Table 4. Average climatic data from Sumber Jaya station

Month	Temperature Avg.	Max.	Min.	Relative Humidity (%)	Pan Evaporation (mm/d)	Wind Velocity (km/h)	Rain-fall (mm)
		°C					
Jan	22.56	26.40	17.40	85.12	3.47	2.49	496.1
Feb	22.86	25.84	18.63	81.57	3.30	2.18	243.1
Mar	22.76	26.92	18.45	80.79	3.69	1.71	342.4
Apr	23.47	27.19	18.61	80.65	4.19	1.71	277.6
May	23.07	26.59	18.54	81.65	3.54	1.39	245.8
Jun	22.16	26.77	15.75	80.95	3.90	1.53	114.8
Jul	21.73	27.50	15.40	78.86	4.61	1.62	119.9
Aug	21.34	27.40	14.72	78.04	3.40	1.71	82.6
Sep	21.59	28.20	14.10	75.60	4.87	1.86	88.91
Oct	22.05	27.90	15.26	76.68	4.56	1.73	199.7
Nov	22.88	27.28	18.37	77.12	4.52	1.93	174.3
Dec	22.54	26.69	17.56	79.53	3.47	2.15	195.6

Source: Utomo *et al.* (1999).

Table 5. Temperature and relative humidity data at Pajar Bulan station

Month	Temperature (°C) Max	Min	Avg	Relative humidity (%)
Jan	26.2	17.9	22.1	85.2
Feb	27.0	17.1	22.1	81.4
Mar	27.3	17.2	22.3	88.5
Apr	28.5	16.9	22.7	88.2
May	29.1	16.2	22.6	88.7
Jun	27.4	15.7	21.6	87.7
Jul	27.0	15.4	21.2	88.8
Aug	28.1	14.2	21.1	87.8
Sep	31.4	15.9	23.6	86.4
Oct	27.7	15.3	21.5	88.0
Nov	27.2	16.9	22.0	86.7
Dec	26.8	17.5	22.1	89.2

Temperature was calculated from 1975-1985,and the humidity data was average from 1975-1995 data.
Source: Utomo *et al.* (1999).

Table 6. Soil type in the Tulang Bawang watershed

Soil Classification according to		
CSR (1983)	FAO	USDA
Gleysol	Fluvisol	Hydra/Fluvaquents/Tropaquepts
Alluvial	Fluvisol	Fluvents
Podzolic	Acrisol	Tropudults
Latosol	Cambisol	Dystropepts

Table 7. Soil Chemical properties from representatvie soils types in Tulang Bawang watershed (Binnie & Partners, 1994b)

Soil classes	pH	CEC	BS%	Ca exchangable	Mg	K	Na	C%	N%	P_2O_5	Al%
Way Pedada											
Thi. Alluvial	3.5-5.5	m-h	m-vh	l-m	m-vh	l-h	l-m	vh	h	l-vh	l-vh
Di. Gleysol	4.5-5.5	l-m	l-h	vl-m	l-h	m-h	l-m	vh	m	l-vh	l-vh
P. Podzolic	4.5-5.5	vl-l	l	vl	vl	l	vl-l	h	l-m	l-m	h-vh
Lambu Purus											
Alluvial	5.4	m	h	m	h	m	l	l-m	m	vl	l
Gleysol	4.8	m	l-m	l	m-h	m	l-m	h	m	var	m-h
Podzolic	4.8	l	l	vl	vl	l-m	l	l	l	vl	h-vh
Way Kelawas/Way Sabuk Sindang Agung/Sumber Jaya Kiri											
Red Latosol (Kelawas)	4.9	l	m	vl	l	l-m	l	h	m	vl	nd
Red Latosol (Sabuk)	4.3-4.8	l	l-h	l	l	m	l-m	h	m	l	nd
Brown Latosol (SJK)	4.9	l	m-h	l	m	m	l	h	l	vl	nd
Terrace (SJK)	4.6	l	m	l	l	h	l	l	m	vl	nd

CEC: cation exchange capacity; BS :base saturation; vl : very low; l: low; m: medium; h:high; vh:very high.

