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Land Use and Cover Changes in a Hilly Area of South Sumatra, Indonesia (from 1970 to 1990)

Tamaluddin Syam, Hiroyo Nishide*, Abdul Kadir Salam,
Muhajir Utomo, Ali Kabul Mahi, Jamalam Lumbanraja,
Sutopo Ghani Nugroho, and Makoto Kimura*

Faculty of Agriculture, University of Lampung, Bandar Lampung, Sumatra, Indonesia; and

**School of Agricultural Sciences, Nagoya University, Chikusa-ku, Nagoya, 464-01 Japan*

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We monitored the land use changes in a hilly area of West Lampung, South Sumatra, Indonesia, from 1970 to 1990. The main data sources were the land use maps produced in 1970, 1978, 1984, and 1990 covering an area of 27 km². The area was divided into 108×108 cell squares (0.25 km×0.25 km) and the largest land use form in the respective squares were mapped using a computer program. Fifty-seven percent of the study site was covered with primary forests in 1970, against 13% in 1990. Areas under plantation which were not recorded in 1970, increased to 60% in 1990. In addition, the change from monoculture plantations (mostly coffee plantation) to mixed plantations was noticeable from 1984 to 1990. Total upland area including upland area under shifting cultivation and upland fields with crops and vegetables only with fruit trees decreased from 21% in 1970 to 0.1% in 1990, clearly suggesting the establishment of plantation agriculture, mainly coffee plantations, in the hilly areas, and the transfer of areas for crop and vegetable production to the middle terraces in Lampung Province. In large areas land-use had changed from some forms to others at intervals of 6–8 y in the study site. Transmigration and resultant impact of increasing population were the major driving forces in land use changes.

Key Words: forest, grassland, plantation, shifting cultivation, transmigration.

The annual income *per capita* in Indonesia was 670\$ in 1992, and it was the lowest among the four ASEAN countries (Indonesia, Malaysia, Philippines, and Thailand). However the mean real annual growth rate was 4.5% in Indonesia between 1965 and 1990, which was comparable to that in Thailand (4.4%). The real annual growth rate of the economy in Indonesia was 7.2% between 1970 and 1980, and 5.7% between 1980 and 1992, respectively. In Lampung Province, South Sumatra, the average annual economic growth rate during the period from 1969 to 1988 was 8.8%, and in 1994, 7.1% (Pemda TK-I Lampung 1992; Kantor Pusat Statistik Propinsi Lampung 1996). These figures were consistently higher than those of the national average.

In contrast to the economic growth rate, however, the income *per capita* in Lampung Province has been lower than the national average. In 1983, the income *per capita* in Lampung was only 371\$ (Kantor Pusat Statistik Propinsi Lampung 1996), almost half of the national income *per capita*. The lower income in Lampung was related to the higher

population growth particularly in the period before 1980, which in turn, indirectly affected the land use changes. In 1930, the population density in Lampung Province which was 376,000, increased to 1,472,000 in 1961, 2,456,000 in 1971, 4,155,000 in 1980, and 5,318,000 in 1990 (Pemda TK-I Lampung 1992). During these periods, the population growth in Lampung Province remained higher than the national average.

The total GDP of Indonesia increased rapidly: 8.4 billion US\$ (b\$) in 1970, 62 b\$ in 1980, and 96 b\$ in 1990. Due to the drastic development of the mining industry, manufacturing industry and commerce sectors. The contribution percentages of the agricultural sector to the total GDP in Indonesia decreased from 47.2% in 1970 through 24.8% in 1980 to 17.6% in 1993 (Asian Development Bank 1970–1992).

The aim of this paper is to monitor the land use changes in the study site located in hilly areas in West Lampung, Lampung Province, in the past 20 y from 1970 to 1990, considering the national policy, transmigration, and the agro-economical circumstances. We were able to examine the land use changes in the study site in close relation with the national policy by analyzing land use maps and several statistics in Indonesia. This report is the first in a report series under the Project entitled “Basic Researches on Developing Techniques for Sustainable Biological Production in the Regions of Red Acid Soils” supported by Ministry of Education, Science, Sports and Culture of Japan. In the following papers, the effects of land use change on soil fertility will be reported in terms of soil chemistry, soil microbiology, and soil enzymology.

