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AN EX-ANTE ECONOMIC ANALYSIS OF PROPOSED MIXED AND ZONAL AGROFORESTRY SYSTEMS FOR THE BATU ARANG FOREST RESERVE, MALAYSIA

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1. INTRODUCTION

In September 1983, a team of local, regional and ICRAF experts conducted a Diagnosis and Design excercise in the Batu Arang Forest Reserve with the intention of identifying appropriate agroforestry systems for research and/or development.

An ex-ante economic analysis of potential systems was carried out to determine whether or not such systems are promising enough to be introduced for either research or development.

The results of the analysis are, of course, questionable, since many of the data are by definition based on hypotheses and guestimates. The analysis should therefore not be taken as gospel, but rather as a basis for discussion before deciding to commit scarce resources to develop or research the proposed agroforestry systems.

2. METHOD OF ANALYSIS

In a situation where two economic entities intend to use the same piece of land to produce goods, the proposed land-use system should be beneficial to each one of these entities. This rather simple economic rule has often been overlooked in the past, resulting in systems heavily favouring the one, to the detriment of the other (see literature on traditional taungya).

Beneficial to the Forestry Department (F.D) means to produce a given quantity of timber at a lower cost. To the participating farmers it means a better standard of living for their family.

To determine the potential beneficial effects of the proposed agroforestry systems to the F.D. and the participating farmers, a 'with' and 'without' analysis is used.

Several models were prepared and analysed with the help of MULBUD, a micro-computer programme developed for such computations (1).

3. "WITHOUT" SITUATION

3.1. Forestry Department

At present the Forestry Department is engaged in a Compensatory Plantation Programme to avoid the projected domestic timber shortages around the turn of this century (see Table 1).

Table 1. Annual timber supply and demand in Peninsular Malaysia (in Million M^3)

Period	Projected average consumption	Projected timber production	Timber surplus/ deficit
1976 - 1980	2.37	9.89	+7.51
1981 - 1985	2.86	6.87	+4.01
1986 - 1990	3.79	6.11	+2.33
1991 - 1995	4.93	5.34	+0.41
1996 - 2000	6.29	5.34	-0.94
2001 - 2005	7.71	5.34	-2.37
2006 - 2010	9.43	5.34	-4.09

Source : Freezaillah b. Che Yeom (2)

The land required to meet this projected shortfall in timber is estimated at around 175,000 hectares. Freezaillah (2) indicates that preliminary examinations have shown that there is sufficient land available in the proposed Permanent Forest Estates for this purpose.

The Forest Department is presently using 3 species for the programme, i.e. *Albizzia falcataria*, *Gmelina arborea* and *Acacia mangium*, which are all grown in short rotations (15 years).

Over this rotation period the estimated timber production per hectare is 280 M^3, i.e. 200 trees at 1.4 M^3 each. An additional 50 M^3 is obtained from thinning during the 8th year of the rotation. The ex-plantation price of 15-year old timber logs was assumed to be M$ 161, while the 8-year old logs were valued at 70%, i.e. M$ 113.

Most of the plantation work is carried out by local contractors, who charge about M$ 2,500 per hectare to the F.D. A detailed economic analysis on a per hectare basis of this model is presented in Table 2 (3).

It is interesting to note that the internal rate of return based on the data of this plantation model is as high as 26.9%, which is higher than that for some of the perennial crops in the area.

Table 2 : Timber plantation model — Area Unit: hectare

SUMMARY RESULTS

Year	Season	Total Labour days	Variable Costs: Labour Costs m$	Variable Costs: Material Costs m$	Variable Costs: Total Costs m$	Returns: Gross Revenue m$	Returns: Net Revenue m$	Returns: N.R./days m$	Sum of Net Present Values m$
1	1	65.00	585.00	1729.30	2314.30	0.00	-2314.30	-35.60	-2066.34
2	1	3.50	31.50	86.00	117.50	0.00	-117.50	-33.57	-2160.01
3	1	4.00	36.00	86.00	122.00	0.00	-122.00	-30.50	-2246.84
4	1	18.50	166.50	156.00	322.50	0.00	-322.50	-17.43	-2451.80
5	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-2451.80
6	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-2451.80
7	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-2451.80
8	1	12.00	108.00	60.00	168.00	5650.00	5482.00	436.83	-237.71
9	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-237.71
10	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-237.71
11	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-237.71
12	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-237.71
13	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-237.71
14	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-237.71
15	1	16.80	151.20	85.00	236.20	45080.00	44843.80	2669.27	7955.10

