# Effects of Land Use, Market Integration, and Poverty on Tropical Deforestation: Evidence from Forest Margins Areas in Central Sulawesi, Indonesia

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*Segala perkara dapat kutanggung di dalam Dia yang memberi kekuatan kepadaku.*
***Filipi 3: 13***

*Hanya dekat Allah saja aku tenang, dari pada-Nyalah keselamatanku. Hanya Dialah gunung batuku dan keselamatanku, kota bentengku, aku tidak akan goyah.*
***Mazmur 62:2-3***

*Tuhan adalah Penolongku. Aku tidak akan takut. Apakah yang dapat dilakukan manusia terhadap aku?*
***Ibrani 13: 6***

**SUMMARY**

Many millions of people in the developing world depend on forests for their livelihoods. Areas of denser forest cover have been shown to contain more poor people. However, there is a potential conflict between poverty reduction and deforestation targets. Agricultural expansion into tropical forests is, in many parts of the world, the means by which rural economies have been developed and livelihoods improved. A further trade-off between economic growth and environmental sustainability is that forest conversion and degradation aggravates climate change. Therefore, tropical deforestation issues have become a challenge for the global community, in particular attempting to balance the goals of poverty reduction and sustainable agricultural production. Although tropical deforestation has been a central part of international environmental discussions in recent years, there remain unanswered questions concerning the processes and linkages involved in tropical deforestation. This dissertation aims to accommodate the complex inter linkages between various factors affecting the tropical deforestation processes by examining the deforestation problem in the vicinity of Lore Lindu National Park in Central Sulawesi, Indonesia.

This dissertation consists of three independent papers that analyse tropical deforestation from many perspectives. The first paper identifies driving forces and characteristic processes of land use changes, in this case forest and non-forest. An adapted Hausman-Taylor panel approach was used in a binary dependent variable, alongside with key socioeconomic, geographical, and geophysical factors to examine the determinants of forest cover dynamics. The results indicate that population growth is negatively correlated with forest cover. Furthermore, deforestation occurred even in remote locations, and in areas with steep slopes.

The second paper links the drivers of deforestation which occur as a result of cash crop expansion and market integration, using price transmission analysis between domestic and international markets. In order to attain this objective, we apply a wide range of econometric techniques including panel model, cross section and time series analysis. Results indicate that a high degree of integration between local and international markets is one of determinants of the area of land under cacao cultivation. The results confirm that decisions to expand the cultivation of cacao will depend more on expectations of future prices than

prevailing prices. The only stabilising effect against cacao expansion is the presence of paddy rice fields in the village.

To reduce poverty without incurring negative environmental effects, such as deforestation, remains a challenge for many developing countries. The third paper contributes to the debate on the link between poverty and deforestation, by providing an alternative approach using a village level perspective and broadening the range of poverty measures used to include subjective well-being (SWB) and poverty proxies. Since poverty is a complex phenomenon, both subjective and objective approaches have been utilised. For the subjective approach this includes using proxies of different aspects of poverty and SWB at the village level. The relationship between deforestation and a number of explanatory variables has been estimated in a Beta regression framework. Results suggest that there is a non-linear relationship between SWB as well as other proxies of poverty and deforestation. The villages which were initially poorest and wealthiest have high deforestation rates, whilst the moderately well-off villages have lower deforestation rates. In contrast, the relative poverty assessment of the objective view shows no empirical evidence that poverty increases the deforestation rate. Moreover, additional objective view proxies measuring particular aspects of poverty show unclear patterns; for each aspect used, variables might increase or decrease the deforestation rate. As an example, high illiteracy rates and less access to markets increase deforestation rates, but an increase in the percentage of irrigated land in a village reduces deforestation rates. Nevertheless, overall between 2001 and 2007, the improvement of village well-being helped to reduce the deforestation rate in this region.

This dissertation accommodates the inter linkages between factors affecting tropical deforestation processes by smallholders. The results of the study are consistent and highly complementary, and finally provide the more effective policy suggestions within a local context, which will better harmonise the goals of economic growth and environmental sustainability.

## Zusammenfassung

Millionen Menschen in unterentwickelten Ländern sind vom Wald als Grundlage ihres Lebensunterhalts abhängig. Es hat sich gezeigt, dass in Gebieten mit dichter Waldbedeckung ein höherer Anteil an armen Menschen leben. Jedoch besteht ein potentieller Konflikt zwischen Armutsbekämpfung und Walderhaltung. Die landwirtschaftliche Expansion in tropischen Waldgebieten ist in vielen Teilen der Welt ein Weg, die ländliche Wirtschaft zu entwickeln und die Lebensgrundlagen der Menschen zu verbessern. Ein weiterer Spannungspunkt zwischen wirtschaftlicher Entwicklung und ökologischer Nachhaltigkeit liegt darin begründet, dass Waldumwandlung und Waldabholzung den Klimawandel beschleunigt. Vor diesem Hintergrund ist der Versuch, eine Balance zwischen Armutsbekämpfung und nachhaltiger landwirtschaftlicher Produktion zu finden, eine globale Herausforderung geworden. Auch wenn die Zerstörung der tropischen Wälder zentraler Bestandteil der ökologischen Diskussion der vergangenen Jahre war, so bleiben dennoch Fragen zu den zugrundeliegenden Prozessen und internen Beziehungen der tropischen Entwaldung. Diese Dissertation zielt darauf ab, die komplexen Verbindungen zwischen den verschiedenen Faktoren, die die Abholzung der Tropenwälder beeinflussen, am Beispiel der Randbereiche des Lore Lindu National Park in Zentral Sulawesi, Indonesien zu untersuchen und darzustellen.

Diese Dissertation besteht aus drei unabhängigen Aufsätzen, die die Abholzung der Tropenwälder aus unterschiedlichen Perspektiven analysieren. Der erste Aufsatz identifiziert treibende Kräfte und charakteristische Prozesse von Landnutzungsänderungen, in diesem Fall zwischen Wald und Nicht-Wald. Um die Determinanten der Waldflächendynamik zu untersuchen wurde ein angepaßter Hausman-Taylor-Panel Ansatz in einer binären abhängigen Variablen zusammen mit sozioökonomischen, geographischen und geophysikalischen Schlüsselfaktoren verwendet. Die Ergebnisse zeigen, dass das Bevölkerungswachstum negativ mit der Waldbedeckung korreliert ist. Darüber hinaus erfolgte Abholzung auch an entfernten Standorten und in Gebieten mit starker Hangneigung.

Der zweite Aufsatz verbindet die Ursachen der Abholzung, die als Folge einer Cash Crop Expansion und Marktintegration auftreten, unter Verwendung von Preis-Transmissions-Analyse zwischen nationalen und internationalen Märkten. Um dieses Ziel zu erreichen, wird ein breites Spektrum von ökonometrischen Techniken einschließlich Panel-Modell, Querschnitt- und Zeitreihenanalyse angewendet. Die Ergebnisse zeigen, dass ein hohes Maß

an Integration zwischen lokalen und internationalen Märkten eine der Determinanten der Kakaoanbaufläche ist. Die Ergebnisse bestätigen, dass die Entscheidungen die Anbauflächen von Kakao auszubauen, stärker von den Erwartungen der zukünftigen Preise als von den vorherrschenden Preisen abhängen. Der einzige stabilisierende Faktor gegenüber der Expansion des Kakaoanbaus ist die Anwesenheit von Paddy-Reis Felder im Dorf.