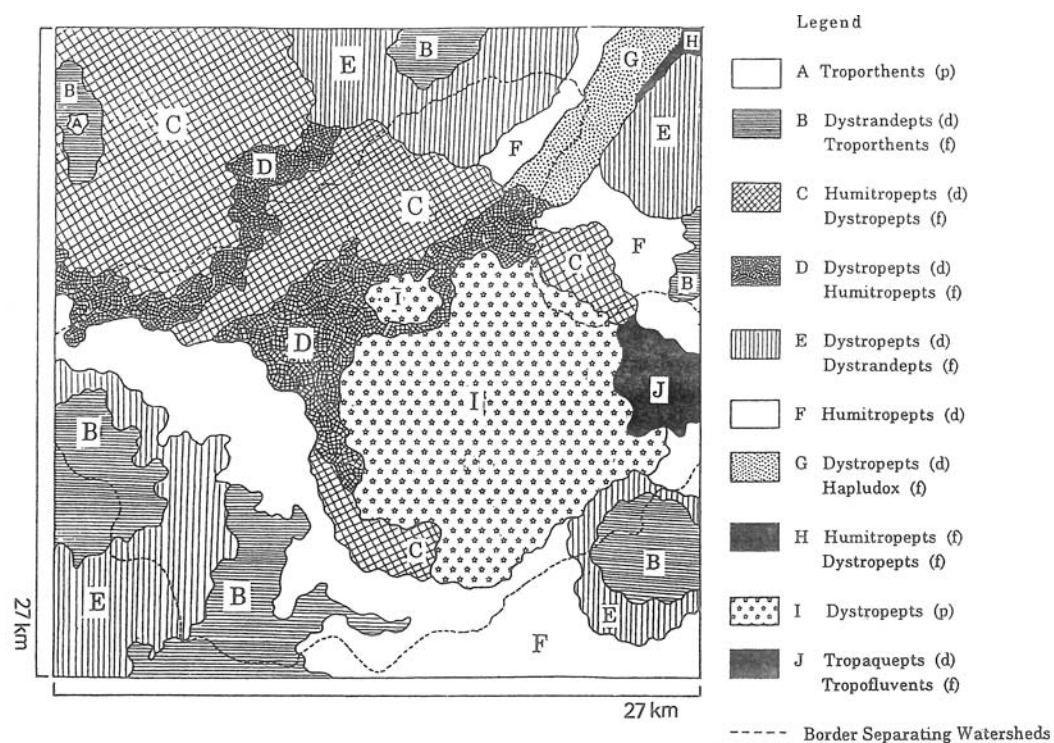


Fig. 1. Soil map of the study site. p, d, and f in parentheses indicate the soil area proportions. p: predominant (>75%), d: dominant (50–75%), f: fair (25–50%).

MATERIALS AND METHODS

Location of study site. The study site which was located at 4°55'S to 5°10'S and 104°19'E to 104°34'E, in West Lampung, Lampung Province, South Sumatra, covers an area of 27 km². This site was located in the hilly area surrounding a watershed (Fig. 2). The elevation of the study site ranges from 780 to 1,700 m above sea level. The areas separating watersheds were mountainous. In addition, there was a mountain (1,623 m) in central part of the study area. Villages were generally located at the low and flat areas. The distribution of major soil groups in the study site is shown in Fig. 1 (Center for Soil and Agroclimate Research 1989•1991).

Data sources of land use information. The main data sources were the land use maps of the area produced in 1970, 1978, 1984, and 1990 and published by Kantor Agraria (now BDN) (Table 1). The maps were patterned according to the land use form. They contained fairly detailed information on the land use form; kind of trees in forest land, kind of crops and number of harvests in agricultural land, etc. We only used the information on land use form.

Data processing (method of mapping). The study site consists of 9 maps; 9 km × 9 km in size designated 1-1 to 3-3 (Fig. 3), however due to the absence of 3 maps covering the upper grids, only 6 grids 1-2 to 3-3 were available in 1970. We prepared the data files