3.2. Potential users of Forest Reserves

Since there is no definite policy yet as to who will be allowed/favoured to participate in an agroforestry scheme in the Forest Reserve, it is difficult to determine the "without" income of the potential participants.

It seems appropriate, therefore, to indicate the three different gross income* categories used to classify villagers in Malaysia, i.e.

Low income	M$	500/month
Medium income	M$	500 to 1,000/month
High income	M$	1,000/month

Many small farmers will fall in the first category, especially when they do not own land (legally). The tin miners employed in the area usually earn a salary less than M$ 500/month; however, they are often provided with housing by the mining company. Furthermore, many of them supplement their income by illegal small-scale farming.

4. "WITH" SITUATION

4.1. Design Considerations

In trying to identify appropriate agroforestry systems, the following considerations had to be taken into account.

*It is understood that this gross income includes food produced for home consumption.

i) F.D. remains legal owner of the Forest Reserve land;

ii) The land-use system has to produce timber in short rotations;

iii) Farmers are not allowed to grow permanent tree crops;

iv) Cassava is not alloyed as an intercrop;

v) The land-use system should prevent soil erosion ;

vi) Labour requirements should not exceed 1.5 man years.

Furthermore, the timber quality of most tree species will generally fall dramatically if spacing at planting time is increased to improve intercropping possibilities (increased tapering and branching). (3).

Two of the tree species used at present, i.e. Acacia and Gmelina, do have a rather dense canopy and are, therefore, unsuitable for mixed agroforestry systems especially when planted at the spacing used in the Compensatory Plantation Programme (3 x 3 meters).

Albizzia falcataria, on the other hand, has a fairly light canopy and may, therefore, be considered for mixed agroforestry systems.

4.2. A Mixed Agroforestry System Based on *Albizzia Falcataria*.

Taking into account the design objectives spelt out in section 2 as well as the design constraints indicated in section 4.1, the team proposed the following mixed agroforestry system.

Year

1 Clearing of land and planting of *Albizzia falcataria* at a 3 by 3-meter spacing.

60% of the land area to be interplanted with annual crops, i.e. chilly, bean and cabbage.

2 Sowing of improved shade-tolerant grasses under trees, e.g. *Brachiaria miliiformis*, *Calopogonium caeruleum*.

3 to 10 Sheep rearing on the improved pasture for a period of 8 years at a declining stocking rate (in ewe-equivalents) i.e. 10, 9.6, 8.7, 7.6, 6.5, 5.2, 3.5, 1.3, due to shading (see Annex 1).

11 to 15 Albizzia trees only.

Such a system will be repeated on an annual basis to ensure a continuous supply of timber as well as a continuous income to the farmers.

Input/output data for the model were partly estimated by the team members and partly derived from the literature collected during the mission (4, 5, 6, 7, 8).

A summary table of the mixed model giving labour inputs/costs, material costs, gross and net revenue, and the net present value at a 12% discount rate is presented in Table 3.