Armutsbekämpfung ohne negative Umweltauswirkungen wie Abholzung, bleibt eine Herausforderung für viele Entwicklungsländer. Der dritte Aufsatz trägt zur Debatte über den Zusammenhang zwischen Armut und Entwaldung bei, indem er einen alternativen Ansatz mit einer Perspektive auf Dorfebene und eine Erweiterung der Palette der Meßgrößen von Armut verwendet, um das Subjektive Wohlbefinden (SWB) und Armuts Proxies einzubeziehen. Da Armut ein komplexes Phänomen ist, wurden sowohl subjektive und objektive Ansätze genutzt. Zu den subjektiven Ansätzen gehört auch die Verwendung von Proxies für verschiedene Aspekte von Armut und SWB auf Dorfebene. Die Beziehung zwischen Abholzung und einer Reihe von erklärenden Variablen wurde in einer Beta Regression geschätzt. Die Ergebnisse legen nahe, dass es eine nicht-lineare Beziehung zwischen SWB sowie anderen Proxies von Armut und Entwaldung gibt. Die Dörfer, die innitial zu den ärmsten beziehungsweise den wohlhabensten gehörten, zeigen hohe Abforstungssraten, während die mäßig wohlhabenden Dörfer eine niedrigere Entwaldungsrate aufweisen. Im Gegensatz dazu zeigt die relative Armutseinschätzung der objektiven Betrachtungsweise keine empirischen Belege dafür, dass Armut die Abholzungrate steigert. Darüber hinaus zeigen weitere Proxies der objektive Ansätze zur Messung bestimmter Aspekte von Armut unklar Muster; für jeden verwendeten Aspekt können die Variablen die Abforstungsrate erhöhen oder reduzieren. So erhöhten beispielsweise eine hohe Analphabetenrate und geringerer Zugang zu den Märkten die Entwaldungsrate, während eine Erhöhung des Anteils der bewässerten Anbauflächen in einem Dorf diese senkte. Dennoch, insgesamt half die Verbesserung der dörflichen Lebensstandarts zwischen den Jahren 2001 und 2007, die Entwaldungs in dieser Region zu reduzieren.

Diese Dissertation geht den Verbindungen zwischen den treibenden Faktoren der Abholzung der Tropenwälder durch Kleinbauern nach. Die Ergebnisse dieser Studie sind in sich konsistent und in hohem Maße komplementäre und bieten Anhaltspunkte für wirksamere Politikansätze, zur besseren Harmonisierung der Ziele von Wirtschaftswachstum und ökologischer Nachhaltigkeit in einem lokalen Kontext.

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## List of Abbreviations

| | |
|---|---|
| ADF | Augmented Dickey Fuller |
| BPS | Badan Pusat Statistik (Centre of Statistical Office) |
| BTNLL | Balai Taman Nasional Lore Lindu |
| CIESIN | Center for International Earth Science Information Network |
| Coef. | Coefficient |
| DEM | Digital Elevation Model |
| DCI | Direct Calorie Intake |
| DRM | Day Reconstruction Method |
| ESM | Experience Sampling Method |
| EMA | Ecological Momentary Assessment |
| FAO | Food and Agriculture Organisation |
| FE | Fixed Effects |
| FEI | Food Energy Intake |
| GIS | Geography Information System |
| GLM | Generalised Linear Model |
| GME | Generalised Maximum Entropy |
| Ha | Hectare |
| HH | Households |
| HT | Hausman Taylor |
| ICCO | International Cocoa Organisation |
| ID | Identity |
| IPB | Institut Pertanian Bogor (Bogor Agricultural University) |
| IPCC | Intergovernmental Panel on Climate Change |
| KPSS | Kwiatkowski–Phillips–Schmidt–Shin |
| LLNP | Lore lindu National Park |
| OLS | Ordinary Least Squares |
| PAT | Poverty Tools Assessment |
| RE | Random Effects |
| REDD | Reducing Emissions from Deforestation and Forest Degradation |
| SE | Standard Error |
| SWB | Subjective Well-being |
| STORMA | Stability of Rainforest Margins |

| | |
|---|---|
| OECD | Organisation for Economic Co-operation and Development |
| UNTAD | Universitas Tadulako (Tadulako University) |
| USD | United States Dollar |
| VECM | Vector Error Correction Model |

# *Chapter 1.*

## General Introduction

Tropical forests cover around just 7 percent of the Earth's land surface, yet are richer in species than any other terrestrial habitat and provide habitat for over half of all species on Earth (CIESIN, 2000; Lindsey, 2007). Tropical forests are also a significant carbon sink, thereby regulating the global climate system (Detwiler & Hall, 1988), and accounting for 20-25 percent of anthropogenic carbon emissions when deforested (Gibbs & Herold, 2007). The destruction of tropical forests therefore contributes to both biodiversity loss and global climate change (Houghton, 2005; IPCC, 2007). Further problems resulting from tropical deforestation include food insecurity, soil degradation and forest degradation (Angelsen, 1995; Geist & Lambin, 2002; Southworth, 2004; Turner II et al., 1995)**.**

From a socioeconomic perspective, many millions of people in the developing world depend on forests for their livelihoods. Areas of denser forest cover contain a disproportionate number of poor people (Sunderlin et al., 2007). However, there is a potential conflict between targets for poverty reduction and deforestation as, in many parts of the world, agricultural expansion into tropical forests is the means by which rural economies have been developed and livelihoods improved. Where economic growth occurs through forest conversion or degradation, this is at the expense of environmental sustainability and climatic stability, with long–term economic, social and ecological impacts on human life. The FAO reports that most tropical deforestation occurs in just a few countries. The 10 countries with the highest rates of deforestation account for more than 50 percent of annual deforestation. Indonesia, as the country with the second highest rate of deforestation, accounts for 7.4 million ha (FAO, 2005).

For such reasons, issues and challenges related to tropical deforestation have received much attention from the global community, in particular attempting to balance the goals of poverty reduction and sustainable agricultural production. The current rate of deforestation is alarmingly high, especially as a result of agricultural conversion, which continues at a high rate of 13 million hectares per year from 1990 to 2005 (FAO, 2005). Houghton (2005) predicted that, if current trends continue, carbon emissions from deforestation will be equivalent to nearly half of the emissions from the burning of fossil fuels since the beginning of the Industrial Revolution. An important commitment of the international community under the Kyoto Protocol is to support selected developing countries that are at risk of large-scale deforestation[1] to reduce emissions from deforestation and forest degradation (REDD) through adequate funding of emission reduction projects[2] (Santilli et al., 2005). Despite the political prominence of tropical deforestation, due to the complex relationships between many interconnected factors involved, there remain many uncertainties about the processes and linkages involved.

A number of studies attempt to understand the causes of tropical deforestation (Angelsen & Kaimowitz, 1999; Geist & Lambin, 2001; Kaimowitz & Angelsen, 1998; Myers, 1994; Wibowo & Byron, 1999). Many studies focus on single causes, with much attention given to shifting cultivation (Angelsen, 1995; Angelsen & Kaimowitz, 1999; Takasaki, 2006; Zhang et al., 2002) and population growth (Carr, 2004; Carr at al., 2005; Cropper & Griffiths, 1994; Hartwick, 2005; Jarosz, 1993). In contrast, Geist and Lambin (2001, 2002) analysed multiple factors and distinguished between direct (proximate) causes and underlying causes. The findings of this study support the view of Geist and Lambin (2001) that there are links between proximate and underlying causes and tropical deforestation. Thus, analyses of tropical deforestation should capture complex interrelated factors. This view is confirmed by several other authors (Bray, 2005; Carrero & Fearnside, 2011; Uusivuori et al, 2002). Other research focuses on the links between factors in tropical deforestation processes (Barraclough & Ghimire, 2000; Chomitz et al., 2007). Nevertheless, few studies in the existing literature include poverty and market aspects in the analysis of tropical deforestation (Kaimowitz & Angelsen, 1998).

Some authors in tropical deforestation studies have turned their attention to understanding how a local scale is more appropriate than a global, regional or national scale as deforestation is context specific (Barraclough & Ghimire, 2000; Kaimowitz & Angelsen, 1998; Scrieciu, 2007). The latter author conducted a macro-scale study of tropical deforestation in 50 countries over an 18 year period and concluded that local level studies provide more effective policy suggestions. Furthermore, agricultural expansion is recognised as the prominent proximate cause of tropical deforestation (Barraclough & Ghimire, 2000; Geist & Lambin, 2001; Kaimowitz & Angelsen, 1998), of which at least 50 percent is caused by smallholders (Barraclough & Ghimire, 2000).

[1] Brazil, Indonesia, Bolivia, Peru, Columbia, and some central African countries.
[2] Programs cover the enforcement of environmental legislation, support economic alternatives such as carbon credits and develop institutional capacities in remote forest regions.