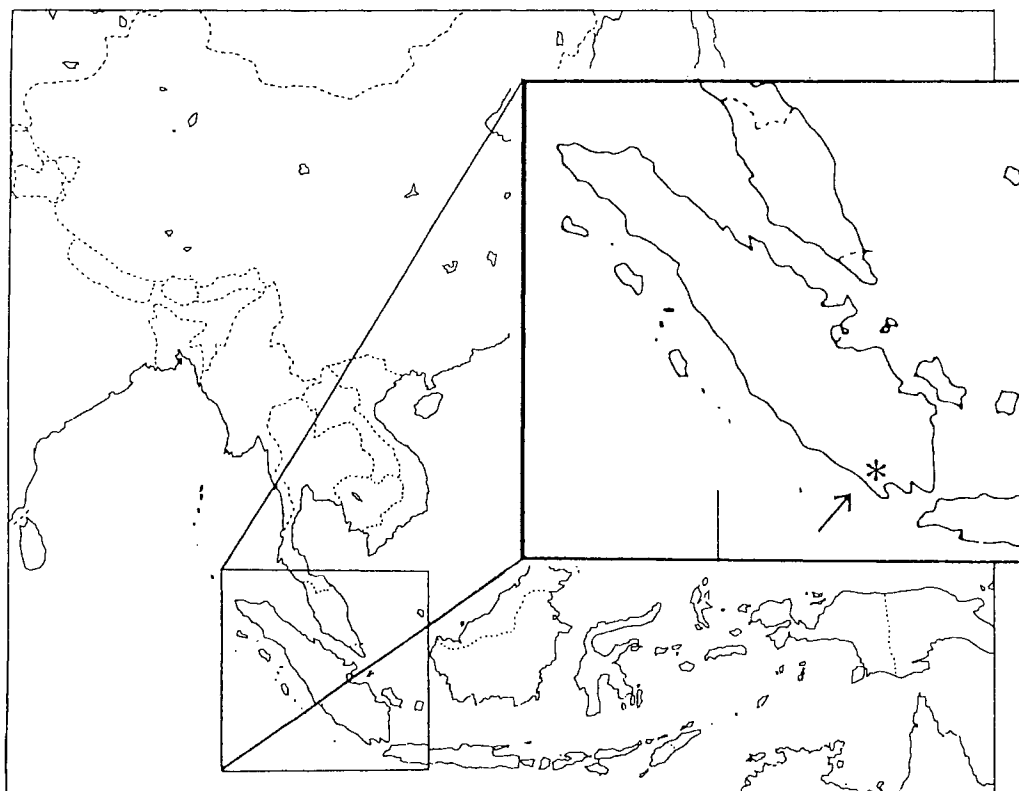


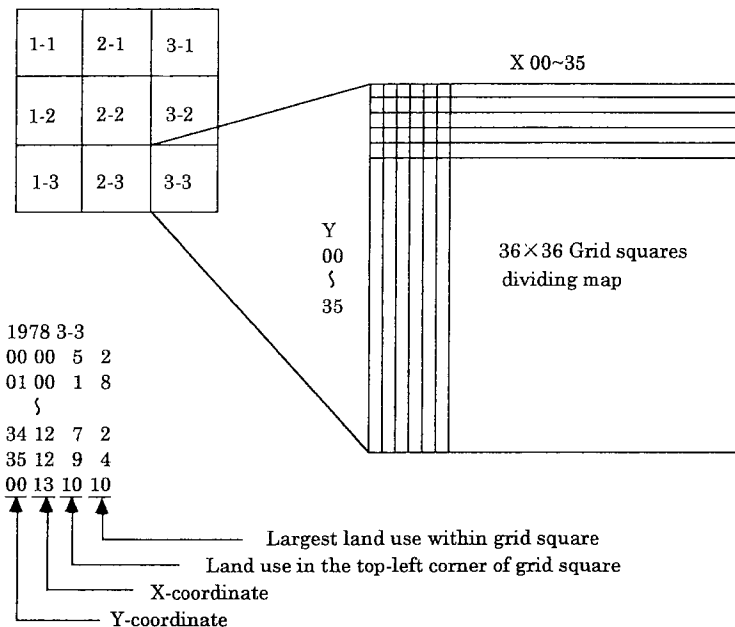
Fig. 2. Location of study site.

Table 1. List of data sources for land use mapping.

Year	Scale	Location	Sources	Mapping	Printing
1970	1 : 100,000	104°20'–105°20'E 4°40'–5°40' S	Land use map (Kantor Agraria)	May, 1970	September, 1970
1978	1 : 25,000	104°19'–104°34'E 4°55'–5°10' S	Land use map (Kantor Agraria)	January, May, July, 1978	November, 1980; February, 1981; March, June, 1983
1984	1 : 25,000	104°19'–104°34'E 4°55'–5°10' S	Revision of 1978 map (Kantor Agraria)	March, 1984	October, 1984; March, December, 1986
1990	1 : 25,000	104°19'–104°34'E 4°55'–5°10' S	Revision of 1978 map and revision of 1984 map (Kantor Agraria)	October, November, 1990	November, 1991; August, 1992

Maps were prepared based on LandSat images and field surveys using topographic maps.

Land use map consists of 9 maps

**Fig. 3.** Coordinate system of land use maps.

from each grid according to the following processes (Himiyama 1991);

1) Each grid was divided into 36×36 cell squares which covered an area of 0.25 km×0.25 km, with coordinates as X(00~35) and Y(00~35).

2) The information on land use form in the map was coded to double figures, the land use form in the top-left corner of the respective cell squares and the largest land use form in the square. The land use form was classified into the following 11 different categories.

- 1: Residential areas, including villages, cemeteries, and playgrounds.
- 2: Paddy fields.
- 3: Upland fields (crops and vegetables).
- 4: Upland area under shifting cultivation.
- 5: Upland fields (mixed, crops and vegetables with fruit trees).

- 6: Plantation lands (monoculture, mostly coffee plantations).
- 7: Plantation lands (mixed).
- 8: Dense forests (mostly primary forests).
- 9: Underbrush forests (mostly secondary forests).
- 10: Ponds.
- 11: Grasslands (mostly *Imperata cylindrica*).

3) The codes of the land use form in the top-left corner for calculating the area of the respective land use forms, using the systematic point sampling method (Coleman and Catling 1982) and the largest land use in respective cell squares for drawing the land use map were stored as a text file using a personal computer with a wordprocessor software (Fig. 2).

4) The program to draw the land use map was run on Chipmunk-basic 3.1.0 (Copyright 1990, 1994 Ronald H. Nicholson, Jr.), BASIC interpreter.

RESULTS

As shown in Fig. 1, Dystropepts, Dystrandeps, and Troporthents (legends B and E) were distributed along the watershed areas, while Tropaquepts and Tropofluvents (legend J) were distributed in the lowland area in the right central part of the map.

Figure 4 shows the land use maps produced in 1970, 1978, 1984, and 1990. Tables 2 to 4 summarize the areas of respective land use forms and of land use change from some form to others. Due to the lack of information in the upper third part, total area considered in the map of 1970 covered 486 km², while in 1978, 1984, and 1990, 729 km² each. In addition, Figs. 5 and 6 sum up the areas of underbrush forests and grasslands, respectively, indicating to and from which form they were changed between 1978 and 1984 and between 1984 and 1990.

