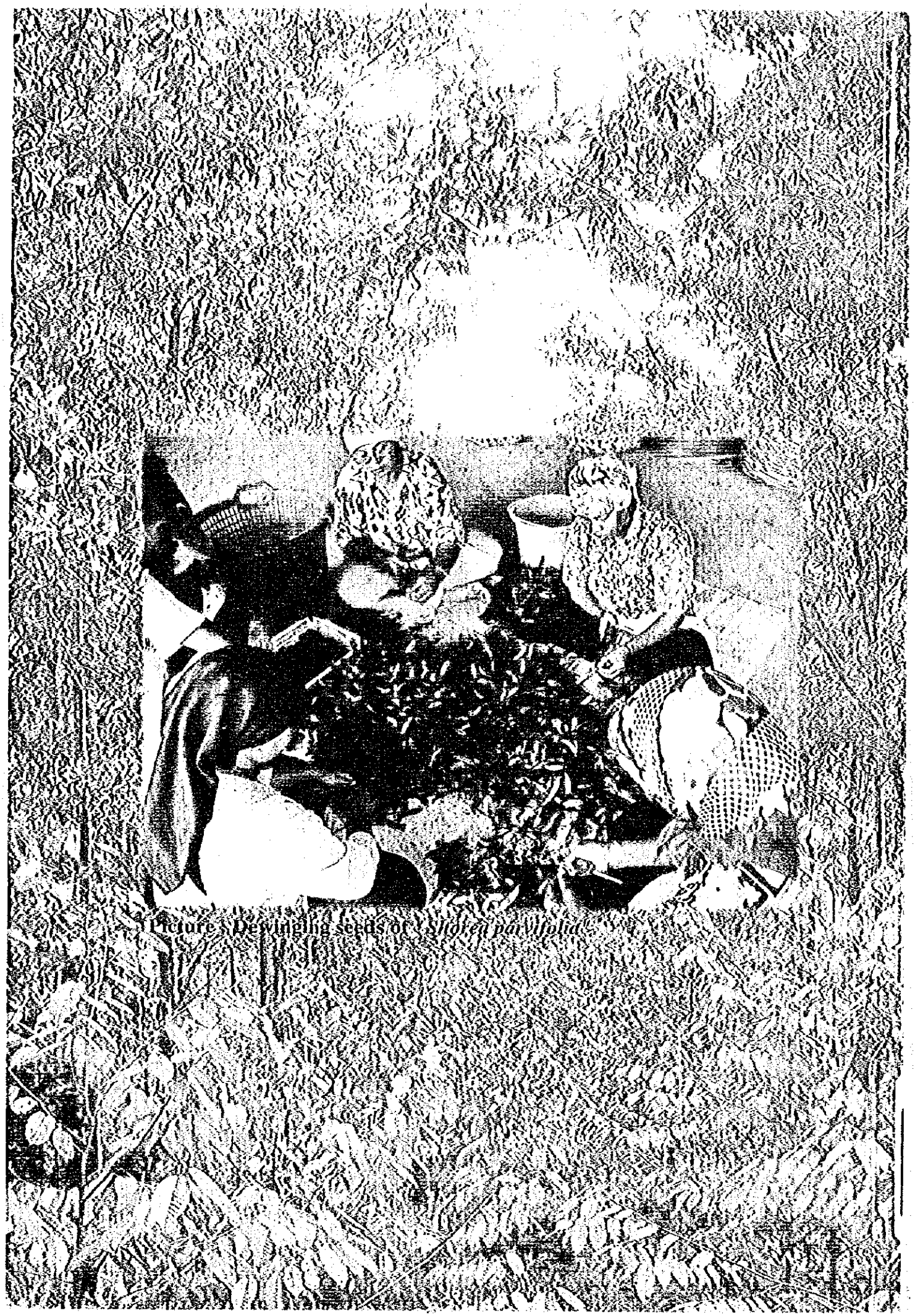
No.	Items	Registration	Working days (Working rate:%)		Travel distance in km(hr)		Fuel consumption (l)		Supervision
			1992	1993	1992	1993	1992	1993	
1	Pajero	ACC-4156	177(65.1)	124(41.5)	22,719	22,061	2,435	2,413	Forestry Department
2	Pajero	ACC-4157	243(89.3)	285(95.3)	26,250	31,628	2,008	2,990	Nursery
3	Pajero	ACC-4158	204(75.0)	281(94.0)	24,336	24,185	2,121	2,386	Nursery
4	Lite Ace	ACC-9607	190(84.4)	224(74.9)	10,573	20,048	1,015	1,977	Ipoh Office
5	Landcruiser	ACC-9608	179(78.2)	250(83.6)	19,379	29,130	1,723	2,641	Forest Road
6	Hilux	ACC-6677	180(80.0)	292(97.7)	10,709	15,446	1,096	1,911	Nursery
7	Fork Lift	WCS-7143	2(8.3)	36(12.0)	(2.0)	(42.0)	40	--	Nursery
8	Bobcat	ACE-1418	3(3.1)	20(6.7)	(4.0)	(28.0)	40	--	Nursery
9	Excavator	ACE-2055	6(25.0)	120(40.1)	(35.0)	(539.0)	180	2,276	Forest Road
10	Tractor	ACE-6470	25(20.7)	59(19.7)	(40.0)	(98.0)	40	150	Nursery
11	Landcruiser	ACF-1771	67(91.4)	217(72.6)	6,324	19,473	664	2,093	Silviculture
12	Cargo Truck	ACF-3827	92(8.3)	104(34.8)	61	11,767	56	1,828	Nursery
13	Motor Grader	ACF-5134	--	49(16.4)	--	(95.0)	--	470	Forest Road
14	Pajero	ACG-670	12(50.0)	294(98.3)	469	24,509	38	2,584	Silviculture
15	Pajero	ACG-696	10(41.7)	218(72.9)	777	18,240	80	1,780	Silviculture
16	Micro Bus	ACH-2756	--	160(80.4)	--	6,157	--	1,312	Nursery
17	Motor Bike	ACH-9871	--	53(23.8)	--	2,391	--	139	Forestry Department
18	Motor Bike	ACH-9913	--	11(4.9)	--	753	--	35	Forest Road
19	Dump Truck	ACK-7318	--	2(8.0)	--	88	--	90	Forest Road
20	Dump Truck	ACL-120	--	28(40.0)	--	2,971	--	1,060	Forest Road
21	Cargo Truck	ACL-5653	--	--	--	--	--	--	Nursery

