Plates

PLATE

A-1

Land use in Cameron Highlands: A watershed scale perspective

Photo taken from Gunung Irau, Cameron Highlands.

Photo taken by Liaw Shen Yeong

PLATE

A-2

Agriculture management: A field scale perspective

Photo taken at Teringkap, Cameron Highlands

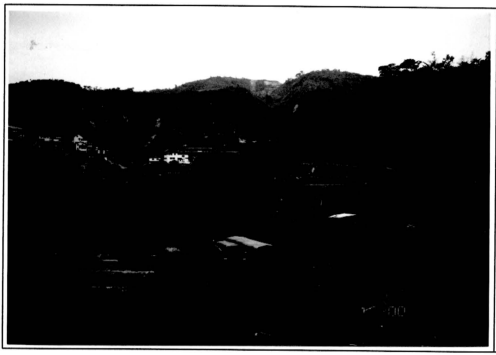


PLATE B-1

Farming activities on steep hill slope-I.
Kea Farm, Cameron Highlands.

PLATE B-2

Farming activities on steep hill slope-II. Background is a number of high rise resorts.
Kea Farm, Cameron Highlands.

PLATE C-1

Land cleared by heavy machinery. Blue Valley, Cameron Highlands.

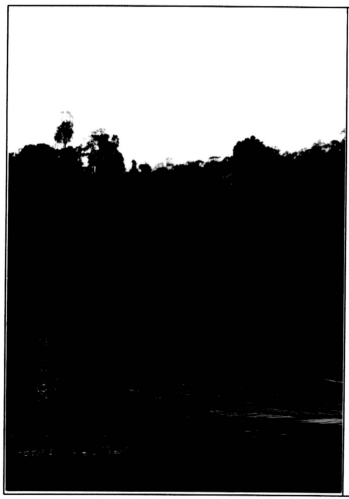


PLATE C-2

Land cleared by heavy machinery on steep hill slope.
Kampung Kuala Terla, Cameron Highlands.

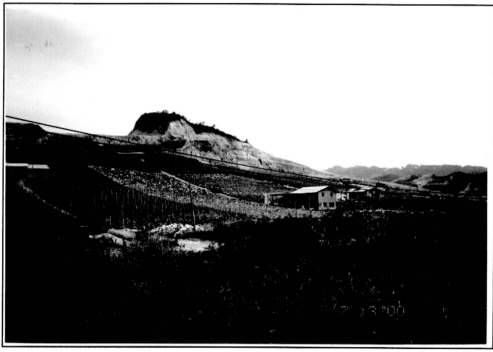


PLATE C-3

Leveling of hill and the exposure of bare soil.
Blue Valley, Cameron Highlands.

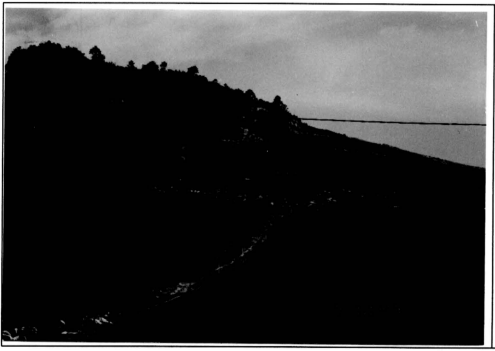


PLATE C-4

Land cleared for cultivation. Severe soil erosion occurred on the bare land.
Blue Valley, Cameron Highlands.

PLATE C-5

A large piece of land cleared for cultivation. Photo taken on 10th Feb. 2000.
Blue Valley, Cameron Highlands. N 4° 35.5' E101° 25.3'
Photo taken by: Mohd. Nadzari bin Ismail.

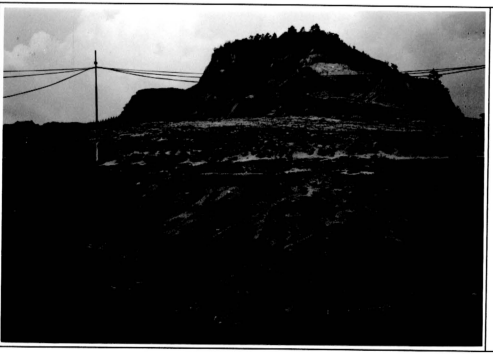


PLATE C-6

. The same location after experienced severe erosion. Photo taken on 13th July 2000.

PLATE D-1

Construction activities on steep hill slope.
Tanah Rata, Cameron Highlands.

PLATE D-2

Highway construction and the exposure of bare soil.
Blue Valley, Cameron Highlands.

PLATE E-1

Heavily silted dry river bed of Telom.

Telom Intake, Kampung Kuala Terla, Cameron Highlands.

PLATE F-1

Deforestation at hill slope.

Trees were felt and landslide occurred on the steep slope.

Teringkap, Cameron Highlands.

PLATE F-2

The entire hill was deforested.

Teringkap, Cameron Highlands.

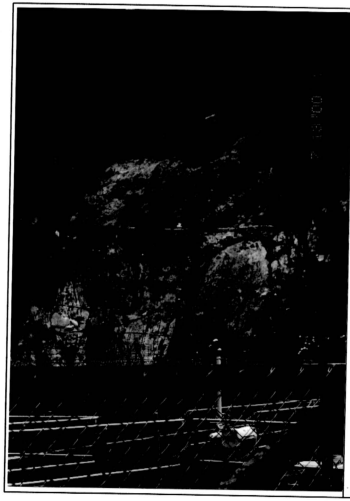
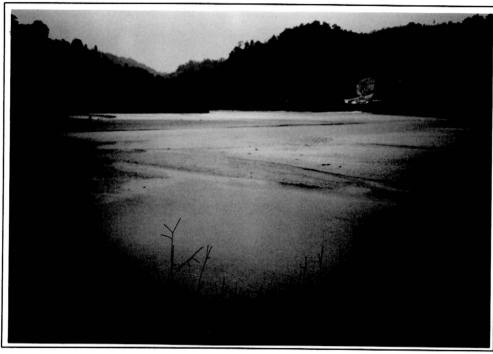


PLATE G-1

Landslide in Cameron Highlands-I. Beside the Telom Intake.