1970 (Fig. 4; Table 2)

Most of the area was occupied by dense forests, 57% (279 km²) of the total area (486 km²), followed by underbrush forests (12%), upland area under shifting cultivation (9.4%), and grasslands (9.0%). Underbrush forests and grasslands succeeded shifting cultivation areas—fallow areas—grasslands—secondary forests. The sum of upland areas in which crops and vegetables were grown with and without fruit trees accounted for 11.2% of the total, and paddy fields accounted for less than 1% of the total. There was no plantation area in 1970.

1978 (Fig. 4; Tables 2 and 3)

When the same area which was mapped in 1970 was observed, the area under dense forests and underbrush forests had decreased markedly from 57 to 44% and from 12 to 7.3% of the total area, respectively, while plantation areas, mainly coffee plantations appeared first in 1978 and occupied 18% of the total area (486 km²; Table 2). The area under paddy fields and grasslands also increased significantly. The distribution percentages of the respective land use forms varied when the upper third area (additional 243 km²) was included. Dense forests occupied 33% of the total area (729 km²), followed by plantation areas 22%, grasslands 18%, and underbrush forests 16% (Table 3).

More complicated and drastic land use changes were recognized when the changes of the respective land use forms from and to other forms were considered. For example as shown in Table 2, although the percentage of grasslands in the total area increased from 9.0% (44 km²) in 1970 to 18% (88 km²) in 1978, the area which was under grasslands both in 1970 and in 1978 accounted for only 4.4% (21 km²) and the remaining area, 13.8% (67 km²), of the

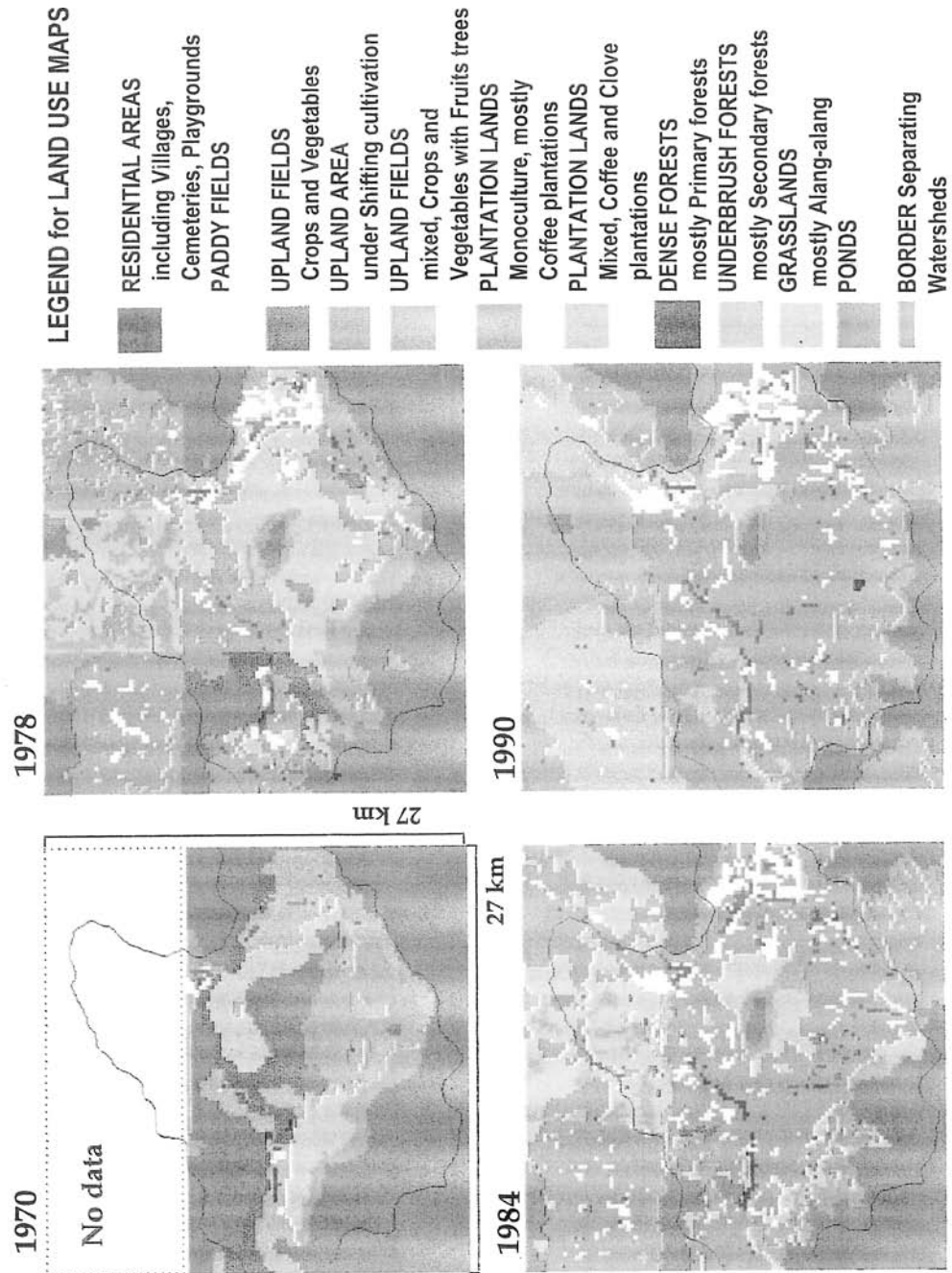


Fig. 4. Land use maps produced in 1970, 1978, 1984, and 1990.