By taking into consideration the findings of a large body of literature regarding tropical deforestation, this thesis analyses tropical deforestation processes from many perspectives, accommodates inter linkages between proximate and underlying causes and uses a local context, based on the significance of agricultural expansion by smallholders. This thesis examines the deforestation problem in a region of tropical forest in the vicinity of Lore Lindu National Park in Central Sulawesi, Indonesia. This park hosts many collections of endemic species and contains several water catchments within the national park (The Nature Conservancy/BTNLL, 2002). Nonetheless, this region is also characterised by some profound problems such as high rates of poverty and deforestation. Forest cover decreased by 4.8 percent from 2001 to 2007 whilst 59.1 percent of households were living below the international poverty line of 2 USD per capita per day in 2007 (Van Edig et al., 2010). Smallholders are the major agents of forest degradation in this area (Maertens et al., 2006; Steffan-Dewenter et al., 2007). Furthermore, a trade-off between the economic gains of agricultural expansion and environmental sustainability is apparent. Thus it is important to devise sustainable development policies which simultaneously reduce poverty, preserve the long-term functioning of the forests and protect peoples' livelihoods.

This dissertation covers three research questions. First, what are the determinants of forest cover areas? Second, what role does market integration between domestic and international markets play in agricultural expansion? Third, what is the relationship between poverty and deforestation? This dissertation uses a broad set of quantitative analyses to explain tropical deforestation and contributes to the literature in four innovative ways. First, this study develops our understanding of the scale of analysis by exploring in depth the causes and processes of deforestation at the village level. Second, the implemented methodology contributes to the advancement of quantitative methods through the application of a panel approach to analyse the determinants of forest cover. Third, this dissertation deepens our understanding of the link between poverty and deforestation by implementing seldom-used poverty measures such as subjective well-being (SWB) and poverty proxies. Fourth, this dissertation supplements an analysis of relevant interconnected drivers of deforestation with the inclusion of the role of international markets using price transmission analysis, which to our knowledge has not yet been investigated.

This dissertation comprises three independent papers. The first paper identifies driving forces and characteristic processes of land use changes, in this case forest to non-forest. An adapted Hausman-Taylor panel approach was used in a binary dependent model, alongside with key socioeconomic, geographical and geophysical factors to examine the determinants of forest cover dynamics**.** The results indicate that high population growth reduces forest cover. Furthermore, deforestation occurred even in remote locations, and in areas with steep slopes.

The second paper aims to identify the factors determining cacao expansion, which is the major driver of deforestation in this area, including the role of market integration between international and local markets. To analyse the factors determining cacao expansion including the role of market integration between international and local markets, we apply a number of econometric techniques including panel model, cross section and time series analysis. The random two-way Random Effects (RE) of the panel econometric and OLS models indicate that population density and availability of agricultural land have positive influences on the expansion of cacao cultivation. However, we can only detect the influence of price transmission on cacao expansion in the OLS model. The only stabilising effect against cacao expansion is the presence of paddy rice fields in the village. This study helps to understand the cacao expansion process that the decisions to expand the cultivation of cacao will depend much on farmers' expectations of cacao future prices rather than the prevailing prices. Thus, the high degree of integration between local and international markets contributes to the expansion of cacao production in the study region.

To reduce poverty without incurring negative environmental effects, such as deforestation, remains a challenge for many developing countries. The last paper analyses the relationship between deforestation and a number of explanatory variables in a Beta regression framework. Results demonstrate an obvious pattern from the subjective view. The initially poorest and wealthiest villages had higher deforestation rates, whilst the moderately well-off villages had lower deforestation rates. In contrast, the objective view shows unclear patterns and suggests that a given aspect may either increase or decrease the deforestation rate. As an example, high illiteracy rates and less access to central markets increase deforestation rates, but an increase in the percentage of irrigated land in a village reduces deforestation rates. Although initially wealthier villages showed higher rates of deforestation, the improvement of village well-being helped to reduce the deforestation rate in this region overall between 2001 and 2007.

The remainder of this dissertation is organised as follows: Chapters 2 to 4 present the aforementioned individual papers and. Chapter 5 concludes this dissertation, with a summary of the policy implications derived from the study overall and suggests topics for future research.

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# *Chapter 2*

## Determinants of Forest Cover Dynamics in the Margins of Protected Forest Areas: Evidence from Central Sulawesi, Indonesia

**Reetz, S., Schwarze, S. and Brümmer, B. 2011.**

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**Abstract:**

Spatially explicit modelling is beneficial for supporting land use planning and land allocation. It allows researchers to examine regional land use changes, in particular patterns of land use, and identify driving forces and characteristic processes of such changes. However, most studies apply static spatially explicit models to land use changes, and less attention has been paid to dynamic analysis. We adapt the Hausman-Taylor panel approach for a binary dependent variable in order to identify the key socioeconomic, geographic, and geophysical factors that determine forest cover dynamics. Our analysis presents the dynamics of forest cover using spatial and socioeconomic data from 2001 and 2007, obtained from Landsat images, and surveys in 80 randomly selected villages, respectively. Our results indicate that population growth is negatively correlated with forest cover. Furthermore, deforestation occurred even in remote locations, and in areas with steeper slopes. In terms of policy implications, the finding of a negative impact of population growth on forest cover suggests that measures which keep population growth at a low rate might be important for forest area conservation. Furthermore, investments in land irrigation, and implementation of innovative community forest management programs, which make forest conservation a viable economic option, could help to alleviate deforestation pressures. Training on environmentally-friendly agricultural practices, such as building terraces on the steep slopes, could support forest conservation as well as reduce landslides and soil erosion in highland areas.

Key Words: *Lore Lindu National Park, forest cover change, Hausman Taylor model, deforestation, land use*

## 2.1. Introduction

Land use which balances both economic benefits and environmental constraints is an ideal long term goal. However, many studies show that in recent years, humans have tended to adopt land use patterns that lower the quality of the environment in order to achieve economic growth through agricultural expansion (Adger & Brown, 1994; Angelsen, 1995; Contreras-Hermosilla, 2000; Fearnside, 2000; Geist & Lambin, 2002; Reardon, 1997). Agricultural expansion into forests and other marginal lands is the main opportunity for poor farmers in many developing countries to improve their economic prospects. However, such short term production decisions improve rural economies at the expense of long term environmental quality (Barbier, 1997). Similar patterns of land use change have occurred in the study area, namely, Lore Lindu National Park (LLNP) in central Sulawesi, Indonesia. This protected area is very important for biodiversity and conservation since it hosts many collections of endemic species and contains several water catchments within the national park (The Nature Conservancy/BTNLL, 2002). However, a previous land use study found that conversion of forests to agricultural use by rural communities has caused substantial forest loss (Maertens, 2003). Since rural communities play a significant role in maintaining the stability of the rainforest, a better understanding of their socioeconomic dynamics can benefit forest conservation. Improved understanding of determinants of forest cover dynamics in forest margins may help to decelerate forest degradations in this area.

Land use change, especially from forest to non-forest use, contributes significantly to global environmental issues such as climatic change, food insecurity, soil degradation, forest degradation, and biodiversity loss (Angelsen, 1995; Geist & Lambin, 2002; Southworth, 2004; Turner II et al., 1995). It thus requires further study to understand its processes and effects. One approach entails spatially explicit modelling, which allows researchers to examine regional land use change patterns as well as identifying driving forces and characteristic processes of such changes. The knowledge gained from such studies has great importance for supporting land use planning and land allocation which help to conserve long term environmental quality. However, existing models of land use change, that accommodate human behavioural components and retain the more fully articulated economic models, remain poorly developed. Improvement of such models has been a challenge for researchers attempting to advance our understanding of complex interactions of social and environmental factors (Irwin & Geoghegan, 2001; Overmars &

Verburg, 2005; Southworth, 2004). Moreover, most studies are limited to static models (Chomitz & Gray, 1996; Chomitz & Thomas, 2003; Cropper et al., 2001; Deininger & Minten, 2002; Müller & Zeller, 2002; Nelson & Hellerstein, 1997). Few studies have been attempted to accommodate dynamic mechanisms (De Pinto & Nelson, 2008; Mertens et al., 2000; Munroe et al., 2004; Vance & Geoghegan, 2002). Accordingly, this paper aims to contribute to the advancement of an empirical methodology. We apply spatial panel in binomial logit models at the village level. Using panel econometric models in conjunction with spatial analysis provides better understanding of determinants of forest cover because it captures the dynamics adjustment. Our paper expands on prior work by accommodating socioeconomic components, recapturing the effect of the time invariant on explanatory variables, and tackling the endogeneity problem.

