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The Dynamics of Cacao Agroforestry in the Margins of Protected Forest Areas

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Introduction

Cacao is the most important cash crop in the vicinity of the Lore Lindu National Park (LLNP), Central Sulawesi, Indonesia. Besides contributing 33 percent to the net crop income of farmers (Schwarze, 2004), it has improved the economy of rural communities. The LLNP is an endemic hotspot; however, it is threatened by the expansion and the intensification of cacao cultivation. For more than two decades, cacao has contributed to a substantial land use change in the study area. This study aims to identify the factors determining cacao cultivation practices. It helps to find policy options which will better harmonize the goals of economic growth and environmental sustainability.

Data and Methods

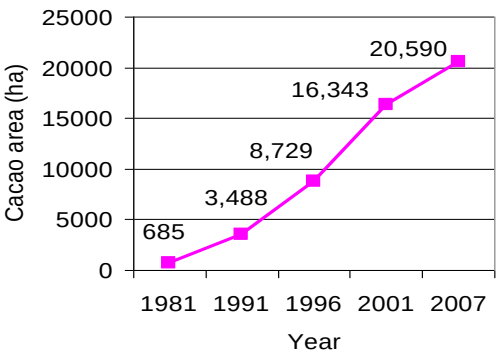
The study combines *GIS* (*Geographic Information System*) and village surveys data. Village surveys were conducted in 80 randomly selected villages out of a total of 119 villages in 2001 and 2007. Land use data were produced from Landsat satellite images in 1983, 2001 and 2007. Data on elevation, aspect, and slope were derived from a digital elevation model. In addition to descriptive analyses we applied a random effects (RE) model to estimate the influences of socioeconomic and geophysical variables on the cacao cultivation area. We used RE model since the effects in the model are considered to be a random sample and it allows estimation of coefficients on time invariant variables such as geophysical aspects.

Results and Discussion

Cacao intensification

In the last 26 years, the cultivated area of cacao has expanded from 685 ha to 20,590 ha in the whole 80 sampled villages (Figure 1). The highest rate of the cacao expansion occurred between 1981 and 1991 with 41% growth per year. Though the annual growth rate has been decreasing from 1981 to 2007, the expansion of cacao area has continued.

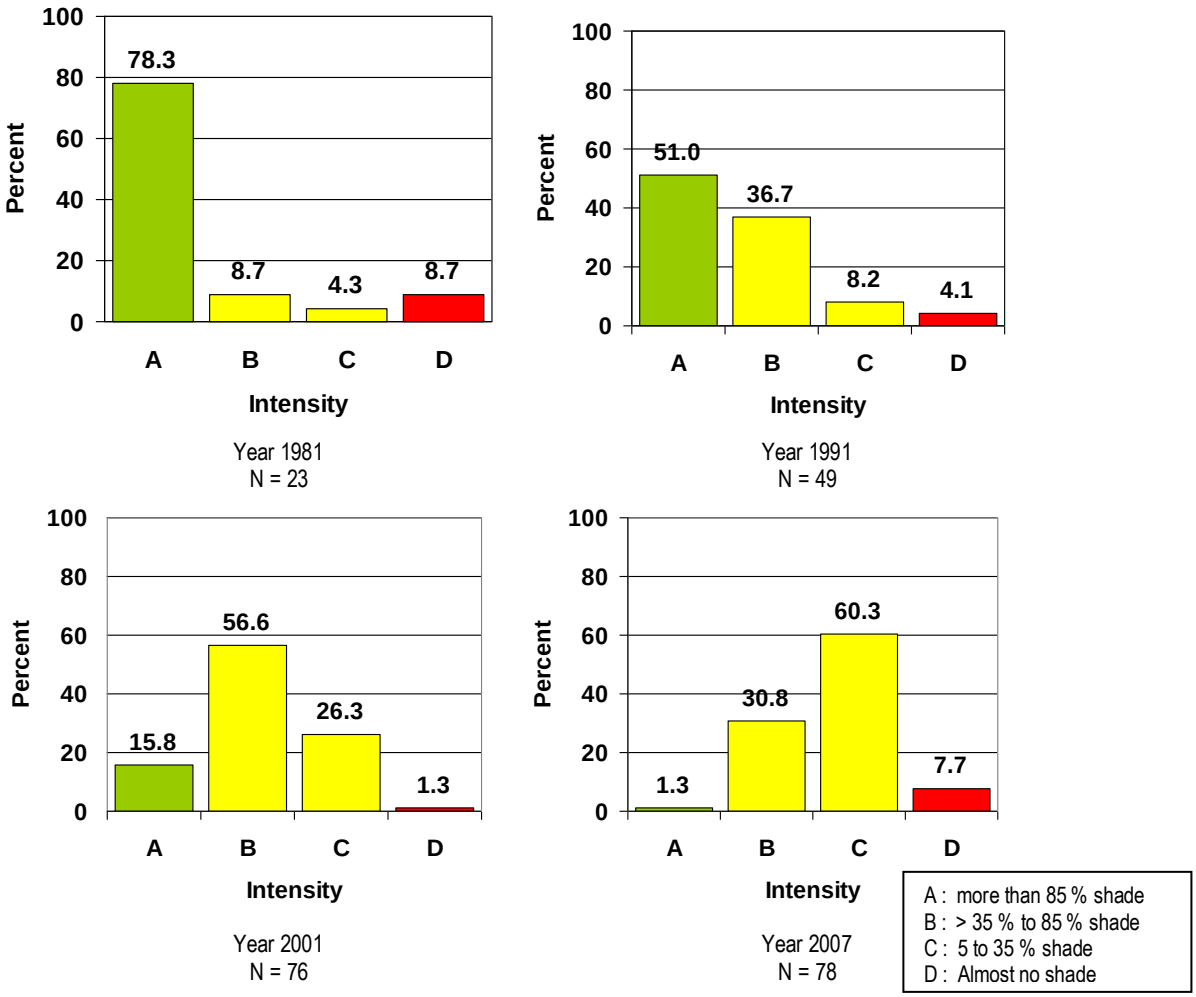
Figure 1. The Change of Acreage of Cacao (ha) between 1981 and 2007