Table 2. Land use forms in 1970 and 1978 and land use changes during 1970 and 1978.

1970																									
LEGEND	RESIDENTIAL AREAS	PADDY FIELDS	UPLAND FIELDS	UPLAND (%)	UPLAND (%)	UPLAND (%)	UPLAND (%)	UPLAND (%)	UPLAND (%)	UPLAND (%)	UPLAND (%)	UPLAND (%)	UPLAND (%)	UPLAND (%)	UPLAND (%)	UPLAND (%)	UPLAND (%)	UPLAND (%)	UPLAND (%)	UPLAND (%)	UPLAND (%)	UPLAND (%)	UPLAND (%)	UPLAND (%)	UPLAND (%)
1	RESIDENTIAL AREAS	1.69	0.35	0.19	0.04	0.56	0.12	0.63	0.13	2.44	0.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
9	PADDY FIELDS	0.94	0.19	0.38	0.08	2.19	0.45	5.25	1.08	3.31	0.88	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
7	UPLAND FIELDS	0.31	0.06	0.06	0.01	0.81	0.17	1.00	0.21	0.81	0.17	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
8	UPLAND AREA Shifting	0.00	0.00	0.06	0.01	3.75	0.77	5.00	1.03	1.06	0.22	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	UPLAND FIELDS Mixed	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	PLANTATIONS Monoculture	1.06	0.22	0.50	0.10	12.19	2.51	14.75	3.03	13.56	2.79	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Mixed	0.00	0.00	0.00	0.00	0.88	0.18	0.81	0.17	0.94	0.19	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Total	1.06	0.22	0.50	0.10	13.06	2.69	15.56	3.20	14.50	2.98	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	FORESTS Dense	0.00	0.00	0.00	0.00	0.13	0.03	2.81	0.58	0.56	0.12	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	FORESTS Underbrush	0.00	0.00	0.00	0.00	0.13	0.03	3.00	0.62	0.13	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	PONDS	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	GRASSLANDS	0.06	0.01	0.56	0.12	5.06	1.04	12.31	2.53	5.94	1.22	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Total 1970	4.16	0.65	1.15	0.36	25.69	5.72	45.56	9.38	26.75	5.92	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

A
B X Y A → B ; Xkm² , Y%

Areas (Xkm² and Y% in 486km²) converted from Land use form A to Land use form B during 1970 and 1978.

Table 3. Land use forms in 1978 and 1984 and land use changes during 1978 and 1984.

LEGEND	1978										1984									
	RESIDENTIAL (%)	PADDY (%)	UPLAND (%)	UPLAND (%)	UPLAND (%)	UPLAND (%)	UPLAND (%)	UPLAND (%)	UPLAND (%)	UPLAND (%)	FORESTS (%)	FORESTS (%)	FORESTS (%)	PONDS (%)	GRASS (%)	Total	Total	Total	Total	Total
	AREAS	FIELDS	FIELDS	AREA	Shifting	FIELD	Mixed	Monoculture	Mixed	Total	Dense	Underbrush			LANDS	1978	1984	1978	1984	1978
1 RESIDENTIAL	2.88	0.39	1.06	0.15	0.50	0.07	0.00	0.00	0.00	0.00	0.38	0.05	0.50	0.07	0.00	12.36	1.70	0.17	12.36	1.70
9 AREAS																				
8 PADDY	1.06	0.15	12.19	1.67	1.13	0.15	0.00	0.00	0.00	8.25	0.19	0.03	2.88	0.39	0.00	36.63	5.02	0.89	36.63	5.02
4 FIELDS																				
UPLAND	0.00	0.00	0.19	0.03	0.19	0.03	0.00	0.00	0.00	1.50	0.21	0.03	0.88	0.12	0.00	7.81	1.07	0.57	7.81	1.07
FIELDS																				
UPLAND AREA	0.00	0.00	0.00	0.00	0.31	0.04	0.00	0.00	0.00	0.44	0.06	1.13	0.06	0.01	0.00	2.38	0.33	0.06	2.38	0.33
Shifting																				
UPLAND FIELDS	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mixed																				
PLANTATIONS	3.25	0.45	6.81	0.93	10.13	1.39	0.00	0.00	0.00	124.69	17.10	40.56	39.63	5.44	0.00	304.50	41.77	7.69	304.50	41.77
Monoculture																				
Mixed	0.25	0.03	0.25	0.03	0.13	0.02	0.00	0.00	0.00	2.63	0.36	0.19	0.38	0.05	0.00	6.94	0.95	0.39	6.94	0.95
Total	3.50	0.48	7.06	0.97	10.38	1.42	0.00	0.00	0.00	127.31	17.46	40.75	40.00	5.49	0.00	311.44	42.72	8.08	311.44	42.72
FORESTS	0.00	0.00	0.06	0.01	0.06	0.01	0.00	0.00	0.00	0.88	0.12	151.25	2.56	0.35	0.13	155.94	21.39	0.14	155.94	21.39
Dense																				
FORESTS	0.06	0.01	0.63	0.09	1.38	0.19	0.00	0.00	0.00	4.75	0.65	33.63	26.56	3.64	0.00	78.63	10.79	1.19	78.63	10.79
Underbrush																				
PONDS	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.06	0.01	0.00	0.06	0.01
GRASSLANDS	0.00	0.00	0.13	0.02	2.13	0.29	0.00	0.00	0.00	10.00	1.37	10.13	44.63	6.12	0.00	123.75	16.98	7.34	123.75	16.98
Total	7.50	1.03	21.31	2.92	16.06	2.20	0.00	0.00	0.00	158.69	21.77	237.69	118.06	16.20	0.19	729.00	18.44	0.03	729.00	18.44