Since we are particularly interested in deforestation in the forest margins, we focus our study on factors that influence forest cover between 2001 and 2007. The study demonstrates that the Hausman Taylor model performs better in estimating factors that determine forest cover than pooled logit (OLS), random effect (RE), and fixed effect (FE) estimators. Our results highlight that population growth is negatively correlated with forest cover. Furthermore, factors which are unexpectedly found to be significant negative influences on forest cover are: increasing distance to the village centres and central markets, and steeper slopes. These findings confirm that deforestation occurred even in remote locations and steeper slope areas and show that limited physical access to central markets does not impede deforestation activities in this area.

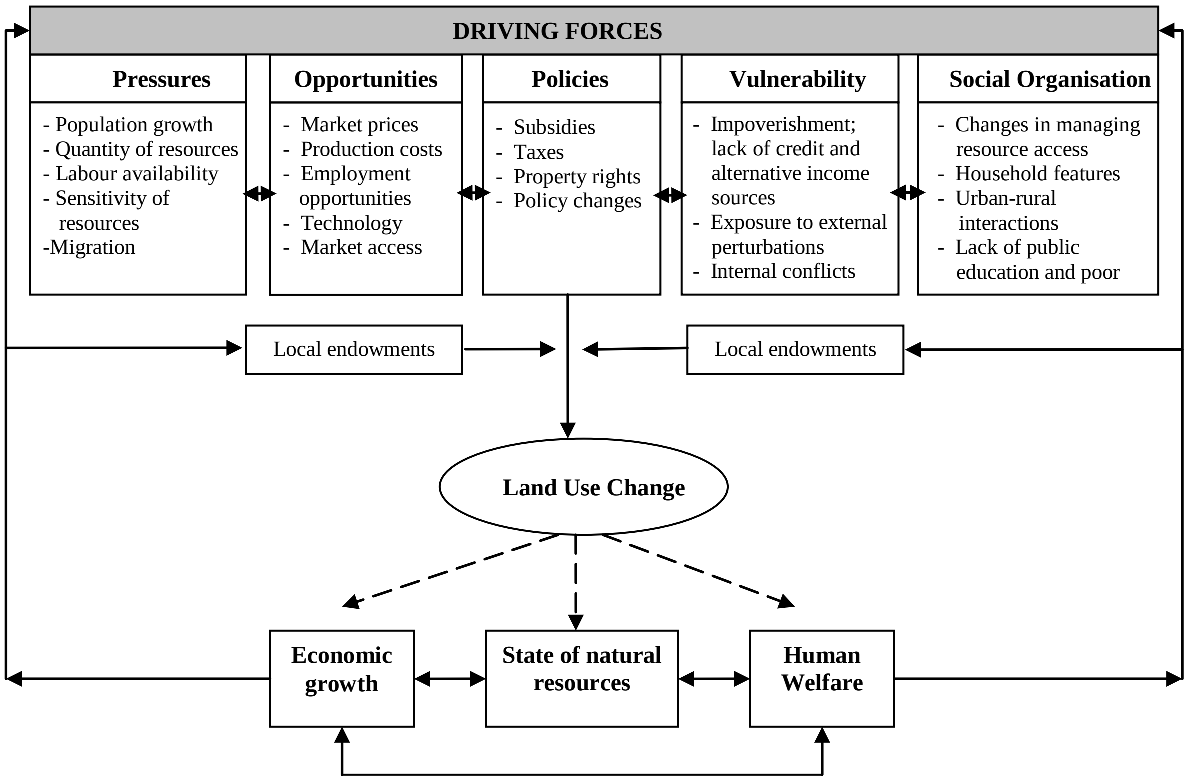
The remaining of this article is organised as follows. Section 2.2 describes the conceptual framework. Section 2.3 explains data and method used. Section 2.4 presents and discusses the empirical results. Section 2.5 concludes the study.

## 2.2. Conceptual Framework

Land use is defined as the use of land to fulfil human needs, and includes both a formal economic definition as well as broader functions such as functional relationships among humans, and between humans and the environment (Campbell, 1997; Latham et al., 2002). Changes in land use, such as forest cover, are not driven by two or three major factors, but involve situation-specific interactions among a large number of factors at different spatial and temporal scales (Lambin et al., 2003). The analysis of land-use/cover changes requires the integration of various scales and processes of change using complex adaptive systems and transitions. Exogenous factors driving land use change originate from complex social systems, and include social, political, demographic, technological, cultural, and biophysical variables. However, some local factors are endogenous to decision makers e.g. the direct regulation of access to land resources, market adjustments, or informal social regulations (Contreras-Hermosilla, 2000; Geist & Lambin, 2002; Ledec, 1985). There is no general theory of land use change at present. To utilise theories applied by different disciplines assists in analysing the process of land use change in specific situations. However, an integrated understanding using such is difficult to achieve due to their distinct approaches (Overmars & Verburg, 2005). As factors causing land use change are complex, it is important to adopt a concept that helps to understand the process of land use change.

To understand the process of land use change, we developed a conceptual framework, which is illustrated in Figure 1.

**Figure 1. Conceptual Framework of Land-Use Change**




**Source: Adopted from Scherr et al., 1996; Kaimowitz & Angelsen, 1998; Müller & Zeller, 2002 and Lambin et al., 2003**

This figure shows that land use change is determined by an interconnected set of driving forces. Those forces, which mainly pertain to socioeconomic aspects, are distinguished into pressures, opportunities, policies, vulnerability, and social organisation. Summarising from the typology of the causes of land use change by Lambin et al., (2003), pressures for land use change result from factors which cause demand for land produce to increase, and thus lead to resource scarcity. Opportunities for land use change are created by market forces. Policies are mainly external factors initiated by local, regional, or central government. Vulnerability reduces the adaptive capacity of people either by internal or external factors. Social organisation refers to factors related to social institutions, resource access, and in attitudes. Local communities, with their specific local endowments (natural and physical factors), might react differently to the interactions of these forces. Subsequently, the responses of communities are manifest in land use changes. Land use change influences economic growth, the state of natural resources, and human welfare in that region, which in turn influence the local endowments and the driving forces. Livelihood strategies, which cover both spatial and temporal issues, portray the dynamics of land use change in a region. The aggregate level of local communities in our study refers to village communities at the forest margins who attempt to adapt to their changing environment over time. The conceptual framework was used to generate variables that influence the probability of lands being allocated to forests use. Furthermore, according to theoretical background and previous research findings, we develop the hypothesised effect of selected variables on forest cover. We selected only driving factors of land use change that relate to pressures, opportunities, policies, vulnerability, and social organisations. The expected signs including the category of variables and the scale of data are summarised in Table 1.

**Table 1. Independent Variables and Their Expected Effects on Forest Cover**

| Independent variables | Expected sign | Scale | Category |
|---|---|---|---|
| **Socioeconomic factors** | | | |
| Population density (person/sq.km) | – | Survey | Pressures |
| Share of Buginese (%)[3] | – | Survey | Pressures |
| Share of irrigated land (%) | – | Survey | Opportunity |
| % of HH with non-agricultural incomes | + | Survey | Vulnerability |
| Frequency of extension worker visit | – | Survey | Social organisation |
| Village borders the LLNP (dummy, 1=yes) | + | Survey | Policies |
| **Location** | | | |
| Distance to village centre (km) | + | Pixel | Opportunity |
| Distance to edge (km) | + | Pixel | Local endowments |
| Distance to river (km) | + | Pixel | Local endowments |
| Distance to market (km) | + | Pixel | Opportunity |
| Distance to all-year road (km) | + | Pixel | Opportunity |
| **Geophysical factors** | | | |
| Elevation (km) | + | Pixel | Local endowments |
| Temperature (° Celsius) | – | Pixel | Local endowments |
| Average precipitation (ml/year) | + | Pixel | Local endowments |
| Slope (°) | + | Pixel | Local endowments |
| Slope lag (°) | + | Pixel | Local endowments |
| Aspect (°) | + | Pixel | Local endowments |