Table 8. Some soil properties from various elevation and land use types at Way Besai subwatershed (Salam *et al.*, 1998)

Site	Depth (cm)	Altitude (m)	Distance (m)	pH (H_2O) (1:2.5)	Organic-C (g/kg)	Total-N (mg/kg)	Available-P	CEC (cmol(+)/kg)
Bukit Rigis								
PF	0-20	1550	0	4.4	60.4	5.5	4.0	43.2
	20-40			4.8	25.0	2.3	1.5	18.2
SF	0-20	1400	628	5.4	41.4	3.4	2.1	18.5
	20-40			4.9	21.7	2.0	1.5	13.7
CP	0-20	1120	1660	4.9	28.5	2.3	1.5	11.4
	20-40			4.9	10.1	1.2	1.0	12.5
CL	0-20	1100	2160	4.4	15.8	1.7	1.5	12.4
	20-40			4.3	7.5	0.8	0.7	12.2
Sekincau								
PF	0-20	1620	0	4.0	73.1	6.1	5.6	41.0
	20-40			4.1	32.7	2.5	3.3	22.4
SF	0-20	1440	530	4.8	42.9	3.5	2.1	15.1
	20-40			4.6	24.5	2.4	1.5	16.1
CP	0-20	1240	1550	4.6	30.9	3.3	1.5	13.5
	20-40			4.4	11.2	1.2	1.0	16.0
CL	0-20	1170	2300	5.2	19.3	1.8	1.8	13.9
	20-40			4.1	7.0	0.9	1.0	13.9
Tri Mulya								
PF	0-20	890	0	5.4	58.0	5.1	3.5	37.6
	20-40			4.9	18.2	2.0	1.3	21.9
SF	0-20	740	335	5.5	38.7	3.2	2.3	24.8
	20-40			5.0	12.5	2.1	2.1	14.8
CP	0-20	490	765	5.4	26.7	2.5	2.8	14.7
	20-40			4.8	7.0	1.3	1.5	11.8
CL	0-20	465	1220	5.2	14.2	1.3	2.1	13.8
	20-40			5.0	5.5	0.7	1.0	12.7
Tri Budi Syukur								
PF	0-20	1240	0	4.9	30.5	1.8	7.3	18.4
	20-40			5.2	3.8	1.1	5.4	15.3
SF	0-20	985	354	5.9	27.5	3.2	7.3	23.9
	20-40			5.7	10.2	1.4	6.1	20.2
CP	0-20	735	826	5.1	22.6	2.6	7.3	14.4
	20-40			5.4	11.1	1.4	6.9	13.2
CL	0-20	710	1427	4.8	13.3	1.8	6.9	11.7
	20-40			5.6	6.5	0.6	6.5	9.2
Puri Mekar								
PF	0-20	940	0	5.5	23.3	2.0	8.9	8.2
	20-40			5.3	13.6	1.2	7.3	4.9
SF	0-20	790	381	5.2	30.0	2.9	10.1	8.4
	20-40			5.7	10.7	1.2	6.9	5.9
CP	0-20	540	940	5.6	23.4	2.5	7.3	11.2
	20-40			5.4	11.4	1.4	6.9	9.3
CL	0-20	525	522	5.3	23.2	2.1	11.1	8.3
	20-40			4.9	8.7	0.9	3.8	6.5

PF: primary forest; SF: secondary forest; CP: coffee plantation; CL: cultivated.