A
B X Y A → B ; Xkm² , Y%

Areas (Xkm² and Y% in 729km²) converted from Land use form A to Land use form B during 1978 and 1984.

Table 4. Land use forms in 1984 and 1990 and land use changes during 1984 and 1990.

LEGEND	1984										1990									
	RESIDENTIAL AREAS	PADDY FIELDS	UPLAND FIELDS	UPLAND (%)	UPLAND (%)	UPLAND (%)	UPLAND (%)	UPLAND (%)	UPLAND (%)	UPLAND (%)	PLANTATIONS	PLANTATIONS	PLANTATIONS	FORESTS (%)	FORESTS (%)	FORESTS (%)	PONDS (%)	GRASS LANDS	Total (%)	Total (%)
1 RESIDENTIAL AREAS	4.56	0.63	2.19	0.30	0.25	0.03	0.00	0.00	0.00	0.00	Monoculture (%)	Mixed (%)	Total (%)	Dense	Underbrush		0.00	0.38	0.05	16.06
9 PADDY FIELDS	1.25	0.17	20.31	2.79	0.44	0.06	0.00	0.00	0.00	0.00	13.94	1.91	14.31	0.13	0.02	0.69	0.00	1.88	0.26	39.00
0 UPLAND FIELDS	0.00	0.00	0.00	0.00	0.31	0.04	0.05	0.01	0.00	0.00	0.44	0.06	0.44	0.00	0.00	0.05	0.00	0.00	0.00	0.88
UPLAND AREA Shifting	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
UPLAND FIELDS Mixed	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
PLANTATIONS Monoculture	4.50	0.62	9.50	1.30	5.81	0.80	2.00	0.27	0.00	0.00	146.13	20.46	152.13	47.13	5.46	37.00	0.00	41.63	5.71	296.69
Mixed	1.89	0.23	4.44	0.61	0.38	0.05	0.31	0.04	0.00	0.00	104.44	14.33	105.44	6.38	0.87	6.44	0.00	14.31	1.96	140.38
Total	6.19	0.85	13.94	1.91	6.19	0.85	2.31	0.32	0.00	0.00	253.56	34.78	258.56	53.50	7.34	43.44	0.00	55.94	7.67	440.06
FORESTS Dense	0.13	0.02	0.06	0.01	0.06	0.01	0.00	0.00	0.00	0.00	4.38	0.60	4.38	0.60	0.95	4.88	0.05	3.38	0.46	92.75
FORESTS Underbrush	0.25	0.03	0.13	0.02	0.56	0.08	0.00	0.00	0.00	0.00	22.31	3.06	23.50	21.81	2.99	28.69	0.00	56.63	7.77	131.56
PONDS	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.31	0.04	0.31	0.00	0.00	0.19	0.00	0.00	0.00	0.50
GRASSLANDS	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.68	0.23	1.69	0.44	0.06	0.50	0.00	5.56	0.76	8.19
Total 1984	12.38	1.70	36.63	5.02	7.81	1.07	2.38	0.33	0.00	0.00	304.50	41.77	311.44	155.94	21.39	78.63	0.06	123.75	16.98	729.00

A
B X Y A → B ; Xkm² , Y%

Areas (Xkm² and Y% in 729km²) converted from Land use form A to Land use form B during 1984 and 1990.