Source : own calculations

The results of the village surveys demonstrate that expansion of the cacao cultivation area was also followed by intensification of production at village level as shown in Figure 2.

Figure 2. Intensification of Cacao Agroforestry



Source : own calculations

The intensification of cacao production means a reduction in shade cover on cacao plots. Cacao cultivation is categorized into four types (A, B, C, and D), which indicate higher cultivation intensity from A to D. For type A, there is more than 85 percent shade cover, while type D is characterised by almost no shade trees. The latter type represents cacao cultivated under a rich variety of forest and planted shade trees. In 1981, 78 percent of the cacao cultivated was of type A. Within ten years, the area share of type A declined to 51 percent. By 2007, there exists almost no cacao anymore which grown under a rich shade tree cover. More than 91 percent was with type B and C, followed by almost 8 percent of type D. This development exhibits the change in the way cacao is cultivated in the study area is becoming more intensive. When cacao was first introduced, only a few farmers directly converted their land to start growing cacao, which was represented by the high share of type A. Most farmers started to cultivate cacao on plots inside the forest due to a lower labour requirement. In addition, they could continue to grow their usual food and cash crops as a source of income and for food security. By practising intensive cacao production with fewer shade trees, farmers obtain higher yield and gain more profits. Thus, gaining higher profit is a driving force underlying the intensification of cacao production. There is a significant increase in annual net returns from 285Euro/ha (65-80% shade) to 780 Euro/ha (<5%shade) on intensified cacao production (Stefan-Dewenter *et al*, 2007). Therefore, there is a trade-off between the economic gains of cacao cultivation and environmental sustainability.

Determinants of cacao expansion

The following table presents the mean values of all explanatory variables used in the econometric model for 2001 and 2007 (Table 1).