Table 3 : Mixed model trees/sheep — Area Unit: hectare

SUMMARY RESULTS

Year	Season	Total Labour days	Variable Costs: Labour Costs m$	Variable Costs: Material Costs m$	Variable Costs: Total Costs m$	Returns: Gross Revenue m$	Returns: Net Revenue m$	Returns: N.R./days m$	Sum of Net Present Values m$
1	1	192.40	1731.59	1994.95	3726.55	3203.99	-522.55	-2.71	-466.56
2	1	13.50	121.50	86.00	207.50	0.00	-207.50	-15.37	-631.98
3	1	23.80	214.20	1667.16	1881.36	0.00	-1881.36	-79.04	-1971.09
4	1	36.80	331.20	269.46	600.66	927.50	326.84	8.88	-1763.38
5	1	16.30	146.70	101.06	247.76	1747.00	1500.24	92.03	-912.10
6	1	14.10	126.90	87.42	214.32	807.10	592.78	42.04	-611.78
7	1	11.70	105.30	72.54	177.84	1391.20	1213.36	103.70	-62.92
8	1	20.70	186.30	113.94	300.24	6308.50	6008.25	290.25	2363.71
9	1	4.80	43.20	29.76	72.96	988.70	915.74	190.77	2693.94
10	1	1.30	11.70	8.06	19.76	460.40	440.64	338.95	2835.81
11	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2835.81
12	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2835.81
13	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2835.81
14	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2835.81
15	1	16.80	151.20	85.00	236.20	45080.00	44843.80	2669.27	11028.63

It should be noted that this net present value of the mixed agroforestry model is considerably higher as from the timber plantation model and since each model requires the same amount of Forest Reserve Land to produce the projected amount of timber, it may be concluded that the productive use of the Forest Reserve Land as a whole would be higher with the mixed model than with the timber plantation model.

4.3. Zonal Agroforestry System Based on *Acacia Mangium* or *Gmelina Arborea*.

Since a mixed agroforestry system seems to hold little potential for Acacia and Gmelina (see 3.1), a zonal agroforestry system was considered. In designing this system, the team assumed that at least twice the area required to meet the projected shortfall in timber would be available if necessary. Secondly, it was assumed that distances between tree strips should not exceed 50 meters to avoid erosion. The latter assumption is only valid if the agricultural strips are used as pasture.

The following model was proposed (1 hectare).

Year

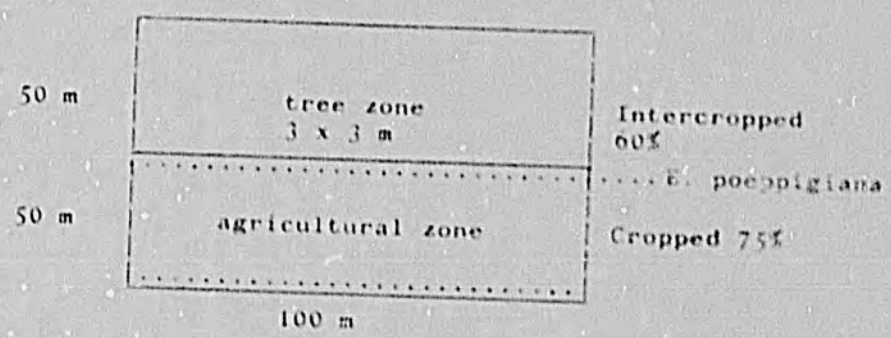
1 Clearing of land and planting Acacia or Gmelina at a 3 by 3-meter spacing on half the land (0.5 hectare).

Planting of rows of *Erythrina poeppegiana* along the boundaries of the tree zone to reduce the negative effect upon the timber trees as well as to provide fodder for animals.

Intercropping the tree zone with chilly, bean and cabbage (60% of the area = 0.3 hectare).

Cropping the agricultural zone with chilly, bean and cabbage (75% of the area = 0.375 hectare; some strips are left uncultivated to avoid soil erosion). (see Figure 1).

Figure 1 : First year overview zonal agroforestry system.



2 Sowing of improved pasture in the agricultural strip.

3 to 15 Sheep rearing on the improved pasture and Erythrina loppings*

*The Erythrina will only be lopped on the pasture side, the pollards facing the timber zone will be left to provide the competition required for good form factor growth of the timber trees.

Stocking rate (in ewe-equivalent) will decline over time due to shading of pasture from the forest zone edge, i.e. 8.8, 8.1, 7.8, 7.5, 7.1, 6.8, 6.5, 6.0, 5.5, 5.0, 4.5, 4.0. (see Annex 1).