**Source: Author**

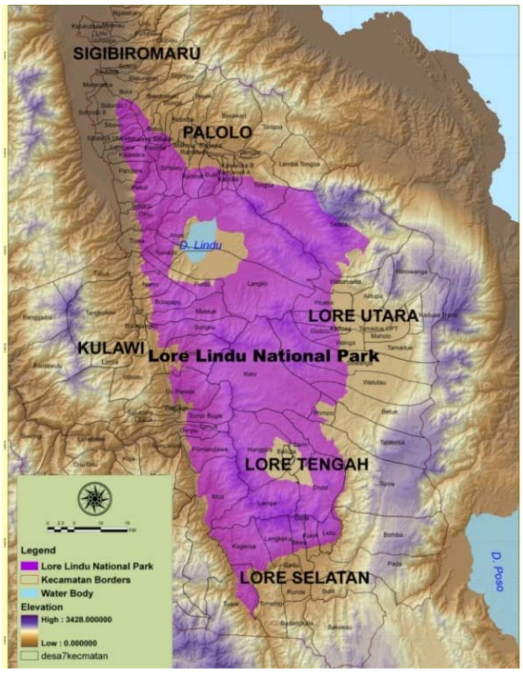
## 2.3. Methods

### 2.3.1. Study Area

The map of the study area (Figure 2) shows the setting of the LLNP, which is highlighted in purple. The total area of the park is 220,000 hectares. It is characterised by complex terrains ranging from lowlands to uplands that reach up to 2,600 meters above sea level, with the majority of the area being mountainous rainforest. There are three types of villages concerning their locations to the park. The first type of village is located outside the park and has no direct border with the park. The second type of village directly borders the park. The third type consists of villages that are located inside the park. In terms of administration, LLNP is under the jurisdiction of two districts (Donggala and Poso). Our research area comprises eleven sub-districts consisting of 119 villages within these 2 districts. Agricultural activities are fundamental to the livelihoods of the communities in this forest margin area. The income of 87 per cent of the surveyed villages depends mainly on agricultural activities (Reetz, 2008).

[3] Migrants from Southern Sulawesi whom have been blamed for increasing pressures on forest cover through conversion to cacao cultivation (Steffan-Dewenter et al., 2007).

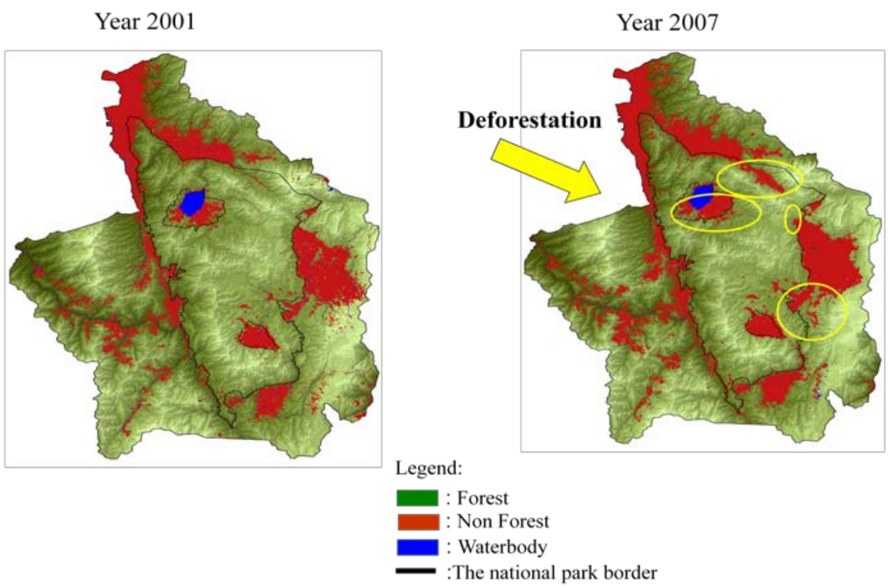
**Figure 2. Map of Study Area**




**Source: TNC**

In Figure 3 we present the land use map of the study area between 2001 and 2007 with the black line depicting the border of the national park. Areas where deforestation occurred are marked with yellow. We can see from Figure 3 that, deforestation has taken place inside and outside the national park area.

**Figure 3. Forest and Non-forest Cover Map of the Research Area**




**Source: own graph**

### 2.3.2. Data

In order to analyse land use change in the study area, three broad types of data have been collected: land cover data, geophysical data, and village survey data. Spatially explicit land cover data were obtained from satellite imagery since data collected on the ground are difficult to obtain, particularly in developing countries. Images of land cover data were derived from the interpretation of a Landsat ETM+ scene. The intensity of light frequency reflected from the earth's surface is used to obtain different colours, structures and patterns. By applying a maximum likelihood classification technique with ground-truth data, the interpretation of land cover data in 2001 resulted in ten land use categories with a resolution of 15x15 meters. These ten land use categories were distinguished into two forest classes: open and closed forest and four classes of agricultural land use: coffee and cacao, coconut, paddy and annual crops, and four other classes: grassland, water, settlement areas, clouds and shadow. As the study focused on deforestation issues, these ten categories of land use were reclassified into two classes. The open and closed forests were classified into forest class and the later categories were classified into non-forest class. A similar classification was applied to obtain a comparable land use map in 2007. The land cover data were aggregated into a 100x100 meter grid resolution[4].

The second type of data is geophysical data, which includes rainfall, air temperature, slope, and elevation data. Rainfall and air temperature were recorded at ten weather stations, which were operated by the STORMA (*Stability of Rainforest Margins*) project. These meteorological data were converted into annual daily means and computed at pixel level using interpolation[5]. Slope and elevation were calculated from a digital elevation model (DEM) with 25 meter topographic contour lines. The DEM has a spatial resolution of 70 by 70 meters and is based on aerial photographs from 1981, 1982, and 1989.

The socioeconomic data was collected in 2001 and 2007 from surveys in 80 randomly selected villages. For the village surveys, 80 of the 119 villages were selected using a stratified random sampling method (Zeller et al., 2002), and we

[4] For the technical details of the land cover aggregation see Erasmi & Priess (2007).

[5] To interpolate the rainfall data, our student assistant applied an inverse-distance weighted (IDW) procedure. The IDW was used because this method is versatile and fairly accurate under a wide range of conditions (Li & Heap, 2008). Using this method, our student assistant estimated the values of an attribute at unsampled points using a linear combination of values at sampled points, weighted by an inverse function of the distance from the point of interest to the sampled points.

designed standardised questionnaires to interview each village's representative. The interviews were conducted by a team comprising two enumerators who interviewed the village leader and other village representatives in each selected village. These, usually 4 to 6, representatives were appointed due to having good knowledge of their village. The interviews consisted of a panel discussion between the two enumerators and these village representatives. From village surveys and land cover data, we accomplish a minimum panel data of two time periods.

### 2.3.3. Data Integration Issue

In order to integrate the three different sources of data (land cover, geophysical and socioeconomic data), a "pixel to people" linkage method (Crawford, 2002) was used. This method is based on the defined boundaries of an official administrative entity (e.g. village, district, county), or, in the absence of such boundaries, GIS techniques are applied to construct artificial boundaries. Linkages of the pixels to the district level (Cropper et al., 2001; Deininger & Minten, 2002) or the village level (Müller & Zeller, 2002) are feasible. Other authors have used another method which connects pixels to household level data (Mertens et al., 2000; Overmars & Verburg, 2005; Rindfuss et al., 2002; Vance & Geoghegan, 2002). Although household level analyses yield better explanations of land use decision making processes, they are costly to implement because cadastral maps are rarely available in developing countries (Rindfuss et al., 2002).

Since we collected the socioeconomic variables at the village level, we compiled this data on to village boundary maps. The data linkage process starts with assigning a unique identity to each village (village ID). The polygon representing the village boundaries was then converted into a raster (grid), and every pixel within a village boundary was assigned a specific village ID, with corresponding socioeconomic information. At this stage, all the grids have the same spatial resolution and are geo-referenced based on the same map projection. Eventually, all pixels with the same village ID are linked to the socioeconomic information from the village surveys.

### 2.3.4. Correcting for Spatial Effects

When using spatially explicit data, one must consider both spatial dependence (spatial lag dependence and/or spatial autocorrelation) and spatial heterogeneity (spatial structure). Spatial dependence is the existence of a functional relationship between a point in space with its nearest neighbourhood. Spatial heterogeneity might arise due to a lack of structural stability across space and/or non-homogeneity of spatial observations (Anselin, 2001). Spatial dependence and spatial heterogeneity problems may result from the integration of different sources of data, from the use of heterogeneous sample designs, or from the use of different aggregation rules (De Pinto & Nelson, 2002). A spatial econometric model that ignores spatial dependence and heterogeneity issues may yield unreliable estimated parameters and statistical inferences (Anselin, 2001). There are three ad-hoc techniques that have been applied in land use studies to correct spatial effects: using latitude and longitude indices, applying regular sampling from a grid, and introducing spatially lagged variables into the model (De Pinto & Nelson, 2002). The latter two techniques are most effective in removing spatial autocorrelation according to De Pinto & Nelson (2008). Since testing for spatially lagged dependence for a spatially limited dependent model is relatively undeveloped (Li et al., 2011)[6], we applied regular sampling from grid[7] and lagged slope variables.