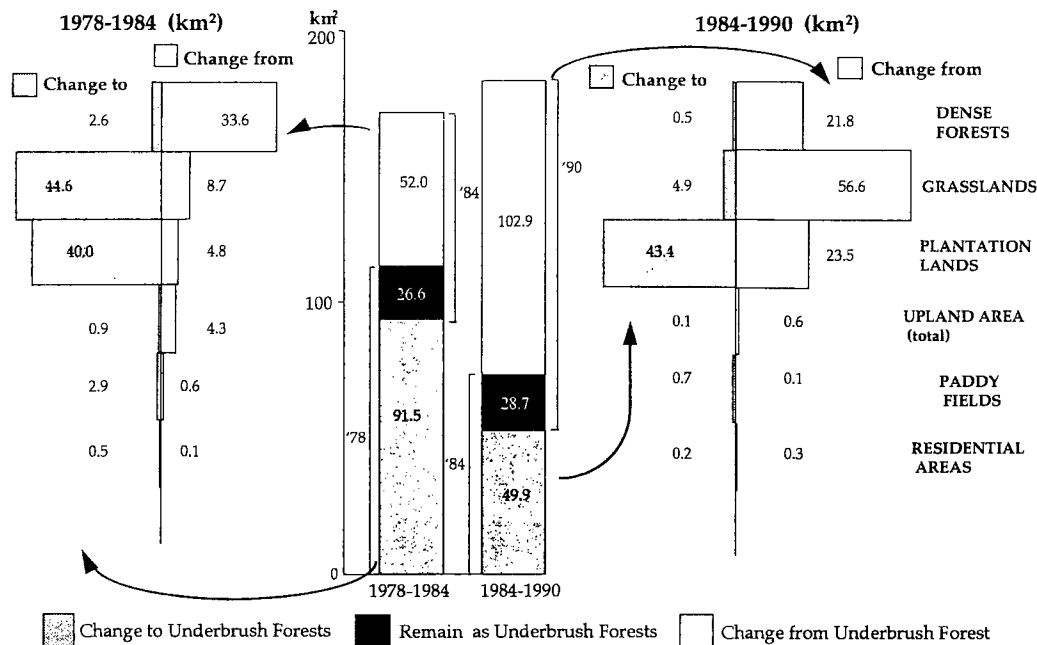


Fig. 5. Areas under underbrush forests (mostly secondary forests) indicating to and from which form they were changed during 1978 and 1984, and during 1984 and 1990.

grasslands was newly converted from underbrush forests (4.6%, 22 km²), dense forests (4.3%, 21 km²), and upland area under shifting cultivation (2.5%, 12 km²). Total plantation area in 1978 was mainly derived from upland area under shifting cultivation (3.2%, 16 km²), dense forests (4.7%, 23 km²) and upland fields (for crops and vegetables and "mixed"; 5.7%, 28 km²).

1984 (Figs. 4-6; Table 3)

Total plantation area doubled from 1978 to 1984, and became the largest land cover (43% of the total area), while the area under dense forests and underbrush forests decreased to nearly two-thirds of the area in 1978 to cover 21 and 11% of the total, respectively. Forty-three percent of grasslands (59 km²), 17% of dense forests (41 km²), 34% of underbrush forests (40 km²), and 67% of upland area under shifting cultivation (24 km²) were converted to land for plantation. Underbrush forests were converted to grasslands (6.1% of total; 45 km²) and plantation areas (5.5%, 40 km²). As for grasslands, 43% of them were converted to plantation areas, while 38% of the underbrush forests were converted to grasslands, which resulted in the apparent occupation of a similar percentage of grasslands in 1978 (18%) and 1984 (17%). Upland area under shifting cultivation also decreased significantly from 1978 (4.8%) to 1984 (0.3%), which was mainly due to the conversion to plantation lands. Area under paddy fields increased from 2.92% in 1978 to 5.02% in 1984 of the total study area.

1990 (Figs. 4-6; Table 4)

Areas for monoculture plantation, mostly coffee plantations, in 1990 were almost the same as those in 1984 covering 41% of the total area. However, nearly half of the areas under monoculture plantations in 1984 were converted to mixed plantations (104 km²) and

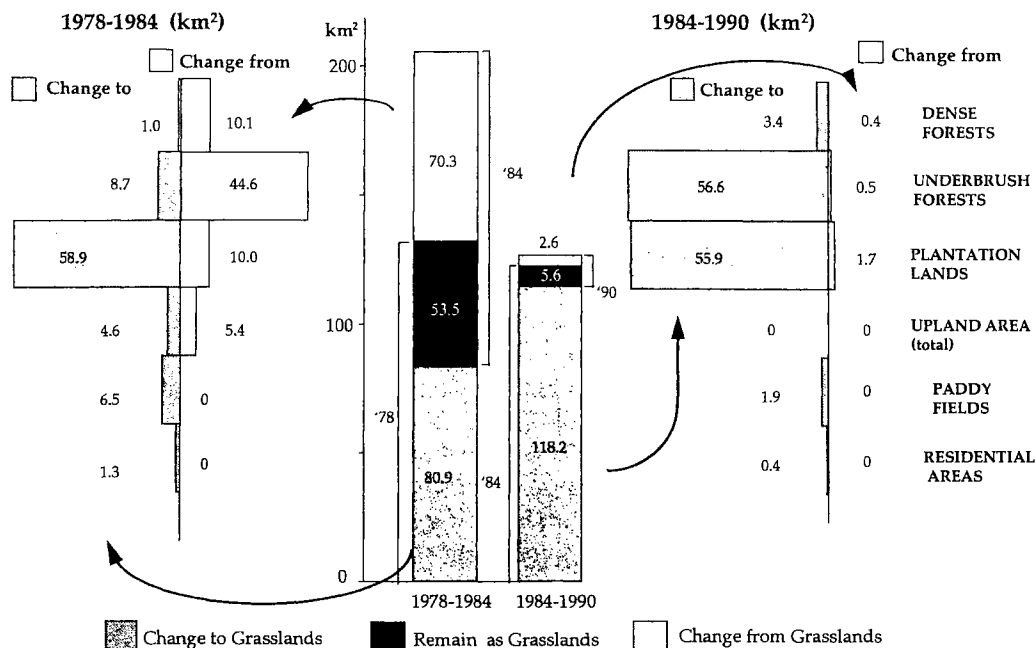


Fig. 6. Areas under grasslands indicating to and from which form they were changed during 1978 and 1984, and during 1984 and 1990.