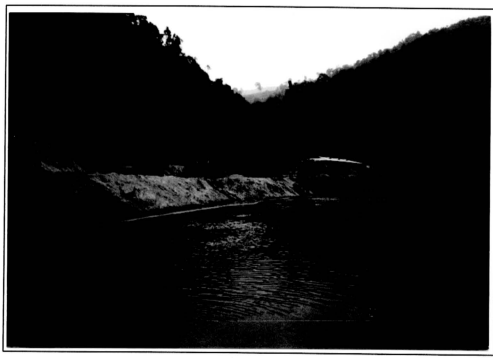


PLATE

I-1

Ringlet Reservoir is filled with sediment.

Ringlet, Cameron Highlands



PLATE

I-2

Excavation at the Habu Weir.

Habu, Cameron Highlands.

Appendix A

REFERENCED TABLES

Appendix A: Table A-1

Hectareage of Vegetable Crops in Cameron Highlands (1998).

Vegetable Crops	Hectareage			
	Peninsular Malaysia	Pahang Darul Makmur	Cameron Highlands	Percentage in Peninsular Malaysia
Asparagus *(Asparagus)*	37	21	21	57%
Brokoli *(Broccoli)*	16	16	16	100%
Cili (Chilli)	2,734	302	15	1%
Daun Bawang *(Spring Onion)*	266	92	92	35%
Daun Ketumbar *(Chinese Parsley)*	40	24	24	60%
Kacang Buncis *(French Bean)*	1,169	277	147	13%
Kacang Pea *(Snow Pea)*	40	40	40	100%
Kacang Seringding *(Butter Bean)*	8	8	8	100%
Kacang Wangi *(Sweet Pea)*	50	45	45	90%
Kangkong *(Water Spinach)*	1,341	88	0.1	0.01%
Kaukei *(Chinese Box Thorn)*	71	68	68	96%
Kobis Bulat *(Cabbage)*	561	401	395	70%
Kobis Bunga *(Cauliflower)*	40	20	20	50%
Kobis Cina *(Chinese Cabbage)*	393	367	367	93%
Lada Besar*(Sweet Pepper)*	167	156	156	93%
Lekio *(Sweet Leek)*	49	48	48	98%
Lobak Merah *(Carrot)*	8	7	7	88%
Lobak Puteh *(Chinese Radish)*	113	90	90	80%
Poh Choy *(Spinach)*	40	40	40	100%
Saderi *(Celery)*	62	15	15	24%
Saderi Cina *(Chinese Celery)*	10	10	10	100%
Salad *(Lettuce)*	846	232	230	27%
Salad Bulat *(Head Lettuce)*	230	230	230	100%
Sawi Bunga *(Leaf Mustard)*	2,383	152	22	1%
Sawi Itik *(Sawi Itik)*	5	5	5	100%
Sawi Kerinting *(Sawi Kerinting)*	1,119	20	20	2%
Sawi Pahit *(Chinese Mustard)*	751	42	37	5%
Sawi Pendek *(Dwarf White Mustard)*	848	34	20	2%
Sawi Puteh *(Chinese White Cabbage)*	1,601	37	13	1%
Sawi Rana *(Indian Lettuce)*	32	32	32	100%
Sayur Raja *(Green Ceylon Spinach)*	10	10	10	100%
Selada Air *(Watercress)*	32	32	32	100%
Terung *(Brinjal)*	1,332	114	12	1%
Timun *(Cucumber)*	3,025	249	12	0.4%
Tomato *(Tomato)*	516	398	398	77%
Tongho *(Garland Chrysanthemum)*	120	120	120	100%
Total	**20,065**	**3,842**	**2,817**	**14%**

Source: Department of Agriculture (DOA), Ministry of Agriculture, Malaysia (1999), *Crops Hectareage Statistics*, in http://agrolink.moa.my/doa/, last updated in December 1999.

Appendix A: Table A-2

Hectareage and Production of Cut Flower Cultivation in Cameron Highlands (1995).

No.	Type	Area (ha)	Production (stalk)
1	Orchid	13.82	1,734,100
2	Chrysanthemum	227.52	123,752,800
3	Rose	109.32	83,796,480
4	Gerbera	29.20	2,133,600
5	Strelitzia	11.02	153,120
6	Limonium	31.50	3,737,746
7	Anthurium	32.76	319,200
8	Peacock	21.00	731,200
9	Carnation	64.80	931,680
10	Aster	29.10	624,800
11	Lilium	23.40	166,500
12	Gypsophila	21.00	326,500
13	Zantedechia	1.60	180,000
14	Statice	1.80	21,520
15	Gladiolus	10.20	1,920,000
16	Liatris	10.20	80,000
Total		**638.24**	**220,529,246**

Source: Federal Agricultural Marketing Authority (FAMA), Cameron Highlands, 1995.

Appendix A: Table A-3

Guideline for Agriculture Activities for Various Crops and Land Slopes in Highlands.

Slope Range	0-2°	2-6°	6-12°	12-20°	20-25°	> 25°
Land Clearing Measures						
Annual (Vegetable and Flower)	1, 2, 4(c), 5, 6, 7, 8		1, 4(a), 5, 6			
Perennial	1, 2/3, 4(c) , 5, 6, 8					

Guidelines:-

1. Land Clearing measures should be conducted in manageable stages so that there will be minimum exposure of the land to erosion process.
2. Clean felling.
3. Selective felling.
4. Method of clearing (a) manual; (b) mechanical; (c) both.
5. Buffer zones for all natural waterways and water bodies should be left undisturbed in any land development scheme.
6. For extensive area, clearing during dry season.
7. Destamping only required for certain crops system.
8. Light burning.