A summary of inputs and outputs of the model is presented in Table 4. It is interesting to note that the returns per unit area of land from the zonal model are considerably lower than those from the mixed model and even less than those from the plantation model. However, the zonal model would require twice the amount of Forest Reserve Land as compared to the mixed or the plantation model, to produce the same amount of timber. The opportunity cost of such additional Forest Reserve Land is rather low because the mean annual increment of logged-over forest is estimated at only 1.41 m^3 over the 55-year rotation period (2). Therefore, the productive use of the Forest Reserve Land as a whole would be higher with the zonal model than with the mixed or plantation model.

Table 4 : Zonal model trees/sheep — Area Unit: hectare

SUMMARY RESULTS

Year	Season	Total Labour days	Variable Costs: Labour Costs m$	Variable Costs: Material Costs m$	Variable Costs: Total Costs m$	Returns: Gross Revenue m$	Returns: Net Revenue m$	Returns: N.R./days m$	Sum of Net Present Values m$
1	1	197.82	1780.42	1800.48	3580.90	3604.49	23.59	0.11	21.06
2	1	7.75	69.75	43.00	112.75	0.00	-112.75	-14.54	-68.82
3	1	22.75	204.75	1548.67	1753.42	0.00	-1753.42	-77.07	-1316.87
4	1	27.75	249.75	181.32	431.07	803.40	372.33	13.41	-1080.25
5	1	19.00	171.00	99.63	270.63	1527.80	1257.17	66.16	-366.90
6	1	18.00	162.00	95.94	257.94	736.30	478.36	26.57	-124.55
7	1	18.00	162.00	92.25	254.25	1422.30	1168.05	64.89	403.81
8	1	23.00	207.00	117.33	324.33	3509.40	3185.07	138.48	1690.21
9	1	16.00	144.00	83.64	227.64	1293.30	1065.66	66.60	2074.50
10	1	16.00	144.00	79.95	223.95	617.30	393.35	24.58	2201.15
11	1	15.00	135.00	73.80	208.80	1185.50	976.70	65.11	2481.93
12	1	13.00	117.00	67.65	184.65	559.50	374.85	28.83	2570.14
13	1	12.00	108.00	61.50	169.50	1005.00	835.50	69.62	2769.62
14	1	11.00	99.00	55.35	154.35	470.00	315.65	28.69	2834.21
15	1	18.40	165.60	91.20	256.80	23788.50	23531.69	1278.89	7133.37

5. "WITH" AND "WITHOUT" COMPARISON

5.1. From the Forestry Department's Point of View.

5.1.1. The mixed agroforestry system

It was assumed that the farmers who are given the opportunity to intercrop and keep sheep between the Albizzia trees will be employed at the official wage rate by the F.D. to clear the land and plant and manage the trees. A contractor will be used to raise the seedlings and to construct the road network. It is envisaged that such an approach would

result in a saving for the F.D. because the contractor's normal overhead cost will be lower while at the same time the weeding costs for the first year will be eliminated since farmers are assumed to take care of the weeds through their annual crops.

Table 5 summarises the annual flow of costs and benefits of the forestry component in the mixed agroforestry model.

Table 5: FD component mixed model — Area Unit: hectare

SUMMARY RESULTS

* Year	* Season	Total Labour days	Variable Costs: Labour Costs m$	Variable Costs: Material Costs m$	Variable Costs: Total Costs m$	Returns: Gross Revenue m$	Returns: Net Revenue m$	Returns: N.R./days m$	Sum of Net Present Values m$
1	1	59.00	531.00	1212.30	1743.30	0.00	-1743.30	-29.54	-1556.51
2	1	3.50	31.50	86.00	117.50	0.00	-117.50	-33.57	-1650.18
3	1	4.00	36.00	86.00	122.00	0.00	-122.00	-30.50	-1737.02
4	1	18.50	166.50	156.00	322.50	0.00	-322.50	-17.43	-1941.98
5	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-1941.98
6	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-1941.98
7	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-1941.98
8	1	12.00	108.00	60.00	168.00	5650.00	5482.00	456.83	272.11
9	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	272.11
10	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	272.11
11	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	272.11
12	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	272.11
13	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	272.11
14	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	272.11
15	1	16.80	151.20	85.00	236.20	45080.00	44843.80	2669.27	8464.92

A comparison with Table 2 shows that the sum of the net present value per hectare increases from M$ 7,955 to M$ 8,465 because of the previously explained decrease in cost.