### 2.3.5. Binary Panel Outcomes Models

In order to investigate the determinants of forest cover, binary panel models were applied. Panel data possesses several advantageous attributes over cross sectional and/or time series data. Panel data models can: control for individual heterogeneity, capture the dynamics of adjustment, increase the precision of regression estimates, allow one to construct and test more complicated behavioural models and are able to identify and measure causal effects. Theoretically, by capturing the dynamics of adjustment, panel models should provide richer insights

[6] Moran I is used to test the spatial autocorrelation in a spatial model. However, to do this test is infeasible in our study due to the high number of observations and in the context of a discrete dependent variable model. We also face the same problem in using spatially weighted matrices to counter spatial effects.
[7] We specified every fourth cell in the X- and Y-direction, which corresponds to a distance between observations of 0.4 km.

(Baltagi, 2001; Kennedy, 2003), in this case, into the analysis of land use change from forests to non-forest use.

In this study, binary outcome models as non-linear panel models were applied to analyse the relationship between exogenous variables and dependent variables. The outcome variable takes value $y_{it} = 1$ if the land use is forest and is $y_{it} = 0$ for non-forest. Observations for $y_{it}$ are then linked to an index function $x'_{it}\beta$, where $x_{it}$ is the Kx1 vector of explanatory variables for pixel *i* at time *t*, and $\beta$ is a vector of unknown parameters to be estimated. The choice of the link function, F(.) then determines the specific statistical model (Cameron & Trivedi, 2008):

$$Pr[y_{it} = 1|x_{it}, \beta, \alpha_i] = F(\alpha_i + x'_{it}\beta) \text{ in general} \quad (1)$$
$$\Lambda(\alpha_i + x'_{it}\beta) \text{ for logit model}$$
$$\Phi(\alpha_i + x'_{it}\beta) \text{ for probit model}$$

Where F(.) is an arbitrary cumulative distribution function (cdf), $\Lambda(.)$ is the logistic cdf, and $\Phi(.)$ is the standard normal cdf. Non-linear panel models with pooled logit, random effect (RE) logit and fixed effects (FE) logit are similar to linear panel data models.

As usual, the model selection between fixed and random effects is based on a standard Hausman test. If the Hausman test between fixed and random effects is rejected, the fixed effects estimator is preferred over the random effects estimator. However, the fixed effects estimator wipes out the time-invariant variables. As an alternative, we use the correlated random effects estimator of Hausman & Taylor (1981). This hybrid technique accommodates both time invariant variables and possibly endogenous regressors. The Hausman-Taylor (HT) estimator allows explanatory variables to be correlated with the unobserved individual effects and recaptures the effect of the time-invariant variables (García-Mainar & Montuenga-Gómez, 2011; Kesina et al., 2011).

## 2.4. Empirical Results and Discussion

### 2.4.1. Descriptive Statistics

Table 2 compares variables used in our model between 2001 and 2007. In this study area the majority of land use is forest, with nearly 85% coverage. During the study period, almost 2% of forest cover was cleared and converted to non-forest use. Population density of this area remains low in comparison with other sub-districts and the provincial level, with less than three people per square kilometre, whilst Buginese migrants are less common. Irrigated land only increases slightly to 6 per cent in 2007. The average percentage of households working outside the agricultural sector increased less than one percent between 2001 and 2007. On average the frequency of extension worker visits is low, although it has increased from nine to fifteen visits per year. The number of villages directly bordering the national park remains unchanged and accounts for over 50% of villages studies.

**Table 2. Descriptive Statistics[a)]**

| **Dependent variable:** | **2001** | | | | **2007** | | | |
|---|---|---|---|---|---|---|---|---|
| | Frequency | | Percentage | | Frequency | | Percentage | |
| **Land use:** | | | | | | | | |
| Forest Land (1) | 25,410 | | 85.99 | | 24,971 | | 84.02 | |
| Non- Forest land (0) | 4,141 | | 14.01 | | 4,751 | | 15.98 | |
| **Independent variables:** | | | | | | | | |
| **Socioeconomic factors:** | Mean | | Std. Dev. | | Mean | | Std. Dev. | |
| Population density (person/sq. km) | 2.793 | | 1.373 | | 2.801 | | 1.356 | |
| Share of Buginese (%) | 3.724 | | 6.981 | | 3.593 | | 5.923 | |
| Share of irrigated land (%) | 5.955 | | 8.720 | | 6.016 | | 9.804 | |
| % of HH with non-agricultural incomes | 11.104 | | 7.648 | | 12.055 | | 9.120 | |
| Frequency of extension worker visits per year | 8.900 | | 15.530 | | 14.525 | | 28.238 | |
| Village Border (1=yes) (0=No) | .652 | | .476 | | .652 | | .476 | |
| **Location:** | Forest Land | | Non-Forest Land | | Forest Land | | Non-Forest Land | |
| | Mean | Std. Dev. | Mean | Std. Dev. | Mean | Std. Dev. | Mean | Std. Dev. |
| Distance to village centre (km) | 2.708 | 2.345 | .114 | .573 | 2.768 | 2.333 | .131 | .521 |
| Distance to edge (km) | .733 | .632 | .007 | .034 | .741 | .650 | .033 | .118 |
| Distance to river (km) | 1.609 | 1.732 | .968 | .995 | 1.639 | 1.776 | .943 | .980 |
| Distance to market (km) | 71.481 | 24.143 | 64.920 | 28.125 | 71.566 | 24.343 | 65.395 | 26.808 |
| Distance to all-year road (km) | 9.464 | 7.202 | 3.645 | 5.428 | 9.589 | 7.201 | 3.759 | 5.454 |
| **Geophysical factors:** | | | | | | | | |
| Elevation (km) | 1.306 | .388 | .817 | .419 | 1.316 | .390 | .822 | .371 |
| Temperature (° Celsius) | 21.998 | 1.485 | 22.752 | 2.069 | 21.856 | 1.465 | 22.433 | 1.953 |
| Average precipitation (ml/year) | 1,624.791 | 60.494 | 1,662.712 | 144.696 | 2,158.951 | 188.806 | 2,069.839 | 321.383 |
| Slope (°) | 15.782 | 9.315 | 5.248 | 6.975 | 15.904 | 9.233 | 5.773 | 7.770 |

**Source: own calculation**

For location, the average distance of forests to village centre, central markets, and all-year roads in 2007 is respectively 0.06, 0.09, and 0.125 kilometres further away than in 2001. This provides evidence that forest encroachment is pushing forest boundaries further from areas of concentrated human activity. Geophysical factors show that the average elevation and slope of non forest land increased by 5 metres and 0.5 degrees respectively. This shows that forest encroachment is moving to higher elevations and steeper areas.

### 2.4.2. Hausman-Taylor Model

In order to identify the determinants of forest cover dynamics we compare pooled logit, random effects (RE), and fixed effects (FE) results (Appendix 1). OLS would likely be biased and inconsistent because the explanatory variables are probably correlated with unobservable individual specific effects in the error component (Baltagi, 2001). The Hausman test between fixed and random effects rejects the random effects model.[8] This rejection implies that the use of fixed effects estimator is superior to the random effects estimator. However, fixed effects eliminates time-invariant variables, such as geophysical information, which are important factors affecting forest cover dynamics, Therefore the fixed effects estimation would be problematic, because of the presence of time invariant and possibly endogenous regressors. The HT estimator is an alternative to accommodate these issues.

In preparation for the HT estimation, we first identify potentially endogenous variables in the model. Endogenous variables are selected based on the highest correlations between time variant in socioeconomic and location variables with the unobserved individual effect (Appendix 2). We concentrate only on correlation with the socioeconomic and location factors because geophysical factors are given in nature. Table 3 reports the results obtained from the HT estimator. Our results show that all factors related to pressures, opportunities, policies, vulnerability and local endowments are significant in determining forest cover. The only insignificant factor in our HT model is frequency of extension workers visit per year, which we used as a proxy of social organisation.