Conservation Structure/Measures						
Annual (Vegetable and Flower)	4	1, 4, 5, 6	1/3, 4, 5, 6, 8	1/3, 4, 5, 6, 8, 9, 10		
Perennial	4	4, 6	1/2, 4, 5, 6, 7, 8			

Guidelines:-

1. Bench terrace
2. Platform/individual basin
3. Plateau/broad bench
4. Drain and waterways
5. Silt pits/traps/contour ditches
6. Hillsides ditches
7. Orchard terrace
8. Check dams
9. Culverts
10. Stone wall/retaining wall/gabions

Agronomic Measures					
Annual (Vegetable and Flower)	3, 5, 6, 7, 10				
Perennial	1, 2, 3, 4, 5, 7, 8, 9, 10				

Guidelines:-

1. Ground cover
2. Contour planting
3. Mulching
4. Minimum tillage
5. High density planting
6. Crop rotation
7. Intercropping
8. Alley cropping
9. Grass strips
10. Wind breakers

Source: Department of Agriculture, Ministry of Agriculture, Malaysia (1998), *Guideline on Agriculture Activities on Steep Land.*

Appendix A: Table A-4: Areas of the Various Catchment in Cameron Highlands-Batang Padang Hydroelectric Scheme

Catchment	Area
Plau'ur River	9.7 km^2
Telom River @ Miles 49	77.7 km^2
Kial River	22.5 km^2
Kodol River	1.4 km^2
Bertam River @ Robinson Falls	21 km^2
Bertam River and Ringlet River	70.4 km^2
Sultan Abu Bakar Dam	181.7 km^2
Jor Main Dam	393 km^2
Mahang Dam	394 km^2

Source: (UM and TNBR, 2001)

Appendix A: Table A-5: Summary of Power Stations

Power Station	Type	Head	Installed Generators	Annual Generation
Kampung Raja	Run-of-river	80 m	0.8 MW	6.2 GWh
Kuala Terla	Run-of-river	37 m	0.5 MW	4.2 GWh
Robinson Falls	Run-of-river	235 m	3 x 0.3 MW	7.6 GWh
Habu	Run-of-river	91 m	2 x 2.75 MW	34 GWh
Sultan Yussuf (Jor)	Reservoir	546 m	4 x 25 MW	320 GWh
Sultan Idris II (Woh)	Reservoir	421 m	3 x 50 MW	480 GWh
Odak	Reservoir	15 m	3 x 1.4 MW	20 GWh
Total				**872 GWh**

Source: (UM and TNBR, 2001)

Appendix A: Table A-6: Rainfall Stations.

Station No./Name	Latitude N	Longitude E	Date Installed/ Closed	Operator	Remarks
Telom Catchment					
9001 Ladang Teh Blue Valley	04°35"10'	101°25"10'	01/48	ESTATE	Manual
9002 Pejabat TNB Kg. Raja	04°33"05'	101°25"00'	01/62	TNB	Manual
9003 Alurmasuk Sg. Telom	04°32"32'	101°25"30'	02/64	TNB	Automatic
9004 Ladang Teh Sg. Palas	04°31"00'	101°25"00'	01/54	ESTATE	Manual
9005 Stn. Talikom Gunung Brinchang	04°31"00'	101°23"00'	05/54-	JPS	Manual
9006 Stn. Janaletrik Bintang	04°29"40'	101°25"30'	07/85 02/66	TNB	Manual
Bertam Catchment					
9007 Balai Kajilklim Tanah Rata	04°28"00'	101°23"00'	02/66	MMS	Manual
9008 Stesen Mardi Tanah Rata	04°23"00'	101°23"00'	01/48	MARDI	Manual
9009 Stesen Janaletrik Habu	04°25"05'	101°23"00'	02/64	TNB	Manual
9010 Ladang Teh Boh (Bhg. Kilang)	04°27"05'	101°25"30'	01/53	ESTATE	Manual
9012 Ladang Teh Shum Yip Leong	04°26"45'	101°21"00'	01/50	ESTATE	Manual
9111 Balai Kajicuaca Tanah Rata	04°28"00'	101°22"00'	01/55	MMS	Manual

Source: (UM and TNBR, 2001)

Appendix A: Table A-7: Areal Rainfall (mm) at Bertam Catchment.

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Yearly
1948	105	151	291	318	300	76	115	144	193	330	241	59	2,323
1949	23	160	110	371	370	153	247	185	287	337	286	282	2,811
1950	210	220	309	238	318	114	151	208	198	248	352	137	2,703
1951	331	192	104	246	174	111	155	209	470	133	495	176	2,796
1952	132	79	504	199	302	77	131	165	188	288	418	169	2,652
1953	120	157	232	388	240	302	146	45	243	235	238	149	2,495
1954	142	84	225	263	262	97	205	102	98	489	244	270	2,481
1955	84	99	116	301	242	170	206	272	153	394	360	218	2,615
1956	128	123	179	420	238	224	229	174	248	333	295	341	2,932
1957	55	132	348	284	332	94	160	80	192	292	350	217	2,536
1958	135	67	118	239	305	91	91	159	135	377	230	56	2,003
1959	44	74	274	246	230	170	95	234	191	415	273	206	2,452
1960	120	77	284	326	321	62	145	138	207	198	259	203	2,340
1961	172	181	180	315	156	131	172	94	303	313	292	211	2,520
1962	117	89	308	363	355	91	81	336	212	389	207	238	2,786
1963	97	40	119	122	254	65	178	166	185	286	386	156	2,054
1964	93	62	65	193	346	122	358	107	161	239	352	151	2,249
1965	18	91	250	229	316	103	145	166	342	300	248	319	2,527
1966	245	124	276	221	186	219	216	210	171	434	289	327	2,918
1967	255	104	145	319	265	120	101	104	180	292	445	71	2,401
1968	43	68	83	104	350	184	147	134	173	325	147	292	2,050
1969	160	59	169	196	361	138	126	257	167	277	397	192	2,499
1970	231	59	177	306	368	121	95	143	330	347	331	406	2,914
1971	238	131	151	53	211	117	113	227	177	189	516	528	2,651
1972	52	252	121	450	251	115	43	191	300	312	352	211	2,650
1973	82	99	109	255	401	236	147	174	169	336	434	266	2,708
1974	61	111	77	338	295	127	173	95	356	142	179	103	2,057
1975	231	143	366	243	259	84	241	74	258	119	274	313	2,605
1976	29	83	214	251	123	258	207	180	166	693	276	120	2,600
1977	84	119	60	235	191	132	90	168	143	562	155	108	2,047
1978	71	60	120	336	275	71	182	63	143	324	276	82	2,003
1979	60	101	150	253	185	203	166	51	161	219	415	54	2,018
1980	82	114	188	102	320	135	93	273	209	329	410	249	2,504
1981	77	94	33	255	356	84	107	49	295	222	192	65	1,829
1982	31	104	296	413	189	95	180	201	259	335	196	84	2,383
1983	75	22	113	60	188	141	244	251	362	139	145	136	1,876
1984	196	230	253	201	313	157	187	120	152	244	254	354	2,661
1985	83	136	316	87	324	52	144	151	211	362	578	240	2,684
1986	106	63	130	320	227	158	147	23	177	252	257	126	1,986
1987	62	41	72	201	291	137	145	285	293	392	125	195	2,239
1988	41	228	191	172	237	253	195	307	298	68	373	196	2,559
1989	96	70	209	259	188	270	181	125	252	334	310	133	2,427
1990	108	34	122	170	271	129	185	108	279	376	246	105	2,133
1991	59	90	181	332	447	109	134	97	177	252	270	135	2,283
1992	41	151	120	201	305	81	146	136	125	241	318	198	2,063
1993	70	98	164	333	244	121	199	162	298	384	242	245	2,560
1994	44	184	273	227	270	191	40	194	255	254	180	183	2,295
1995	110	61	171	322	160	239	151	388	261	402	326	214	2,805
1996	134	98	199	330	275	178	147	252	129	510	351	362	2,965
1997	65	226	311	228	124	195	186	180	165	311	378	196	2,565
Minimum	18	22	33	53	123	52	40	23	98	68	125	54	1,828
Maximum	331	252	504	450	447	302	358	388	470	693	578	528	2,965
Mean	109	112	189	255	270	143	158	168	223	311	305	204	2,444
Standard Deviation	70	56	94	90	72	59	56	78	75	113	99	97	299
Coefficient of Variability	64%	50%	50%	35%	27%	42%	35%	47%	34%	36%	32%	48%	12%