It can furthermore be computed that the cost of production per m^3 of sawlog (discounted at 12%) would be reduced from M$ 9.15 in the plantation model to M$ 7.33 in the mixed agroforestry model.

It may therefore be concluded that on the basis of the assumptions mentioned above, the mixed model satisfies the F.D's objectives and is worth considering.

5.1.2. The zonal agroforestry system

It has been assumed that farmers who participate in the zonal system will be employed at the official wage rate by the F.D. to clear, plant and manage the trees on half of the land. Clearing and cultivation of the other half will be the responsibility of the farmers. It is furthermore assumed that the roading cost per hectare does not decrease and will be the responsibility of the F.D. who will use a contractor to do the work.

A summary of costs and benefits of the foresty component in the zonal model is presented in Table 6.

Table 6 : FD component zonal model — Area Unit: hectare

SUMMARY RESULTS

* Year	* Season	Total Labour days	Variable Costs: Labour Costs m$	Variable Costs: Material Costs m$	Variable Costs: Total Costs m$	Returns: Gross Revenue m$	Returns: Net Revenue m$	Returns: N.R./days m$	Sum of Net Present Values m$
1	1	29.75	267.75	863.00	1131.75	0.00	-1131.75	-38.04	-1010.49
2	1	1.75	15.75	43.00	58.75	0.00	-58.75	-33.57	-1057.32
3	1	2.75	24.75	43.00	67.75	0.00	-67.75	-24.63	-1105.55
4	1	8.75	78.75	78.00	156.75	0.00	-156.75	-17.91	-1205.16
5	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-1205.16
6	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-1205.16
7	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-1205.16
8	1	6.00	54.00	30.00	84.00	2825.00	2741.00	456.83	-98.12
9	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-98.12
10	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-98.12
11	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-98.12
12	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-98.12
13	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-98.12
14	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-98.12
15	1	8.40	75.60	42.00	117.60	22540.00	22422.39	2669.33	3998.37

A comparison with Table 2 shows a sharp decline in the net present value per unit area of land for the F.D. from M$ 7,955 to M$ 3,998. However since twice the area is required to produce the same quantity of timber, total net benefits to the F.D. from the zonal model are slightly higher than from the plantation model. The m³ production cost of sawlogs (discounted at 12%) falls slightly from M$ 9.15 to M$ 9.0. However, this saving in the cost of production per m³ may be offset by a decrease in the ex-plantation price of sawlogs because of increased haulage distances (twice the area to collect the same amount of wood). Transportation per m³ are estimated around M$ 0.075/m³/km. (9). An increase in average haulage distance of, say 30 km would therefore increase the haulage cost by M$ 2.25 m³ which would be equivalent to M$ 0.41/m³ discounted at 12% over a 15-year period. An increase in average haulage distance of about 11 km would therefore offset the M$ 0.15 gain made on the cost of production ex-plantation.

5.2. From the Farmer's point of view.

5.2.1. The mixed agroforestry system
The farmer's net benefits from the mixed agroforestry model are derived from 3 different activities.

i) Labour activities for F.D. for tree cropping over a 15-year period;

ii) Crop activities during the first year;

iii) Livestock activities from year 2 to year 10.

A summary of the number of man-days per year spent on each activity as well as the net returns to labour (gross revenue minus material costs) are presented in Table 7.

The whole farm model, i.e. 15 hectares, shows a gradual increase in the total returns to family labour mainly because the farmer keeps increasing his flock of sheep. The flock reaches its maximum capacity in year 10, i.e. 53.1 ewes and remains stable from then on. After reaching this size, no further investment in buildings is required, thus increasing the annual income by M$ 383. No purchase of animals is required either; the model takes care of this automatically.

