Tropentag 2011
University of Bonn, October 5 - 7, 2011
Conference on International Research on Food Security, Natural Resource Management and Rural Development

Poverty and Tropical Deforestation in Forest Margin Areas: Evidence from Central Sulawesi, Indonesia

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Introduction

One key priority of national and international development policies is to combat poverty in developing countries. Ideally, poverty reduction should not have negative external effects which might aggravate global warming. However, these goals have been difficult to achieve. An example from South East Asia shows that poverty was reduced considerably over the last three decades, yet regional deforestation rates are the highest in tropical regions (Wunder, 2001). The link between poverty and deforestation is complex as it depends on factors such as geographical location and institutional arrangements, and is further complicated by the large number of methods available for measuring and approaching poverty. Our study provides an alternative approach towards the poverty-deforestation link from the village level perspective. Our study contributes to the debate over the links between poverty and deforestation. The use of poverty proxies including subjective well-being (SWB) assessments serves to capture the multidimensionality of poverty and therefore help to formulate improved policy suggestions to reduce future forest losses.

Data and Methods

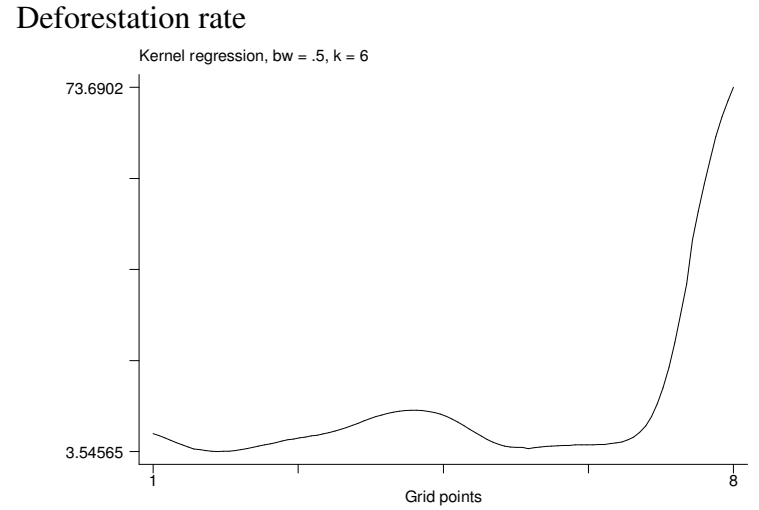
The study combines *GIS* (*Geographic Information System*) and village surveys data. Village surveys were conducted in 80 randomly selected villages out of a total of 119 villages in 2001 and 2007. The land use information was derived from Landsat ETM+ scenes and was compiled into a 100 x 100 meter grid resolution. Data on elevation, aspect, and slope were derived from a digital elevation model. To estimate the influence of poverty on deforestation, we apply a beta regression model. The dependent variable in our model is the rate of deforestation between 2001 and 2007, which ranges between 0 and 1. The estimation of beta regression is performed by maximum likelihood.

Results and Discussion

Before performing our analysis, we illustrated the relationship between SWB and the rate of deforestation using kernel density estimation (Figure 1). The form of the kernel density estimation suggests that there is a non-linear relationship between both variables. Deforestation decreases as the SWB value increases from 1 to 2, increases until 4, remains constant between 5 and 6, and drops until 6, at which point it increases rapidly beyond 8. Subsequently, the deforestation rate decreases again. For this reason, we introduced the SWB

variable as a polynomial in our model.[1] The results of the beta regression model, which analyses the influence of poverty on deforestation, are presented in Table 1. Because the interpretation of the estimated coefficients is not straightforward compared to normal linear models, we also present marginal effects. To specify our model we adopted a general to specific approach, which is superior to a specific to general approach. The LR test shows that the effects of insignificant variables of the full model are equal to zero[2], and therefore their inclusion did not improve the model. In the beta regression, the precision parameter with its identity link, showed as ln phi(ϕ), is presented on a logarithmic scale to ensure that it remains positive.

Figure 1.Subjective Well Being (SWB) vs. Deforestation Rates



Source: Study findings

The high significance (1%) of the ln phi(ϕ) variable in our model indicates that the precision coefficients can be treated as a full model parameter instead of a nuisance parameter (Zeleis, Cribari-Neto, Grün, Simas, & Rocha, 2011).

All variables in our estimated model are highly significant at the 1 percent level except for "marginal effect of percentage household with no land", which is significant at the 5 percent level. Our results suggest that there is a non-linear relationship between deforestation and SWB as well as other proxies of poverty. The relationships found differ depending on whether poverty is viewed from a subjective or objective perspective. The subjective assessment indicates that only the extreme poor and rich villages have high rate of deforestation. In contrast, the relative poverty assessment as an objective view shows no empirical evidence that poverty increases the deforestation rate. Moreover, additional proxies derived from particular elements of poverty dimensions also within an objective view have an unclear pattern; variables might increase or decrease the deforestation rate. High illiteracy rates and less access to markets increase deforestation rates, whilst the availability of electricity in a village increases the deforestation rate. Nevertheless, from the overall subjective perspective, between 2001 and 2007 the improvement of village well-being encouraged a reduction in the deforestation rate. Other proxies that consider multiple aspects of poverty include: share of poor households in a village (objective approach), and the SWB,

[1]We have also checked for linearity of other poverty proxy variables. The results indicate that those variables are non-linear. However, adding a square term for those variables does not improve the beta regression model.