Source: UM and TNBR, 2001

Appendix A: Table A-8: Areal Rainfall (mm) at Telom Catchment.

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Yearly
1954	150	86	199	225	266	74	168	162	123	506	223	284	2,465
1955	88	104	59	280	194	133	129	168	164	335	295	266	2,215
1956	130	78	186	304	162	218	182	134	169	343	279	300	2,483
1957	69	64	300	204	425	36	110	74	133	262	437	332	2,446
1958	177	82	145	195	217	116	75	104	89	371	193	72	1,836
1959	59	53	241	285	262	93	46	128	153	432	296	178	2,226
1960	131	57	302	352	168	59	192	111	155	165	210	220	2,123
1961	202	145	179	337	98	103	125	113	266	258	292	228	2,345
1962	112	52	299	256	144	88	49	287	218	470	194	300	2,469
1963	216	99	199	75	203	104	106	106	170	322	303	185	2,087
1964	106	198	90	256	254	110	369	40	156	244	229	176	2,229
1965	24	103	228	326	245	102	123	199	278	371	350	233	2,582
1966	164	154	129	245	123	178	161	193	242	404	307	236	2,538
1967	324	264	102	257	229	107	62	88	225	302	399	132	2,490
1968	55	40	139	91	239	203	114	91	107	253	132	248	1,710
1969	134	106	211	170	313	129	52	250	125	322	265	253	2,330
1970	399	79	130	290	338	64	117	169	315	220	302	510	2,865
1971	254	148	154	72	151	58	79	228	166	152	326	672	2,461
1972	50	179	87	472	159	201	71	179	331	303	379	219	2,629
1973	121	113	119	243	321	230	172	123	153	658	297	264	2,814
1974	92	153	128	428	322	159	135	78	378	112	162	130	2,276
1975	219	145	227	162	186	58	286	91	180	125	278	346	2,305
1976	25	74	168	233	99	159	179	202	180	276	259	184	2,037
1977	54	153	36	177	260	152	127	196	155	558	142	140	2,148
1978	133	95	179	250	230	57	180	79	117	266	224	209	2,019
1979	101	96	171	260	191	211	158	65	200	209	514	75	2,251
1980	86	107	196	141	308	136	158	274	150	361	316	189	2,423
1981	73	116	69	243	295	89	71	79	289	236	149	110	1,818
1982	31	118	232	338	280	63	134	155	195	319	249	199	2,314
1983	78	35	90	86	185	199	247	161	258	141	160	228	1,867
1984	252	329	290	226	343	79	218	77	97	257	205	259	2,625
1985	126	190	230	102	302	96	122	106	157	344	396	151	2,321
1986	139	22	209	229	122	89	81	21	190	250	228	199	1,780
1987	152	26	172	187	213	106	113	213	272	448	135	205	2,242
1988	65	133	232	174	211	132	101	318	327	97	339	183	2,312
1989	159	23	170	191	203	111	134	91	217	250	255	80	1,884
1990	106	92	89	255	226	86	154	79	172	345	169	138	1,910
1991	57	56	359	206	364	99	72	95	109	302	200	206	2,124
1992	53	194	47	196	227	86	139	122	179	205	339	218	2,007
1993	110	75	205	237	213	142	186	121	294	317	279	322	2,502
1994	57	299	288	255	206	169	31	192	221	328	294	185	2,416
1995	238	77	159	230	181	157	124	283	187	303	336	196	2,470
1996	161	99	208	380	180	192	93	204	108	390	269	343	2,627
1997	40	189	137	249	77	124	144	89	240	424	352	207	2,307
Minimum	24	22	36	72	77	36	31	21	89	97	132	72	1710
Maximum	399	329	359	472	425	230	369	318	378	658	514	672	2865
Mean	127	116	177	236	226	122	134	144	196	308	272	228	2280
Standard Deviation	80	68	74	85	75	50	64	70	69	115	83	105	272
Coefficient of Variability	63%	59%	42%	36%	33%	41%	48%	48%	35%	37%	31%	46%	12%

Source: UM and TNBR, 2001

Appendix A: Table A-9: Streamflows Stations.

Station No./Name	Lat. N	Long. E	Date Installed	Catchment Area (km^2)	Type of Instrument
6002 Telom River @ Miles 49	04°32"35'	101°25"28'	09/55	77.7/87.3*	KENT-FLOAT
9003 Bertam River @ Robinson Falls	04°27"55'	101°23"14'	08/56	21.2	KENT-FLOAT/PRESSURE BULB/SEBA-FLOAT

Note:

*Catchment area for Telom River has changed since 1964. It is due to the additional flow from Plau'ur diversion.

Source: (UM and TNBR, 2001)

Appendix A: Table A-10: Streamflow (mm) at Bertam River @ Ronbinson Falls.