After year 15, the annual returns from forestry labour will drop from M$ 986 to 644 because the farmer only needs to replant the forestry plot, eliminating the labour input for land clearing (36 man-days).

Although the income from the model compares quite favourably with, for example, a miner's income of M$ 3,500 to 4,800/year, security of income from the agroforestry model will probably be less because the "forest user" is not a wage earner but also an enterpreneur assuming risks with the crop and sheep enterprise. Also, during the first 5 years, income from the agroforestry model will be less than that from a regular mining job.

It should be noted, furthermore, that the labour requirements of this 15-hectare farm model exceeds the one-man equivalent once the farm gets into a steady state (around year 10). Such a problem may be overcome by engaging other family members in the farm work. However, this may carry its cost if such family members are already gainfully employed elsewhere. Another solution is to employ a shepherd to look after all farmers' sheep on a communal basis. Each farmer would contribute to the wages of the shepherd in relation to his/her part in the total flock.

Table 7 : Net returns to farm labour per hectare of a mixed agroforestry system (M$)

	Forestry (labour)		Crops		Sheep		Total	
Year	mand	n.returns	mand	n.returns	mand	n.returns	mand	n.returns
1	59	531	133	2,421	-	-	192	2,952
2	3	31	-	-	10	-	13	31
3	4	36	-	-	20	-1,581	24	1,545
4	19	166	-	-	18	814	37	980
5	-	-	-	-	16	1,647(80)	16	1,647
6	-	-	-	-	14	720(106)	14	720
7	-	-	-	-	12	1,319(117)	12	1,319
8	12	108	-	-	9	605(127)	21	713
9	-	-	-	-	5	959(159)	5	959
10	-	-	-	-	1	452(254)	1	452
11	-	-	-	-	-	-	-	-
12	-	-	-	-	-	-	-	-
13	-	-	-	-	-	-	-	-
14	-	-	-	-	-	-	-	-
15	17	151	-	-	-	-	17	151

In brackets the value of the stock which will be absorbed by the next hectare to be cleared.

Table 8. Net returns to farm labour on a 15-hectare mixed agroforestry farm (in M$)

	Forestry (labour)		Crops		Sheep		Total		
Year	mand	n.returns	mand	n.returns	mand	n.returns	mand	n.returns	Acreage farmed (ha)
1	59	531	133	2,421	-	-	192	2,952	1
2	62	562	133	2,421	10	-	205	2,983	2
3	66	598	133	2,421	30	-1,581	229	1,438	3
4	85	764	133	2,421	48	-767	265	2,418	4
5	85	764	133	2,421	64	880	282	4,065	5
6	85	764	133	2,421	78	1,600	296	4,785	6
7	85	764	133	2,421	90	2,919	308	6,104	7
8	97	872	133	2,421	98	3,523	328	6,816	8
9	97	872	133	2,421	104	4,482	334	7,775	9
10	97	872	133	2,421	105	4,934	335	8,227	10
11	97	872	133	2,421	105	5,316	335	8,609	10
12	97	872	133	2,421	105	5,316	335	8,609	10
13	97	872	133	2,421	105	5,316	335	8,609	10
14	97	872	133	2,421	105	5,316	335	8,609	10
15	114	986	133	2,421	105	5,316	352	8,723	10

Although on paper this model seems to provide a reasonably good income, comparable to the medium income category, its adoptability will depend on whether or not there are farm families which view their present income position (level as well as security) as inferior to the one offered by this mixed agroforestry system.

5.2.2. Zonal agroforestry system

The per hectare income (returns to family labour) of the zonal agroforestry model are presented in Table 8. It should be noted that labour activities for the F.D. are less than in the mixed model because only half the area is used for tree cropping. Labour input for the crop activities are higher because of a larger cropped area, but also because labour input for clearing half the land will have to be borne by the farmer and is therefore allocated to the crop activities. Labour input for sheep rearing also increases because sheep are kept until year 15, and because additional labour is required to lop branches from the Erythrina rows.