For the pressures driver, we assign two socioeconomic variables: population density and the share of Buginese dwellers. A higher population density reduces the probability of forest cover; however, a higher of share of Buginese in a village increased the probability of forest cover. This seems to contradict previous findings  that Buginese migrants are increasing forest pressures through forest conversions to cacao cultivation (Steffan-Dewenter et al., 2007). Based on this previous finding we expected a higher share of Buginese to be negatively correlated with forest cover. However, an alternative interpretation might be that Buginese people migrate primarily to areas of higher forest cover where more opportunities to profit from the expansion of cacao cultivation.

[8] Data for the Hausman test is detailed appendix 1.

**Table 3. Hausman-Taylor Estimation for Determinants of Forest Cover Change**

| **Dependent variable:** Land use (1=Forest land; 0=Non-Forest land) | | | | y = Xb (predict) = .850 |
|---|---|---|---|---|
| **Independent variables:** | Estimated | | | Category |
| **Socioeconomic factors:** | Coef. | | SE | |
| Population density (person/sq. km) | -0.008 | *** | 0.002 | Pressures |
| Share of Buginese ethnic group (%) | 0.002 | *** | 0.000 | Pressures |
| Share of irrigated land (%) | 0.001 | ** | 0.000 | Opportunity |
| % of HH with non-agricultural incomes | -0.000 | ** | 0.000 | Vulnerability |
| Frequency of extension worker visits per year | -0.000 | | 0.000 | Social organisation |
| Village Border (1=yes) (0=No) | 0.037 | *** | 0.007 | Policies |
| **Location:** | | | | |
| Distance to village centre (km) | -0.039 | *** | 0.011 | Opportunity |
| Distance to edge (km) | 0.145 | *** | 0.013 | Local endowments |
| Distance to river (km) | 0.022 | *** | 0.004 | Local endowments |
| Distance to market (km) | -0.002 | *** | 0.000 | Opportunity |
| Distance to all-year roads (km) | 0.010 | *** | 0.001 | Opportunity |
| **Geophysical factors:** | | | | |
| Elevation (km) | 0.331 | *** | 0.024 | Local endowments |
| Temperature (° Celcius) | -0.009 | *** | 0.003 | Local endowments |
| Average precipitation (ml/year) | -0.000 | *** | 0.000 | Local endowments |
| Slope (°) | -0.004 | *** | 0.000 | Local endowments |
| Slope lag (°) | 0.022 | *** | 0.001 | Local endowments |
| Aspect (°) | 0.000 | | 0.000 | Local endowments |
| cons | 0.451 | *** | 0.089 | |
| N observation | 54,954.000 | | | |
| Wald Chi$^2$ / LR chi2(17) | 14,809.590 | | | |
| Probability > Wald Chi$^2$ / Chi$^2$ | 0.000 | | | |

*,**,*** Significant at the 10%, 5%, and 1% level, respectively.
**Source: own calculation**

The socioeconomic opportunity factor– share of irrigated land, represented by paddy rice cultivation– is positively related to forest cover. A higher share of irrigated land increases the probability of forest cover. We suggest this is because where irrigated lands are available, increased profits may be more easily obtained by agricultural intensification on food crops rather than expansion, thereby discouraging deforestation. Opportunities drivers for locational factors give both positive and negative effects to forest cover depending on the variables used. Increasing distance to forest edges, rivers, and all-year roads increases the probability of forest cover, as might be expected. However, somewhat unexpectedly, increasing distances to central markets and village centres decrease the probability of forest cover, indicating that deforestation occurred even in remote areas. One possible explanation for this phenomenon is that people are hesitant to cut forests close to village centres as this violates the community customary law (hukum masyarakat adat)[9] as

[9] The community customary law plays an important role in governing land use rights and managing natural resources in the local community (Engel et al., 2010). Lembaga Adat is a traditional village council court which imposes traditional fines to those who violate customary law. The fines depend on the severity of violations, with expulsion from the village being the strongest sanction (Mappatoba, 2004).

well as formal law. Instead, illegal activities such as logging and establishing new cacao plots in the national park area are carried out away from the village centres, in order to avoid facing customary and legal sanctions. The socioeconomic factor for the vulnerability driver is higher share of non-agricultural income, which decreases the probability of forest cover. This demonstrates that income opportunities for economic diversification and variation exist in more developed areas with less forest cover. The fact that villages directly bordering the national park, as a policy driver on socioeconomic factors, had increased probabilities of forest cover indicates that national parks are effective strategies for forest conservation.

Every geophysical factor as local endowments is highly significant in influencing forest cover, with the exception of variable aspect. Higher elevation increases the probability of forest cover. Other local endowments such as: temperature, annual precipitation, and slope decrease the probability of forest cover. The finding that land with steeper slopes is less likely to be forest was unexpected. Furthermore our data set confirms that no forest cover is found on extremely steep areas. This is explained by our field observations of landslide occurrence. Landslides, whether wholly natural events or aggravated by human-induced soil erosion in very steep areas is one cause of deforestation in our study area.

To generalise Hausman and Taylor's specification test to nonlinear contexts remains a challenge for future research (Hahn & Meinecke, 2005). Furthermore, for the limited dependent panel model, the magnitude of coefficients estimates there is no direct interpretation to quantify the relationship between the outcome and the independent variables. Marginal effects are usually used to express the probability of land being forest when there is change in the explanatory variable and everything else remains constant (Long & Freese, 2006). However, a function to calculate marginal effects for HT model in the binary response context has not yet been developed in the latest Stata 12 program. Thus, the estimation of HT in this context is basically a linear probability approach, in this case represented by the magnitude of the estimated coefficients. The results indicate that local geophysical endowments have the highest influence on probability of forest cover, particularly elevation. The second most important determinant is the distance to the forest edges, which shows that the probability of land being forest is higher when the surrounding land is also forest. The socioeconomic factors with the strongest influence on land use are whether the areas have direct border with the national park and high population density.

## 2.5. Conclusions and Policy Implications

The application of spatial panel econometric models to our land use study has shown how certain key factors significantly influence the land use change dynamics. Our work contributes to an advance in empirical methodology at village level, by applying spatial panel binomial logit models. The HT model has some advantages over conventional panel models since it accommodates the effect of time-invariant variables and possibly endogenous regressors. As evidence, despite lower population density in the study area, the HT model was able to capture the dynamics of population growth, which indicate negative correlation between population growth and forest cover. Furthermore, our results for the distances to central markets and village centres and slope variable were unexpected. At greater distances from village centres fewer forests are found. Deforestation also occurred in remote and steep areas. The marginal effects of the HT model suggest that geophysical factors- especially elevation, proximity to the forest land, setting of national park borders and high population density- strongly influence the probability of lands being forest. Several policy implications can be derived from this study, namely: maintaining a two child policy will keep population growth rates low, investment in irrigated land is would reduce rates of agricultural expansion, and innovation programs such as community forest management might provide an economically viable alternative to forest conversion. Strategies involving investment in irrigated land will require further study such as cost-benefit analysis, which is beyond our scope. Facilitating training on environmentally-friendly agricultural practices, such as building terraces on the steep slopes, is also important to reduce landslides and soil erosion in highland areas.

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# *Chapter 3*

## Linking Deforestation and Market Integration: Evidence from Cacao Expansion in Forest Margin Areas in Central Sulawesi, Indonesia

**Reetz, S, Schwarze, S., and Brümmer, B.**

A preliminary version of this paper was presented orally at the 2nd World Congress of Agroforestry, August 23-28, 2009 in Nairobi, Kenya and at the Tropentag Conference, October 6-8, 2009 in Hamburg, Germany.

**Abstract**

Agricultural expansion contributes to forest degradation and deforestation processes in many parts of the world. Cash crop expansion which leads to tropical deforestation has a particularly strong relationship with international trade and prices. In previous studies on deforestation and cash crop expansion, this relationship has not yet been fully addressed. We study an area in the vicinity of the Lore Lindu National Park. The objective of our study is to identify the factors determining cacao expansion, which is the major driver of deforestation in this area, including the role of market integration between international and local markets. We estimate the extent of price transmission using a Vector Error Correction Model (VECM) with the Johansen procedure. The price transmission of related parameters along with other variables are then included in an OLS model to estimate their influence on cacao area. Our findings indicate that population density and availability of agricultural land have large positive effects on the expansion of cacao expansion. The only stabilising effect to the cacao expansion is the percentage of paddy rice fields in the village. The high degree of integration between local and international markets contributes to the expansion of cacao production in the study region. Although the area of cultivation responds more slowly than changes in cacao prices, the high speed of adjustment, which transmits higher prices in the international market to the farm gate level, causes farmers to continue the expansion of cacao production in this region. Finally, the article discusses policy options which will better harmonise the goals of economic growth and environmental sustainability.