Table 9. Size of catchment and discharge of the main rivers in Lampung (Wiryawan *et al.*, 1999)

River	Catchment areas (ha)	Discharge (m^3/s)
Mesuji	Mostly located at South Sumatra	155
Tulang Bawang	1.015.000	80-360
Seputih	755.000	3-48
Sekampung	567.500	216
Semangka	152.500	0.18-247

(a) hilly until mountanious areas, (b) undulating to rolling areas (peneplain), (c) alluvial plain, (d) swampy areas with *dataran pasang surut*, (e) river basin areas. The highest mountain in Lampung is Mount Pesagi, its summit reaching 2262 m.

Local

The proposed location for benchmark site was located at the upper Tulang Bawang subwatershed with elevation from 600 asl to 1200 asl. The area is dominated by a hilly and mountanious relief.

GEOLOGY

Most of the rock materials in Tulang Bawang watershed were derived from volcanic and sediment materials from quarter, tertier, and pre-tertier era. The oldest volcanic quarter materials are Lampung Tuff (Qlv) and Ranau Tuff (Qrv) which are composed of dasitic and liparitic materials. The two materials were finally covered by a recent volcanic material (Qhv) which covers about 40% in the central part of the watershed and is composed of andesitic and basaltic materials. The Qhv is mainly located at the centre part of this area. At the lower part of Tulang Bawang watershed, sediment materials from tertier and quarter era are easily found. The sediment materials are composed of sand and clay material.

A Semangko fault is found in the western part of Lampung Province which stretches from northern part to southern part. The earthquakes in Lampung Province in 1934 and 1994 were due the activity of this fault.

Table 10. Mean Monthly Riverflow (m^3/s) of Way Besai river (occupies 389 km^2) at Sumber Jaya

Year	Jan	Feb	Mar	Ap	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1975	29.0	30.8	18.4	23.1	15.6	10.77	10.3	10.2	9.81	13.1	21.2	11.2
1976	15.4	17.5	18.9	23.8	14.2	7.75	6.61	7.58	5.6	7.07	18.4	14.7
1977	22.9	24.6	20.1	28.9	16.6	27.19	13.9	7.91	10.4	6	12.8	25.7
1978	24.8	21.7	37.8	23.6	27.9	21.22	17.4	14.2	21.9	18.6	32.1	41.8
1979	34.3	42.7	22.2	29.1	29.3	18.81	18.0	12.2	12.5	13.9	19.8	
1980	29.7	21.8	22.0	22.9	17.6	13.17	10.3	10.3	12.3	19.8	33.4	35.1
1981	23.1	27.6	28.2	39.1	35.9	19.44	15.7	12.2	20.7	13.0	15.9	16.6
1982	37.0	38.8	19.8	31.2	17.7	8.96	8.16	5.46				
1983	40.4	17.3	27.7	27.1	28.6	15.21	11.0	6.95	5.18	6.73	17.9	16.9
1984	24.1	14.3	31.8	28.2	29.8	14.86	11.1	14.7	20.4	25.7	19.2	23.5
1985	31.4	23.8	24.4	30.6	17.3	18.99	23.1	17.7	14.9	18.6	18.5	25.2
1986	27.0	23.9	38.1	26.2	19.3	17.72	18.8	15.5	22.7	23.8	32.8	32.1
1987	45.4	27.4	34.9	33.3	28.1	18.84	14.3	10.3	8.11	9.54	14.9	31.0
1988	53.5	35.7	37.5	17.1	22.4	15.53	11.6	7.66	12.2	28.9	22.5	
1990	21.3	29	24.4	20.1	18.1	15.8	9.91	12.6	9.33	4.76	5.49	25.5
1991	37.7	27.3	34.5	40.7	28.4	13.2	7.75	5.85	5.32	3.84	16.7	33.3
1992		35.4	28.4	20.5	10.7		12.5	17.1				
1995	28.1	40.9	38.4	49.8	26	20.1	23	12	9.19	10.1	23.1	17.9
1996	22.1	39.2	29.9	36	13.4	13.9	14.4	13.9	17.9	32.5	32.3	18.7
1997	18.3	15.6	24.5	25.1	39.3	15.4	11.9	6.88	5.69	5.55	6.59	19.2
Nobs	19	19	20	20	20	20	19	20	19	18	18	16
Min	15.4	14.3	18.4	17.1	13.4	7.75	6.61	5.46	5.18	3.84	5.49	11.2
Max	53.5	42.7	38.4	49.8	39.3	27.19	23.1	17.7	22.7	32.5	33.4	41.8
Mean	29.7	27.4	28.4	29.2	23.3	15.87	13.5	10.8	12.7	14.5	20.2	24.3
SD	9.43	8.50	6.95	7.48	7.18	4.497	4.66	3.40	5.77	8.60	8.05	8.26
CV	31.6	31.0	24.4	25.5	30.8	28.32	34.3	31.3	45.3	59.1	39.8	34.0