The income from the 15-hectare farm model over a 15-year period is presented in Table 9. A comparison between the mixed and zonal farm model shows a significantly higher income for the zonal model. However, such increase in income is only obtained at a proportionally higher labour input. The returns to labour from the two models do not differ significantly - M$ 20.3 and M$ 20.1 per manday (undiscounted) respectively for the mixed and the zonal system.

From the farmer's viewpoint there is, therefore, little difference between the two models except that the risks involved in the zonal model are higher since a smaller percentage of the total income is derived from the "risk-free" forest labour wages. On the other hand, farmers may favour the zonal model because it offers a better opportunity to obtain legal ownership of the land.

6. SUMMARY AND CONCLUSION

Of the two agroforestry models examined in this paper, the mixed agroforestry system with *Albizzia falcataria* seems to be the most beneficial from the F.D's point of view, while the economic benefits from the zonal and the mixed system to the farmers are similar.

In the first instance it seems prudent to start researching/developing the mixed agroforestry system to test the validity of the different assumptions (technical as well as social) made in this paper.

Table 9 : Net returns to farm labour per hectare of a zonal agroforestry system (in M$)

	Forestry (labour)		Crops		Sheep		Total	
Year	mand	n.returns	mand	n.returns	mand	n.returns	mand	n.returns
1	30	270	168	2,677	-	-	198	2,947
2	2	18	-	-	6	-	8	18
3	3	27	-	-	20	-1,506	23	-1,479
4	9	81	-	-	19	700 (42)	28	781
5	-	-	-	-	19	1,428 (32)	19	1,428
6	-	-	-	-	18	640 (32)	18	640
7	-	-	-	-	18	1,330 (32)	18	1,330
8	6	54	-	-	17	597 (42)	23	651
9	-	-	-	-	16	1,210 (32)	16	1,210
10	-	-	-	-	16	537 (32)	16	537
11	-	-	-	-	15	1,112 (53)	15	1,112
12	-	-	-	-	13	492 (53)	13	492
13	-	-	-	-	12	944 (53)	12	944
14	-	-	-	-	11	415 (53)	11	415
15	8	72	-	-	10	1,199 (477)	18	1,271

In brackets the value of the stock which will be absorbed by the next hectare to be cleared.

Table 10 : Net returns to farm labour on a 15-hectare zonal agroforestry farm

(in M$)

Year	Forestry (labour)		Crops		Sheep		Total		Acreage farmed (ha)
	mand	n.returns	mand	n.returns	mand	n.returns	mand	n.returns	
1	30	270	168	2,677	-	-	198	2,947	1
2	32	288	168	2,677	6	-	206	2,955	2
3	35	315	168	2,677	26	-1,506	229	1,486	3
4	44	396	168	2,677	45	-806	257	2,267	4
5	44	396	168	2,677	64	622	276	3,695	5
6	44	396	168	2,677	82	1,262	294	4,335	6
7	44	396	168	2,677	100	2,592	312	5,665	7
8	50	450	168	2,677	117	3,189	335	6,316	8
9	50	450	168	2,677	133	4,399	351	7,526	9
10	50	450	168	2,677	149	4,936	367	8,063	10
11	50	450	168	2,677	164	6,048	382	9,175	11
12	50	450	168	2,677	177	6,540	395	9,667	12
13	50	450	168	2,677	189	7,484	407	10,611	13
14	50	450	168	2,677	200	7,899	418	11,026	14
15	58	522	168	2,677	210	9,098	436	12,225	15

However, a zonal approach should not be written off entirely at this stage, especially because it seems to be the only solution for the trees best suited for short rotation timber production at the moment, i.e. *Acacia mangium* and *Gmelina arborea*. Different models may be examined to increase the production from the agricultural zone so as to enable the farmer to subsidize the forestry operations in the tree zone.

REFERENCES

1. Etherington, D.M. and P.J. Matthews. 1984. Approaches to the economic evaluation of agroforestry farming systems. In "Agroforestry Systems". Vol. 2. No. 1. The Hague: Martinus Njhoff, The Netherlands (forth-coming).