underbrush forests (22 km²). On the other hand, 30% of dense forests (47 km²), 34% of grasslands (42 km²), and 47% of underbrush forests (37 km²) were converted to monoculture plantations, and these areas were larger than those converted to mixed plantations. Though the area for paddy fields increased only slightly from 36.6 km² in 1984 to 39.0 km² in 1990, 13.9 km² of the paddy field area in 1984 were converted to plantation areas and 14.3 km² of plantation areas in 1984 were converted to paddy fields in 1990. The area under dense forests decreased further during 1984 and 1990 mainly due to the conversion to plantation areas (7.3% of the total), while the area underbrush forests increased by 7% of the total area from grasslands (7.8%, 57 km²), and plantation areas (3.2%, 24 km²). The area under mixed plantations increased drastically between 1984 and 1990 and occupied 19% of the total area, mainly due to the change from monoculture plantations (14%, 104 km²). In addition, the area under grasslands decreased markedly from 17% in 1984 to 1.1% in 1990 changing to underbrush forests (7.8%) and plantation areas (7.7%).

Thus, Tables 2 to 4 and Figs. 5 and 6 show that the actual changes in land use form, both the increase and decrease of respective areas, were not simple in the study site. The conversion from some land use form to others was very rapid within a period of 6–8 y.

Based on the land use change between 1970 and 1990, it was generally recognized that the land use change started from the areas near villages and extended to the mountainous areas, the border separating watersheds (Fig. 4). A small area in the central part of the study site remained as dense forests, because the area was mountainous and designated as preservation forest. No significant relationships between the land use change and soil properties were observed in this area (Figs. 1 and 4).

DISCUSSION

The history of the policy on transmigration in Indonesia dates back to the era of Dutch rule, when it was small in scale and called "colonization." The policy was taken over by the government of Republic of Indonesia as a major issue in the Five-year Plan until now. The Five-year Plan started in 1969 and is now in the sixth phase.

Transmigration in Indonesia aims at transferring people living in the densely populated islands, mainly in Java Island, to sparsely populated islands. About 130 thousand families had migrated in the 1970s, when Sumatra Island received 43% of them. Lampung Province alone received 15% of them during this period, as it is located in the southern arm of Sumatra and near densely populated West Java. Transmigration in Indonesia recorded a peak of about 400,000 families in 1980–1984 and 1985–1989. Sumatra Island received an additional 316,000 families, and Lampung Province, 68 thousand families during 1980 and 1989 (Hirose 1993). The above figures correspond to the number of people who migrates under government control. Many spontaneous transmigrants, though there is no statistical record, also played a significant role in the increase of the population. It is considered that the virgin forests were cleared for agriculture mainly by spontaneous transmigrants.

Transmigration, which led to the increase of the population, was the major driving force for the land use changes in Lampung Province. In the 1970s, two remarkable land use changes were recognized, one was the change from dense forests (mostly primary forests) to grasslands and the other was the emergence of plantation lands (Fig. 4). The former was derived from the repeated use of forests for shifting cultivation with a cycle too short for regeneration, leaving vast areas of infertile grasslands. The land under plantations was mainly derived from dense forests and upland areas including upland area under shifting cultivation in the 1970s. The national policy aiming at obtaining foreign currency led to the increase of agricultural product for international market.

During 1978 and 1984, when transmigration recorded a peak in Sumatra and in Lampung Province, the land area under plantations increased drastically from 159 to 311 km², mainly from grasslands (59 km²), dense forests (41 km²), and underbrush forests (40 km²; Table 3). Total upland area including upland area under shifting cultivation and upland field growing crops and vegetables with fruit trees decreased from 100 km² in a total of 486 km² in 1970, 51 km² in a total of 729 km² in 1978, to 10 km² in a total of 729 km² in 1984 (Tables 2 and 3). This decrease clearly indicated the establishment of plantation agriculture, mainly coffee plantations, in the hilly areas, and the transfer of areas for crop and vegetable production from this area to the middle terraces in Lampung Province.

The land use change from land under monoculture plantations to mixed plantations was noticeable during 1984 and 1990 (Table 4, Fig. 4). The areas showing this change were those where plantations were introduced first in the area, presumably because the leading farmers in these areas aimed at a stable and higher income. At same time, the land use change from plantations to underbrush forests was also recognized (Fig. 4).

In conclusion, the land use and land cover in the study site changed drastically in the past 20 y from 1970 to 1990, due to the transmigration policy and the agro-economical circumstances. As mentioned above, the actual land use change was far more complex than the apparent change estimated from the change in areas under respective land use forms. In the past studies on land use and cover change, limited attention had been paid to the properties of soils in the study area. The dominant soils in Indonesia as well as in the

Southeast Asian countries are Acrisols and Ferralsols (Ultisols) which are generally infertile and prone to erosion under careless management of lands (FAO/UNESCO 1979). As the impact of human activities associated with the increase in population and industrialization is likely to lead to the intensification of land/soil use in the near future, the rational plans for future land use forms are urgently needed to harmonize with the national economic development in the Southeast Asian countries.

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