Nobs: number of observation; SD: stadard deviation; CV: coeficient of variation.

LAND USE CHANGES

The study conducted by Syam *et al.* (1997) in the upper Tulang Bawang subwatershed showed that in 1970 the forest occupied 57.38% of that areas which became 21.39% in 1990. On the other hand, the monoculture plantation (coffee plantation) increased from 0% in 1970 to 41.77% in 1990 (Table 11). The

booming of coffee price in 1998 and has encouraged people to open protected forests and reforestation areas around Sumber Jaya District, and change into coffee plantation. Syam *et al.* (1999) also showed that a sharp change also occured in the middle terrace areas of the Lampung region as shown in Table 12.

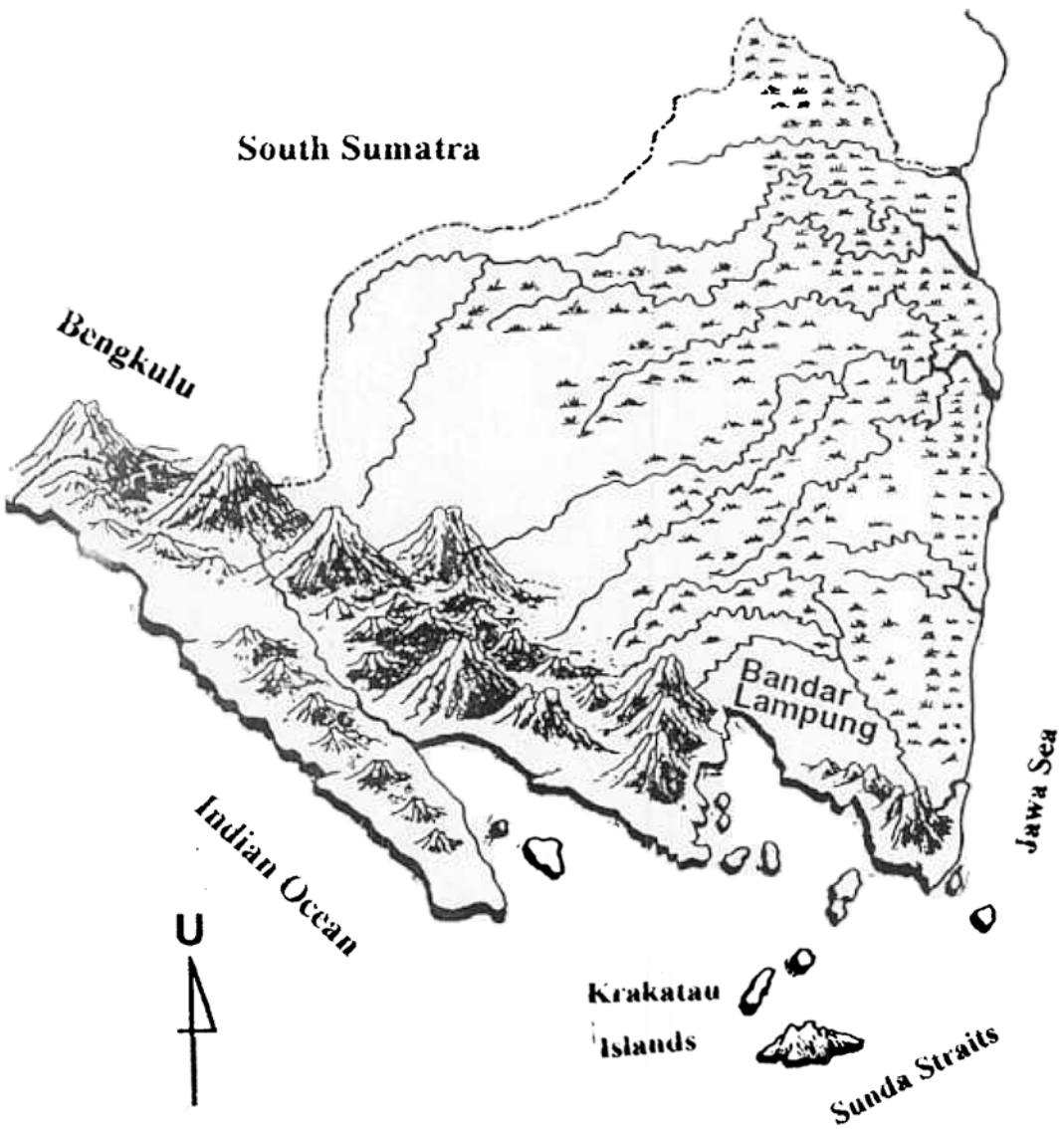

Figure 4. Topography of the Lampung region.

Table 11. Changes in percentage of land use system from 1970 to 1990 in upper Tulang Bawang subwatershed (Syam *et al.*, 1997)

Land use type	1970	1978	1984	1990
Residental areas	0.83	1.03	1.70	2.20
Paddy fields	0.36	2.92	5.02	5.35
Upland fields (crop and vegetables)	5.29	2.20	1.07	0.12
Upland fields under shifting cultivation	9.38	4.81	0.33	0.00
Plantation lands (monoculture)	0.00	20.83	41.77	41.11
Plantation lands (mixed)	0.00	0.93	0.95	19.26
Dense forests (primary forest)	57.38	32.60	21.39	12.72