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Yearly
1949	58	61	161	156	252	154	235	157	208	227	218	215	2102
1950	182	181	244	224	243	138	131	132	138	165	202	151	2131
1951	141	179	257	152	146	97	121	117	329	183	281	233	2236
1952	142	150	106	255	241	136	109	98	121	157	219	184	1918
1953	151	150	175	219	229	265	130	71	156	126	137	132	1941
1954	87	82	121	166	191	114	174	86	55	202	177	193	1648
1955	182	105	122	131	175	150	173	177	124	229	242	200	2010
1956	178	138	150	202	221	209	209	143	181	211	208	223	2273
1957	185	139	134	222	254	137	150	70	114	145	181	182	1913
1958	154	120	108	112	178	94	84	88	80	159	168	113	1458
1959	67	35	91	169	182	166	73	129	135	200	221	187	1655
1960	154	98	108	205	240	111	148	89	130	133	148	135	1699
1961	109	136	208	186	171	129	143	66	197	178	196	195	1914
1962	139	107	116	229	270	140	105	177	160	219	223	177	2062
1963	152	105	95	91	126	91	83	99	86	145	198	153	1424
1964	101	83	76	91	158	99	184	121	131	158	221	168	1591
1965	109	92	116	154	206	124	117	117	236	197	226	236	1930
1966	184	154	154	173	167	192	160	143	147	241	229	212	2156
1967	238	169	186	162	195	124	107	91	106	134	215	152	1879
1968	105	87	78	72	152	139	97	86	99	140	112	138	1305
1969	126	88	97	117	198	128	104	152	117	176	216	198	1717
1970	215	136	119	144	176	120	97	99	157	208	201	215	1887
1971	284	154	138	99	112	102	82	139	129	104	198	327	1868
1972	191	184	124	262	225	172	112	114	152	182	211	186	2115
1973	125	106	99	143	211	187	139	153	129	196	278	253	2019
1974	163	143	117	179	220	147	123	109	177	135	133	112	1758
1975	166	115	162	176	177	128	178	111	148	104	147	206	1818
1976	124	96	106	135	115	133	140	125	131	206	186	136	1633
1977	115	99	80	109	120	116	88	90	90	229	143	104	1383
1978	92	75	72	135	170	76	97	86	101	147	190	114	1355
1979	95	77	83	123	116	112	114	83	107	119	205	131	1365
1980	95	90	109	86	147	107	86	158	133	198	149	212	1570
1981	144	129	97	140	168	96	92	78	166	124	147	104	1485
1982	80	86	120	176	155	126	115	101	166	179	134	112	1550
1983	95	76	81	64	88	81	109	110	172	116	109	115	1216
1984	115	187	149	171	207	162	159	114	125	144	162	196	1891
1985	110	112	160	104	181	112	100	107	104	196	287	217	1790
1986	148	104	107	176	143	109	91	73	101	158	178	135	1523
1987	97	77	76	109	159	96	77	169	172	224	184	182	1622
1988	101	125	170	141	173	150	123	187	239	162	225	184	1980
1989	150	100	125	157	157	99	133	88	119	164	171	153	1616
1990	110	96	86	97	163	91	120	93	107	163	177	140	1443
1991	85	88	117	126	214	240	97	88	93	116	136	117	1517
1992	102	101	96	99	116	99	88	86	86	125	187	128	1313
1993	99	102	100	222	294	114	143	121	171	229	191	234	2020
1994	128	148	163	153	164	145	110	120	163	141	160	133	1728
1995	123	91	105	149	120	120	96	177	133	176	236	186	1712
1996	138	130	134	172	190	155	133	126	120	243	220	250	2011
1997	147	173	148	143	124	119	159	101	115	174	256	179	1838
Minimum	58	35	72	64	88	76	73	66	55	104	109	104	1216
Maximum	284	187	257	262	294	265	235	187	329	243	287	327	2273
Mean	134	115	125	153	180	132	123	115	140	171	193	174	1755
Standard Deviation	44	35	41	46	45	38	35	32	47	38	41	47	267
Coefficient of Variability	32%	30%	32%	30%	25%	29%	28%	28%	33%	22%	21%	27%	15%

Source: UM and TNBR, 2001

Appendix A: Table A-11: Streamflow (mm) at Telom River @ Miles 49.

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Yearly
1949	37	205	62	67	133	120	211	185	180	201	193	176	1771
1950	199	241	207	187	216	117	141	149	131	142	233	116	2079
1951	217	181	103	126	124	80	116	134	159	162	384	148	1934
1952	144	182	246	203	217	126	113	118	101	129	251	175	2004
1953	138	234	134	137	176	256	210	111	165	97	122	58	1836
1954	116	109	93	93	109	67	121	124	104	175	96	183	1391
1955	146	154	20	35	71	90	122	116	119	135	169	202	1378
1956	157	136	81	90	109	179	169	132	159	146	148	220	1727
1957	128	105	114	133	176	140	104	91	99	119	176	210	1595
1958	181	144	103	93	115	90	78	89	73	119	127	95	1308
1959	108	95	105	84	113	92	79	79	77	120	138	117	1206
1960	107	99	104	122	155	106	118	99	104	99	137	130	1379
1961	166	134	106	131	134	107	93	83	107	121	142	142	1468
1962	161	114	147	134	133	95	87	119	106	155	144	160	1555
1963	140	114	107	88	95	74	80	73	73	122	176	145	1287
1964	99	113	101	96	123	95	140	99	110	119	159	147	1403
1965	107	92	107	142	166	108	103	114	153	177	194	195	1658
1966	171	120	125	128	122	109	128	119	124	199	180	169	1693
1967	232	167	192	132	157	98	96	88	116	137	185	200	1801
1968	135	91	101	86	106	115	94	75	75	117	91	150	1235
1969	120	84	92	106	173	123	100	134	114	188	200	249	1682
1970	276	146	117	133	175	123	112	120	145	189	191	252	1978
1971	503	214	159	97	103	96	82	107	126	97	159	463	2206
1972	183	129	95	174	146	125	92	92	167	175	218	229	1826
1973	189	144	126	138	167	168	136	144	118	210	241	278	2060
1974	174	141	123	175	166	95	93	71	113	90	97	81	1418
1975	119	80	111	83	111	73	107	71	86	62	134	182	1221
1976	105	65	65	74	76	80	83	78	89	136	148	155	1153
1977	134	105	75	77	97	94	77	84	81	285	151	173	1435
1978	180	97	110	123	143	71	96	53	68	111	188	201	1441
1979	119	78	88	113	114	128	121	63	113	100	264	181	1483
1980	112	79	108	99	166	129	108	179	103	193	195	197	1670
1981	130	91	62	121	168	75	61	36	88	69	84	80	1065
1982	46	49	60	178	153	76	69	61	81	123	140	157	1195
1983	140	72	68	47	79	89	129	105	147	109	114	196	1295
1984	183	288	219	160	193	154	152	104	89	128	117	164	1949
1985	123	125	165	94	144	85	81	62	78	146	187	165	1455
1986	195	90	139	121	96	99	65	48	76	113	129	182	1351
1987	138	81	104	94	131	92	79	158	133	211	171	199	1592
1988	136	112	142	137	135	109	118	170	205	121	183	172	1739
1989	223	105	109	161	138	106	102	82	101	130	132	152	1540
1990	122	106	71	101	162	97	102	94	102	169	181	174	1480
1991	123	69	96	136	171	123	141	91	93	142	170	187	1544
1992	147	109	99	103	125	105	93	85	86	121	176	176	1424
1993	135	104	119	126	153	122	133	99	145	199	208	239	1783
1994	166	159	164	143	154	139	112	124	136	179	220	197	1892
1995	184	136	128	125	133	138	130	190	146	163	236	209	1918
1996	172	173	141	162	216	189	147	130	135	144	111	204	1926
1997	99	101	95	103	102	81	124	74	78	114	204	200	1374
Minimum	37	49	20	35	71	67	61	36	68	62	84	58	1065
Maximum	503	288	246	203	217	256	211	190	205	285	384	463	2206
Mean	154	126	114	119	140	111	111	104	114	143	171	180	1588
Standard Deviation	66	49	42	35	35	34	32	35	32	42	52	60	277
Coefficient of Variability	43%	39%	36%	29%	25%	31%	28%	34%	28%	29%	31%	33%	17%