No.	Working days (Working rate:%)			Travel distance in km(hr)			Fuel consumption (l)			Date of registration
	1994	1995	Total	1994	1995	Total	1994	1995	Total	
1	106(35.8)	92(31.2)	468(40.3)	18,524	14,704	78,008	1,920	1,572	8,340	15.May 1992
2	280(94.6)	269(91.2)	1,077(92.7)	37,335	22,990	118,203	4,080	2,274	11,352	15.May 1992
3	304(102.7)	289(98.0)	1,078(92.8)	26,015	21,365	95,901	2,666	2,175	9,348	15.May 1992
4	170(57.4)	202(68.5)	786(70.5)	10,870	12,855	51,346	1,112	1,381	5,515	29.June 1992
5	223(75.3)	250(84.7)	902(80.9)	26,314	21,545	96,368	2,871	2,538	9,773	29.June 1992
6	319(107.8)	314(106.4)	1,105(99.1)	19,491	18,633	61,282	2,500	1,911	7,478	29.June 1992
7	53(17.9)	119(40.3)	210(23.0)	(63.1)	(101.4)	(208.5)	30	220	290	13.July 1992
8	55(18.6)	43(14.6)	121(12.3)	(68.0)	(39.5)	(139.5)	155	61	259	1.October 1992
9	108(36.5)	111(37.6)	345(37.7)	(375.0)	(381.0)	(1,330.0)	1,140	1,130	4,726	5.October 1992
10	69(23.3)	95(32.2)	248(24.5)	(69.3)	(86.7)	(291.0)	356	416	962	8.November 1992
11	267(90.2)	257(87.1)	808(84.1)	27,302	20,208	73,307	3,332	2,429	8,518	29.December 1992
12	66(22.3)	53(18.0)	225(24.6)	3,416	1,330	16,574	635	291	2,813	30.December 1992
13	58(19.6)	81(27.5)	188(21.1)	(166.0)	(274.0)	(535.0)	584	1,216	2,270	8.January 1993
14	245(82.8)	267(90.5)	818(89.5)	24,748	21,599	71,325	2,602	2,176	7,400	16.February 1993
15	278(93.9)	274(92.9)	780(85.3)	22,542	19,917	61,476	2,653	2,425	6,938	18.February 1993
16	295(99.7)	293(99.3)	748(91.7)	10,371	9,620	26,148	2,032	1,692	5,086	24.June 1993
17	126(42.6)	129(43.7)	308(37.8)	4,209	4,418	11,018	212	224	575	7.July 1993
18	155(52.4)	190(64.4)	356(43.7)	10,539	15,174	26,466	1,002	329	1,366	9.July 1993
19	135(45.6)	78(26.4)	215(31.9)	9,953	3,860	13,901	2,531	1,030	3,651	19.November 1993
20	161(55.4)	138(46.8)	330(49.9)	9,818	6,624	19,413	3,103	1,957	6,120	10.December 1993
21	73(24.7)	54(18.3)	127(22.4)	8,914	5,686	14,600	2,060	1,119	3,179	31.March 1993

Note:1.The working rate is calculated with the following equation.

Days utilized/scheduled days utilized(the total number of days in month minus Sundays and holidays)

2.The year means the fiscal year(from April to March).



Picture 1 Dewinging seeds of *Shorea parvifolia*