Underbrush forests (secondary foresets)	11.88	16.20	10.79	18.05
Ponds	0.00	0.03	0.01	0.07
Grasslands	8.96	18.44	16.98	1.12

Table 12. Changes in percentage of land use system from 1978 to 1993 in the middle terrace area of Lampung region (Syam *et al.*,1999)

Land use type	1978	1984	1993
Residental areas	5.48	4.75	5.77
Paddy fields	0.00	0.12	14.83
Upland fields	7.54	33.99	32.28
Mixed gardens	0.18	1.12	3.49
Plantation lands	2.35	4.90	14.42
Primary forest	13.80	0.00	0.06
Secondary foresets	20.25	18.52	10.18
Swampy forest	0.00	2.38	1.63
Swamps	0.28	10.48	10.98
Grassland	50.09	22.86	6.30

HUMAN POPULATION DENSITY

Geographically, Lampung province is located at 3°45' South Latitude and 103°40' EL-105°50' EL with the total area of 35376 km^2. The population number of Lampung in 1998 was 6,95 millions, and was estimated to reach 7,08 millions in 1999 (Wiryawan *et al*, 1999). In 1998 the poplation density of Lampung was 210 persons per km^2 (Table 13).

Table 13. The population number and density of several regencies of Lampung Province in 1998 (Wiryawan *et al*., 1999)

Regency	Number of population	Density (per km^2)
Bandar Lampung	917.734	4.635
South Lampung	1.071.129	315
East Lampung	857.861	186
Tanggamus	797.880	235
West Lampung	389.023	82
Tulang Bawang	707.482	90

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