Source: UM and TNBR, 2001

Appendix A: Table A-12

Estimates of Sediment Yield from Small Forested and Disturbed Humid Tropical Catchments (modified from Douglas *et. al.*, 1992).

Name of Catchment	Catchment Area (km^2)	Sediment Yield (t/ha/yr)	Sediment Yield ($m^3/km^2/yr$)	Source
a) Forested catchments in Malaysia				
▸ Telom River, CH	77	0.53	35.3	1956
▸ Mupor River, Johor	21.8	0.41	27.3	1973
▸ Gombak River, Selangor	140	0.97	64.7	1975
▸ W8S5, Ulu Segama	1.1	3.12		1992
b) Secondary forest catchments in Malaysia				
▸ Tekam River, Pahang	0.47	0.35	23.3	1986
▸ Sipitang, Sabah	0.15	0.6	40	1990
c) Cleared or logged catchments in Malaysia				
▸ Tekam River, Pahang	0.47	6.6	440	1986
▸ Bt. Berembun, Negeri Sembilan	0.13	0.22	14.7	1990
(supervised)	0.30	1.89	126	1990
(normal)	0.15	3.0	200	1990
▸ Sipitang, Sabah	0.56	16.0	1,067	1992
▸ Baru, Ulu Segama				
d) Catchments affected by urbanization in Malaysia				
▸ Jinjang River	10.3	10.6	704.0	1991
▸ Kelang River, Zoo Negara	14.2	14.8	986.7	1991
e) Other tropical catchments with yields >1,000 tons/km^2/yr				
▸ Cigulung, East Java	43	10.9	723.3	1982
▸ Cikeruh, Java	250	112.0	7,466.7	1982
▸ Ok Ningi, New Guinea	4.56	107.5	7,164	1981
▸ Ok Tedi, New Guinea	420	78.6	5,23.8	1981

Note: "Erosion rate" in m^3/km^2/year is calculated from 'Sediment Yield' assuming a mean sediment density of 1,500 kg/m^3.

Appendix A: Table A-13: Annual Sediment Excavation

Year	Excavation Rate-Telom River Basin (m^3/yr)	Excavation Rate – Bertam River Basin (m^3/yr)	Excavation Rate - Ringlet River Basin (m^3/yr)	Excavated Deposit by Annual Contract from Ringlet Reservoir (m^3/yr) *	Total Sediment excavated (m^3/yr)
1983	11,380	6,244	78,441	86,400	182,465
1984	13,581	4,645	76,349	86,400	180,975
1985	15,737	5,665	38,608	84,750	144,760
1986	16,050	8,111	58,263	84,750	167,174
1987	23,416	9,242	40,138	66,700	139,496
1988	18,912	12,417	46,557	77,867	155,753
1989	27,445	17,328	53,436	77,867	176,076
1990	11,287	12,781	17,586	77,867	119,521
1991	21,540	26,931	40,202	88,100	176,773
1992	12,901	18,010	44,750	81,189	163,761
1993	12,100	18,145	25,135	81,189	143,480
1994	4,661	6,888	31,075	81,189	130,724
1995	5,528	10,844	21,632	81,189	126,104
1996	22,262	12,282	53,962	81,189	176,606
1997	18,233	9,385	35,615	81,189	151,333
1998	34,198	10,789	32,235	81,189	165,322
1999**	34,198	10,789	32,235	81,189	165,322
Mean	**16,827**	**11,857**	**43,374**	**81,189**	**156,270**

Note:

*Recorded excavated deposit by annual contract from Ringlet Reservoir is only available in 1984 (172, 800 m^3), 1986 (169, 500 m^3), 1987 (66, 700 m^3), 1990 (233, 600 m^3), and 1991 (88, 100 m^3). As the excavation started in 1983, excavated quantity recorded in 1984 will be average out for 1983 and 1984. This type of averaging is also applied for 1986 and 1990. For 1992 to 1998, the overall mean will be used.

** 1999 figure is estimate to be same with 1998.

Source: Modified from UM and TNBR (2001).

Appendix A: Table A-14

Measured Sediment Deposited in Ringlet Reservoir by Profile Survey.