2. Freezaillah b. Che Yeom. 1982. Forest resource development in peninsular Malaysia. In "Tropical Forests - Source of Energy Through Optimisation & Diversification", Universiti Pertanian Malaysia.

3. von Carlowitz, P.G. 1983. Some considerations of agroforestry interventions for the Malaysian Compensatory Plantation Programme, Nairobi ICRAF. (unpublished).

4. Wan Mohamed, W.E., K.F. Ng., I. Ismail and M.S. Samat. 1982. Meningkatkan Pendapatan Pekebun Kecil Getah Menerusi Perkebunan Campuran. Seminar Kebangsaan Pekebun Kecil Getah Malaysia Serdang Selangor.

5. Wan Mohamed, W.E. 1982. Animal Production in Rubber Plantation - A review. Asian Livestock Bulletin, Asian Pacific Region Vol. II No. 10. Rome: F.A.O.

6. Wan Mohamed, W.E. 1982. Feasibility Tempat Membaik-baik Biri Biri. (unpublished) Kuala Lumpur: Rubber Research Institute Malaysia (R.R.I.M).

7. Wan Mohamed, W.E. and M.Z. Ahmed Hamidy. 1983. Performance of Dorset Horn Crossbreds under Rubber. Kuala Lumpur: R.R.I.M. Planters Conference.

8. MARDI. 1982. Anggaran Kos Pengeluaran Dan Pendapatan Untuk Tanaman Dan Temakan. Kuala Lumpur: MARDI.

9. von Carlowitz, P.G. 1983. Forest Plantation Revenues (unpublished). Nairobi: ICRAF.

Assumptions on fodder production/carrying capacity

The following assumptions are the results of some educated guesses by ICRAF scientists. They should therefore not be interpreted as factual but rather as a starting point for discussion. It is the feeling of the scientists concerned that their guestimates may be improved upon by a thorough literature review and by developing some biological models forecasting yield responses of different crops to different light intensities which in turn may be determined by canopy densities, sun angles,etc., as well as to underground competition between herbaceous and woody components.

General assumptions

- Potential dry matter production of a mixture of *Calopogonium caeruleum* and *Brachiaria miliiformis*, under unshaded conditions from the second year onwards 12,000 kg/hectare.

- Availability pasture production under grazing conditions 50%.

- Dry matter requirements of sheep estimated at 1 kg/ewe/day. (2.5% of 40 kg body weight).

Specific assumptions for mixed agroforestry models

- Area available for grass production 90% of the total, i.e. 0.9 hectare.

- Pasture production decline due to increased shade from the canopy and competition is assumed to be as follows:

System year	%	System year	%
3*	68.8	7	43.8
4	65.0	8	35.0
5	58.8	9	23.8
6	51.3	10	8.8

(expressed as a percentage of the potential production)
*third system year is the second pasture year.

Specific assumptions for zonal agroforestry model

- Area available for grass production 0.45 hectares i.e. 50% of area utilised at 90% (roads, pathways etc). Potential dry matter intake therefore 12,000 x 0.5 x 0.9 x 0.5 = 2,700 kg/annum.

- Annual decline in pasture production due to shade (height growth timber trees on the edges) is 4% until year 10, increasing to 6%/year from year 10 onwards because of the combined effects of shade and pasture degradation.

- Data from Costa Rica show an average D.M. fodder production per tree of 13.93 kg ± 3.6 kg. (1). A conservative estimate is therefore 10 kg/tree/year. In the zonal system this production has to be reduced by half because only one side of the Erythrina trees are lopped. Assuming a 2-meter interval between trees, the total number of Erythrina trees per hectare of the zonal system is 100 and therefore the total d.m. fodder production 500 kg/hectare/annum. The consumption availability of these Erythrina loppings is assumed to be 100%.

1. Russo, R.O.A. 1983. Effecto de la Poda de Erythrina poeppigiana (Walpers) O.F. Cook (Poro), Sobre la nodulacion, produccion de biomasa y contenido de nitrogeno en el suelo en un sistema agroforestal "Cafe-Poro". MSc. Thesis, Universidad de Costa Rica.

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