Table 1. Means Comparison of Explanatory Variables between 2001 and 2007

Socioeconomic Variable (N=80)	Mean (2001)	Std Dev.	Mean (2007)		Std Dev.
Population density	3.3	1.54	3.4		1.54
N. of motorcycle	24.9	36.07	71.5	***	85.02
N. of handtractor	5.0	8.06	9.0	**	12.70
N. chainsaw	4.0	4.60	3.6		2.81
% of wet-land paddy	13.0	18.63	13.1		19.16
% of Bugisnese ethnic	5.7	8.41	5.2		7.10
Cacao price (IDR)	8,026.3	1821.02	12,846.1	***	1853.93
Land availability (ha) /head	.6	.55	.6		.36
Geophysical Variable	**Mean (2001)**	**Std Dev.**	**Mean (2007)**		**Std Dev.**
Slope (degree)	6.0	4.14	12.4	***	7.32
Elevation (meter)	698.7	336.46	952.0	***	421.36
Dist. to the street (meter)	3,951.1	6444.01	5,518.5		6347.88
Dist. to the river (meter)	863.1	821.58	1,166.6	**	1,166.61
Dist. to the forest (meter)	9.5	12.40	490.8	***	478.65

***** significant at 1%; ** significant at 5%; *significant at 10%**

The number of motorcycles, the number of hand tractors and the cacao prices were significantly higher in 2007 than 2001. The increase of motorcycles from 24.9 to 71.5 units per village represents better access to markets. Both factors, higher cacao price and better access to markets, stimulate farmers to sell more cacao to the market. The increase of hand tractors from 5 to 9 units per village explains that less labour is required for land preparation of wet-land paddy. This could indirectly lead to the cacao expansion process. The previous study found that the use of hand-tractors, as a labour saving technology, has increased upland expansion and intensified pressure on forests in this area (Maertens, 2003). The slope was significantly steeper in 2007 than 2001 from 6 to 12.4 degree. Also the elevation was significantly higher in 2007 than 2001 from 699 to 952 meter. These values show that the cacao cultivation was expanded at higher elevations and in steeper areas. Furthermore, the location where cacao was cultivated was getting further away from rivers and forests. The increase of distance to forest from 9.5 to 491 meter might indicate that the deforestation has occurred.

The factors influencing the intensification of cacao agroforesty were analysed using a random effect model. In the regression analysis we use the area of cacao as a dependent variable and socioeconomic and geophysical variables as dependent variables as shown in Table 2.

Table 2. The Influencing Factors of the Dynamics of Cacao Agroforestry

Socioeconomic Variable (N=80)	Coefficient	Robust Std Err.	P>z	
Population density	.016	.101	.117	
N. motorcycle	.003	.002	.032	**
N. Handtractor	.012	.016	.437	
N. Chainsaw	.054	.017	.002	***
% of wet-land paddy	- .033	.010	.002	***
% of Bugisnese ethnic	.060	.019	.002	***
Cacao price (ln)	.627	.275	.022	**
Land availibility(ha)/head	1.11	.300	.000	***
Geophysical Variable	**Coefficient**	**Robust Std Err.**	**P>z**	
Slope (degree)	.089	.032	.007	***
Elevation (meter)	.000	.000	.912	
Dist. to the street (meter)	-.000	.000	.983	
Dist. to the river (meter)	-.000	.000	.272	
Dist. to the forest (meter)	.000	.000	.357	

***** significant at 1%; ** significant at 5%; *significant at 10%**

The Hausmann test resulted the value of Prob>chi2 = 0.362, which is greater than critical value (α =0.05). This leads to no rejection of the null hypothesis that assumes RE estimator is fully efficient, and we concluded that the RE model provides consistent estimates. The output of estimated coefficients of the RE model confirms that most socioeconomic variables have significant influence on the expansion of cacao from 2001 to 2007, except for population density and number of hand tractor variables. Moreover, most of the socioeconomic variables have positive influence, except for the percentage of wet-land paddy variable, which has a negative effect on cacao expansion. For geophysical variables, slope is the only variable that has a significant and positive influence on cacao expansion.

Conclusions and Recommendation

The purpose of this paper was to analyse the characteristics and dynamics of cacao agroforestry and to analyse the determinants of cacao expansion in the margins of the LLNP area. Empirical results are used to explain the dynamic of cacao agroforestry in the region. From this study we conclude that there is an increasing percentage of cacao fields with less shade at village level. Simultaneously, there is a gradual conversion from forestland to cacao. The main drivers of this process are the number of motorcycles, the number of chainsaws, percentage of Bugisnese ethnic, cacao price, land availability per head and slope in the village. The only stabilising effect to the cacao expansion is the percentage of wet land paddy fields in the village. The rate of cacao expansion can be decelerated through some policy options without diminishing the economic gains of cacao. In this study we suggest promotion of the expansion of irrigation schemes to reduce cacao expansion.

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