No. of Reservoir Profile Survey	Year	Measured Total Deposit (m^3)	Silt Deposit at Ringlet Reservoir between Two Consecutive Surveys (m^3)	Average Annual Silt Deposit at Ringlet Reservoir (m^3)
1	1965	33,500	33,500	16,750
2	1967	107,600	74,100	37,050
3	1969	126,900	19,300	9,650
4	1970	147,800	20,900	20,900
5	1975	415,000	267,200	53,440
6	1981	531,700	116,700	19,450
7	1984	686,000	154,300	51,433
8	1986	850,000	164,000	82,000
9	1987	1,003,000	153,000	153,000
10	1990	1,717,000	714,000	238,000
11	1991	1,961,000	244,000	244,000
12	1996	2,600,000	639,000	127,800
13	1998	3,099,485	499,485	249,743
14	1999	3,533,326	433,841	433,841

Source: Modified from UM and TNBR, (2001)

Appendix A: Table A-15

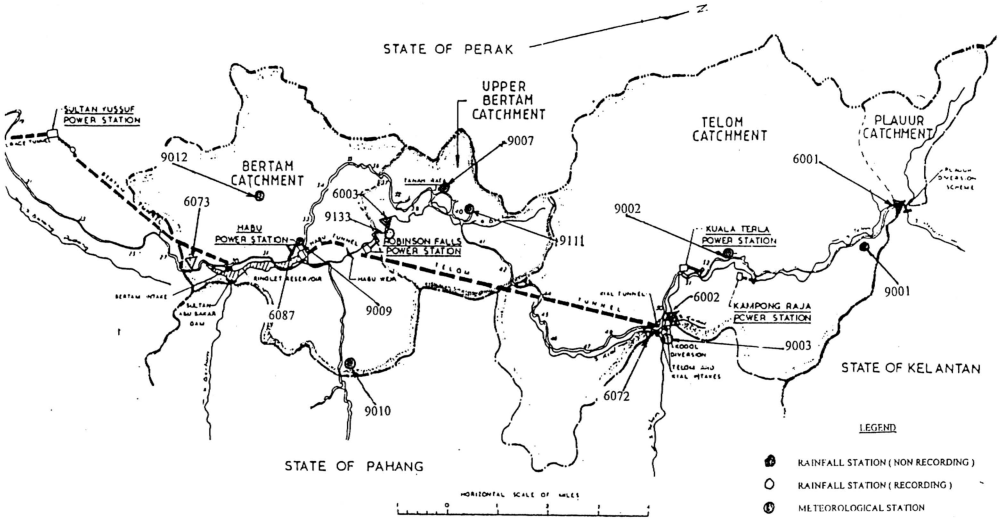
Lost of Storage Capacity, calculated from reservoir profile survey.

No. of Profile Survey	Year of Survey	Measured Deposit (m^3)	Remaining Storage Capacity (m^3)	Lost of Storage Capacity (%)
1	1965	33,500	6,666,500	0.5
2	1967	107,600	6,592,400	1.6
3	1969	126,900	6,573,100	1.9
4	1970	147,800	6,552,200	2.2
5	1975	415,000	6,285,000	6.2
6	1981	531,700	6,168,300	7.9
7	1984	686,000	6,014,000	10.2
8	1986	850,000	5,850,000	12.7
9	1987	1,003,000	5,697,000	15.0
10	1990	1,717,000	4,983,000	25.6
11	1991	1,961,000	4,739,000	29.3
12	1996	2,600,000	4,100,000	38.8
13	1998	3,099,485	3,600,515	46.3
14	1999	3,533,326	3,166,674	52.7

Source: Modified from UM and TNBR, (2001)

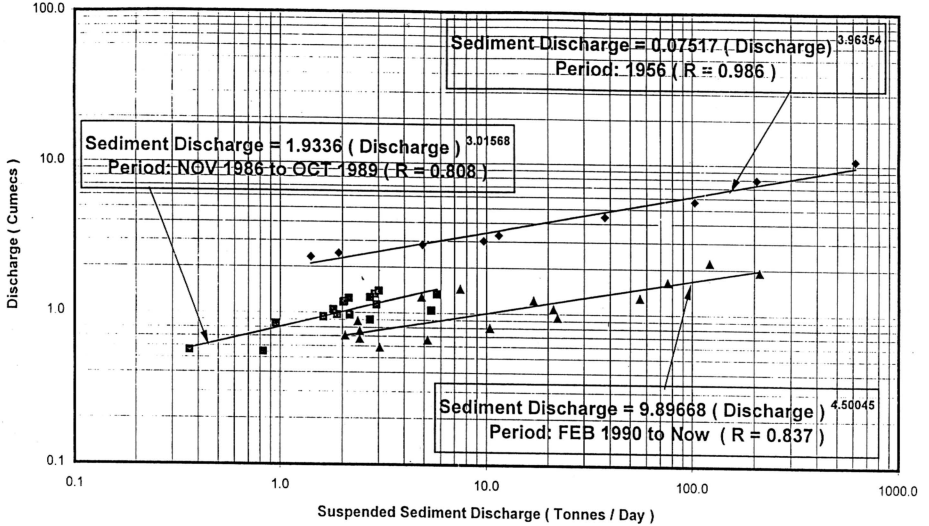
Appendix B

REFERENCED FIGURES



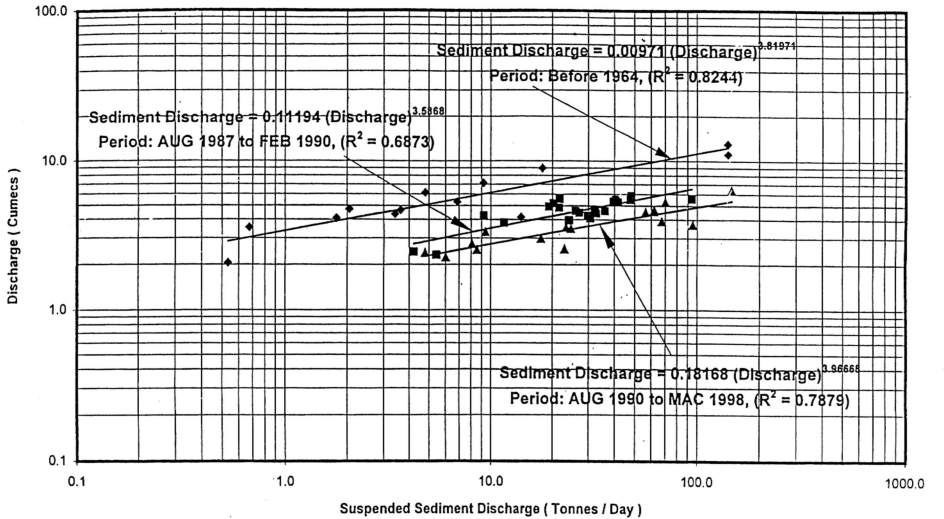
ppendix B: Fig. B-1: Distribution of Meteorological Stations in Cameron Highlands.