[2] LR test (Prob> chi2) with ρ-value = 0.871

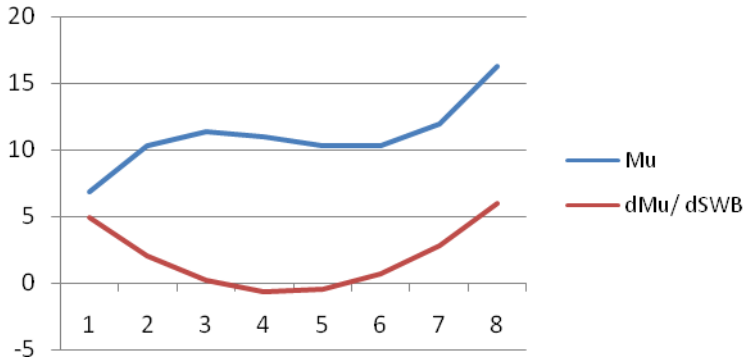
which also has a highly significant influence on the deforestation rate. A higher share of poor households in the village reduces the rate of deforestation; if the share of poor households in a village increases by 10 percent, the deforestation rate is reduced by 0.01. This shows that people from poor households are not the direct actors who open up forests for agricultural uses. Furthermore, because the SWB enters the regression in form of a polynomial function, we present Figure 2 to illustrate the impact of this variable on the deforestation rate.

Table 1.Beta Regression Estimations

Variable:	**Estimated**		Marginal Effects (Mfx) at x		
	Coef.		Coef.(Mfx)		SE (Mfx)
% Change of irrigated land	– . 025	***	– .001	***	.000
% of HH with electricity	.009	***	3e-04	***	.000
Distance to market (10 km)	.179	***	.006	***	.001
% of HH that are members of informal rotating savings groups (arisan)	– .021	***	– .001	***	.000
% of HH with no land	– .011	***	– 3e-04	**	.000
% of illiteracy in the working age population	.030	***	.001	***	.000
% of females in the village	– .079	***	– .003	***	.000
Averaged slope (degree)	– .217	***	– .007	***	.000
Averaged elevation (000 m)	– 1.871	***	– .060	***	.010
Forest size in 2001 (km^2)	.006	***	2e-04	***	.000
% of poor HH	– .026	***	– .001	***	.000
SWB in 2001 cubic	.200	***	See Figure 3		
SWB in 2001 squared	– 2.634	***	See Figure 3		
SWB in 2001	10.584	***	See Figure 3		
Change of SWB from 2001 to 2007	– .221	***	– .007	***	.002
Constant	– 6.962	***			
/ln phi(ϕ)	5.157	***			

Number of observed villages	52
Prob> chi2	0.00
Phi (ϕ)	173.633
Log Likelihood	150.088
Parameter	17

Figure 2. Marginal Effects of SWB



Source: Study findings

The marginal effect of the SWB variable is a derivative of the polynomial function (Mu) with respect to the SWB value in 2001 (dMu/dSWB), which reflects the real relationship between deforestation and SWB in 2001. Figure 2 shows that the deforestation rate decreases until a SWB of 4 is reached in 2001, beyond which it increases again. The marginal impact between SWB in 2001 and the deforestation rate hence follows a U-shaped functional form. This shape indicates that the extreme poor and the rich villages are responsible for high deforestation rates. When we look at the changes in wealth corresponding to changes in SWB from 2001 to 2007, we find that an increase in wealth ranking reduces the deforestation rate. Further, a one level well-being improvement within the last six years reduces the deforestation rate by 0.007. However, proxies of different aspects of poverty such as: share of poor households in a village (an objective measure), and the subjective well-being perception suggest different results. The relative poverty assessment as an objective view provides no empirical evidence that poverty increases the deforestation rate.

Conclusions and Recommendation

By considering different dimensions of poverty, we found that objective and subjective poverty measures yielded contrasting results. The objective relative poverty assessment provides no empirical evidence that poverty affects the deforestation rate. Further objective measures of aspects of poverty show contrasting patterns; particular variables might increase or decrease the deforestation rate. On the contrary, subjective assessments clearly indicate that extreme poor and rich villages have high rates of deforestation. Although wealthier villages had higher deforestation rates during 2001, by 2007 increases in well-being had decreased the rate of deforestation in this region. Our findings highlight for the benefit of future research on links between poverty and deforestation that a holistic consideration of poverty is required, as different approaches and measures yield contrasting results. Give that improvements in village well-being appears to eventually lower rates of deforestation, policy measures aimed at reducing poverty may also reduce deforestation. However, the non-linear relationship between initial SWB and deforestation suggests that there remain trade-offs between forest conservation and poverty reduction. Policy makers should therefore consider this trade-off, and aim to improve education and training on environmentally-friendly agricultural practices, such as agro-forestry systems and terrace construction in highland areas to reduce landslides and soil erosion, which are particularly important for highland deforested areas. Another option would be to help and encourage informal rotating savings groups (arisan), which help farmers manage their financial resources in order to intensify agricultural production, since this leads to long-term forest preservation. Investment in irrigation is another policy option since it has a forest-conserving effect; nonetheless cost-benefit analyses are required in order to assess the viability of such investments.

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