rce: (UM and TNBR, 2001)



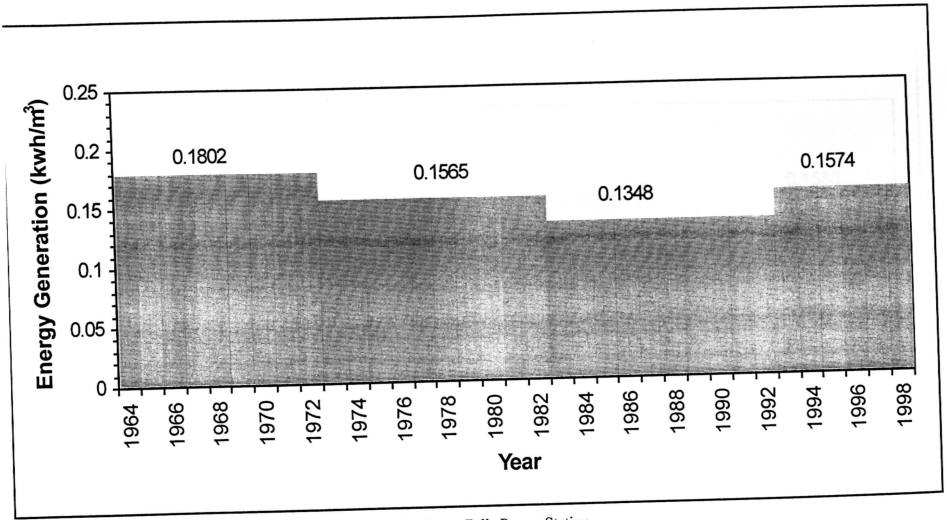
Appendix B: Fig. B-2: Sediment Rating Curve for Bertam River at Robinson Falls.

Source: (UM and TNBR, 2001)



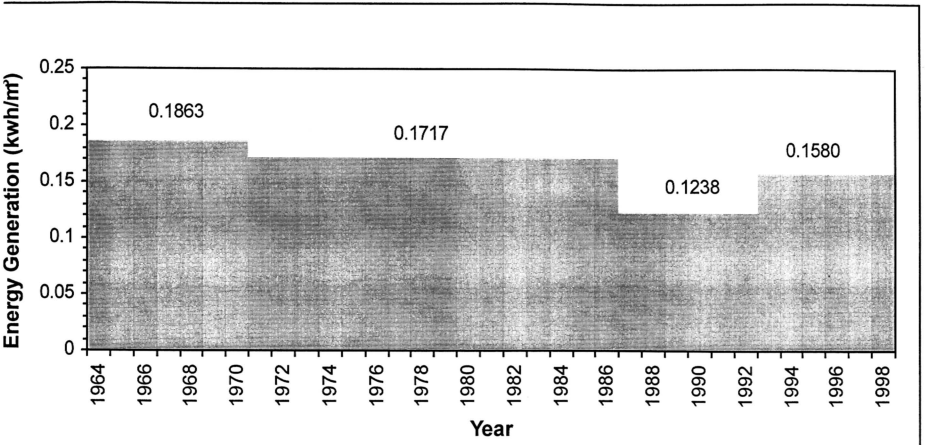
Appendix B: Fig. B-3: Sediment Rating Curve for Telom River at Miles 49.

Source: (UM and TNBR, 2001)



ppendix B: Fig. B-4: Energy Generation per unit Runoff for Robinson Falls Power Station

urce: Modified from UM and TNBR, 2001.



ppendix B: Fig. B-5: Energy Generation per unit Runoff for Habu Power Station

ırce: Modified from UM and TNBR, 2001.

Appendix C

SOIL EROSION COMPUTATIONAL MODEL

Appendix C: Soil Erosion Simulation

UM and TNBR (2001) gives a comprehensive scenario regarding the soil erosion rate in the hydroelectric catchment of Cameron Highlands by using a soil loss computation model. This computer model simulates soil erosion based on the Revised Universal Soil Loss (RUSLE) equation. The model was implemented with Arcview's Avenue Version 3.1 (the Arcview language script) and a Dynamic Link Library (DLL) written in C language. RUSLE is an empirical equation for estimation of soil loss from a cropped field under specific combination of rainfall regimes, soil slope, cropping practice and management systems (Morgan, 1995). It was developed as a method to predict average annual soil loss from sheet and rill erosion.

The RUSLE is given by:

$$A = RKLSCP$$

Where, A = annual soil loss, t/ha

R (rainfall erosivity factor) = 835.6 (t.m.cm)/(ha.hr), estimation method based upon empirical study carried out by Bols (1978) in Indonesia.

K (the soil erodibility factor) = 0.2 (t/ha per unit of R), Rengam Series is the dominant soil series in the hydroelectric catchment.

LS = the combined index of slope length factor and the slope gradient factor. The model developed by UM and TNBR calculates LS factors by using the Digitize Elevation Model (DEM) of Geographical Information System software, ArcView.

CP = the cropping management factor and the erosion control practice factor. Both are depending on the land use type and soil conservation practice. The CP factors for various land use specified by UM and TNBR are shown in **Table C-1**. The simulation in a grid size of 20×20 m^2 was carried out with land use maps of 1947, 1966, 1974, 1982, 1990 and 1997.

Appendix C: Table C-1: Estimates CP values for Various Land Use Type

Land Use Type	**CP Values used in the simulation**
Forest	0.001#
Grassland, Shrub Forest, Shifting Cultivation	0.015
Market Gardening, Mixed Agriculture, Floriculture	0.25*
Tree Cultivation, Orchards, Tea	0.005#
Residential Area, including Infrastructure	0.003
Mining	0
Agriculture Experiment Station	0
Water Bodies	0
Bare Land	1

Note:
#Morgan (1995).
*Roslan and Tew (1996).

Source: Reproduced from UM and TNBR, (2001)