**Keywords:** *Lore Lindu National park, cacao expansion***,** *price transmission analysis*

### 3.1. Introduction

Agricultural expansion is one of the main causes of tropical deforestation. The evidence from the world's remaining tropical forests –Brazil, Indonesia, Malaysia and the Philippines– shows that agricultural expansion is an important factor affecting forests (López & Galinato, 2005). Moreover, the FAO (2001) reports that large and small-scale agriculture combined account for 73 percent of forest conversion in the tropics. Within the literature examining the relationship between agricultural expansion and deforestation, two approaches have been distinguished, namely the population and the market approach (Angelsen, 1999). The population approach is based upon assumptions of subsistence, which stresses that population growth is the driving force of deforestation, whereas the market approach usually concentrates on the role of prices, technology and market accessibility in order to describe deforestation processes (Angelsen, 1999). Our study focuses upon the market approach, since we particularly concentrate on deforestation caused by the agricultural expansion of cacao, which is a non-subsistence product. Geist & Lambin (2001) showed that the expansion of cash crop production causes three times more deforestation than the extension of food crop production. Furthermore, high commodity prices have driven the expansion of export crop production (O'Brien & Kinnaird, 2003; Pender, 2009; Weis, 2000). Such evidence confirms the link between international prices, agricultural expansion and deforestation in the tropics (Lambin et al., 2003).

Some studies have investigated the relationship between deforestation and international trade (Barraclough & Ghimire, 2000; DeFries et al., 2010; Ferreira, 2004; Jinji, 2006). The latter two authors cover in particular the effects of trade liberalisation on deforestation. Other scholars have concentrated on the influence of high prices of cash crops in international markets on deforestation in developing countries (Gaveau et al., 2009; Gbetnkom, 2005; O'Brien & Kinnaird, 2003). Gaveau et al. (2009) found the relationship between tropical deforestation and agricultural prices by comparing the plots of time-series data between the deforestation rate and coffee prices in Southwest Sumatera, Indonesia. Gbetnkom (2005) investigated the speed of forest clearance in Cameroon by including coffee, cacao and food prices as explanatory variables in the OLS estimation and found these prices to be significant. Furthermore, O'Brien & Kinnaird (2003) used a correlation coefficient between deforestation rate and prices of robusta coffee to explain deforestation in Lampung, Indonesia. Nevertheless, previous studies on the drivers of deforestation by cash crop expansions have not yet thoroughly explored the integration between domestic and international markets. The objective of our study is to identify the factors determining cacao expansion, which is one of the drivers of deforestation in this area, including the role of market integration between international and local markets. We use price transmission analysis to quantify the extent of market integration between domestic and international markets. Furthermore, our study helps to find policy options which will better harmonise the goals of economic growth and environmental sustainability.

Many studies show that expansion of cash crops, such as palm oil, coffee and cacao, contribute to forest degradation and deforestation processes in many parts of the world (Gaveau et al., 2009; Godoy et al., 1997; Kazianga & Masters, 2006). We focus on cacao because in our study area there is a trade-off between the economic gains of cacao cultivation and environmental sustainability. On one hand, cacao is the most important cash crop in the vicinity of the Lore Lindu National Park (LLNP), Central Sulawesi, Indonesia, contributing 33 percent of net crop income of farmers (Schwarze, 2004) and has improved the economy of rural communities. On the other hand, the expansion and the intensification of cacao cultivation have threatened the LLNP as an endemic hotspot, and have contributed to deforestation in this study area for more than two decades.

To analyse the factors determining cacao expansion including the role of market integration between international and local markets, we apply a number of econometric techniques. Thus it is important to highlight some general ideas that explain the steps involved and the rationale behind the methodological choices. Firstly, we estimate price transmissions using a Vector Error Correction Model (VECM) with the Johansen procedure, using monthly cacao price data to obtain market integration parameters between local and international markets. From the local producers' perspective, the prevailing price is usually more important. Yet, the prevailing market price is the result of market integration. Thus secondly, we apply a two-way effects panel model that takes price transmissions into account to analyse the influences of socioeconomic and geophysical variables on the cacao cultivation areas. The results of the two-way RE estimation suggest that the prevailing prices have no influence on the decision to expand the cultivation of cacao. We might imagine that the decision to expand the cultivation of cacao will depend more on farmers' expectations of future prices rather than the prevailing prices. The inclusion of market integration parameters into the panel models is intended to examine the effect of future prices using market integration between local and international markets on cacao expansion. However, since at this stage we include price transmissions between the world and the sub-district prices, the two-way effects panel model eliminates the price transmission variables from the model because they only vary across time but not across villages. As a consequence, we need to include price transmission parameters which vary across villages. Therefore for the next procedure, we predict price transmissions at the village level using cacao prices at the farm gate level. Due to ill-posed and/or ill-conditioned cacao price data at the farm gate level, we therefore apply Generalised Maximum Entropy (GME) to yield a robust estimation to predict price transmissions between villages and the world market. Finally, we integrate the predicted price transmissions at the village level using GME into our second model using an Ordinary Least Square (OLS) regression to better explain the relationship between cacao cultivation and price transmissions. However, due to limited prices data, we only can estimate our second model in a cross section.

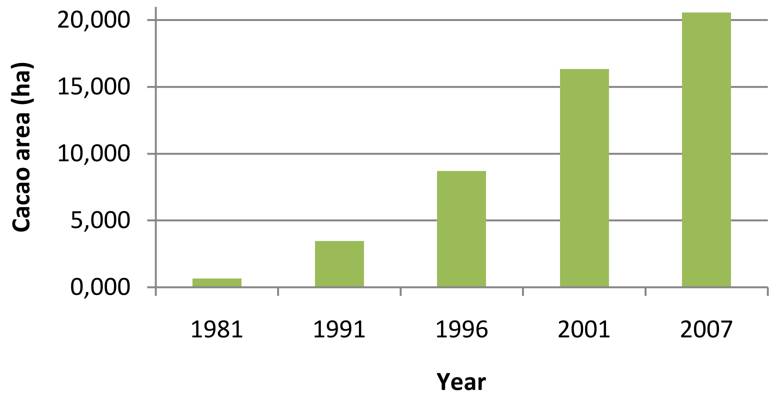
Our findings indicate that the expansion of cacao cultivation is largely determined by factors such as population density and availability of agricultural land. The only stabilising effect to cacao expansion is the percentage of paddy rice fields in the village. The long-run integration between local and international markets is high, with almost 82 percent of changes in international cacao prices having been transmitted to domestic prices between 2001 and 2007. Furthermore, the speed of adjustment is relatively fast with about 34 percent of the divergence from the long-run equilibrium being corrected each month. This evidence supports the argument that a high degree of integration between the local and world markets contributes to the gradual conversion of forests to cacao cultivation. Policy implications derived from this study are: further expansion of irrigation schemes to reduce cacao expansion (which so far has been mainly limited to the lowlands) and improvement of physical (hard) infrastructure, such as transportation and storage, and (soft) infrastructure, i.e. commercial and institutional, to increase market integration of other agricultural products. This latter option would give farmers the opportunity to remain engaged in existing agricultural production, since the market would become more efficient overall and transaction costs would be reduced. Farmers would not then be so reliant on further expansion of cacao production in order to improve their livelihood.

The remainder of this article is organised as follows. Section 3.2 describes the development of cacao as a cash crop in the study area. Section 3.3 explains the data and methods used. Section 3.4 presents and discusses the empirical results. Finally section 3.5 concludes the study.

## 3.2. Cacao Development in the Area of Study

In last two decades, the area under cacao cultivation has expanded from 685 ha to 20,590 ha in the sampled villages (Figure 4)[10]. Although the highest annual growth rates of cacao cultivation occurred between 1981 and 1996, after which growth decreased until 2007, nevertheless, the area of land under cacao cultivation continues to expand (Reetz, 2008).

**Figure 4. Cultivated Cacao Area Changes (ha) between 1981 and 2007**




**Source: Village surveys and own calculations**

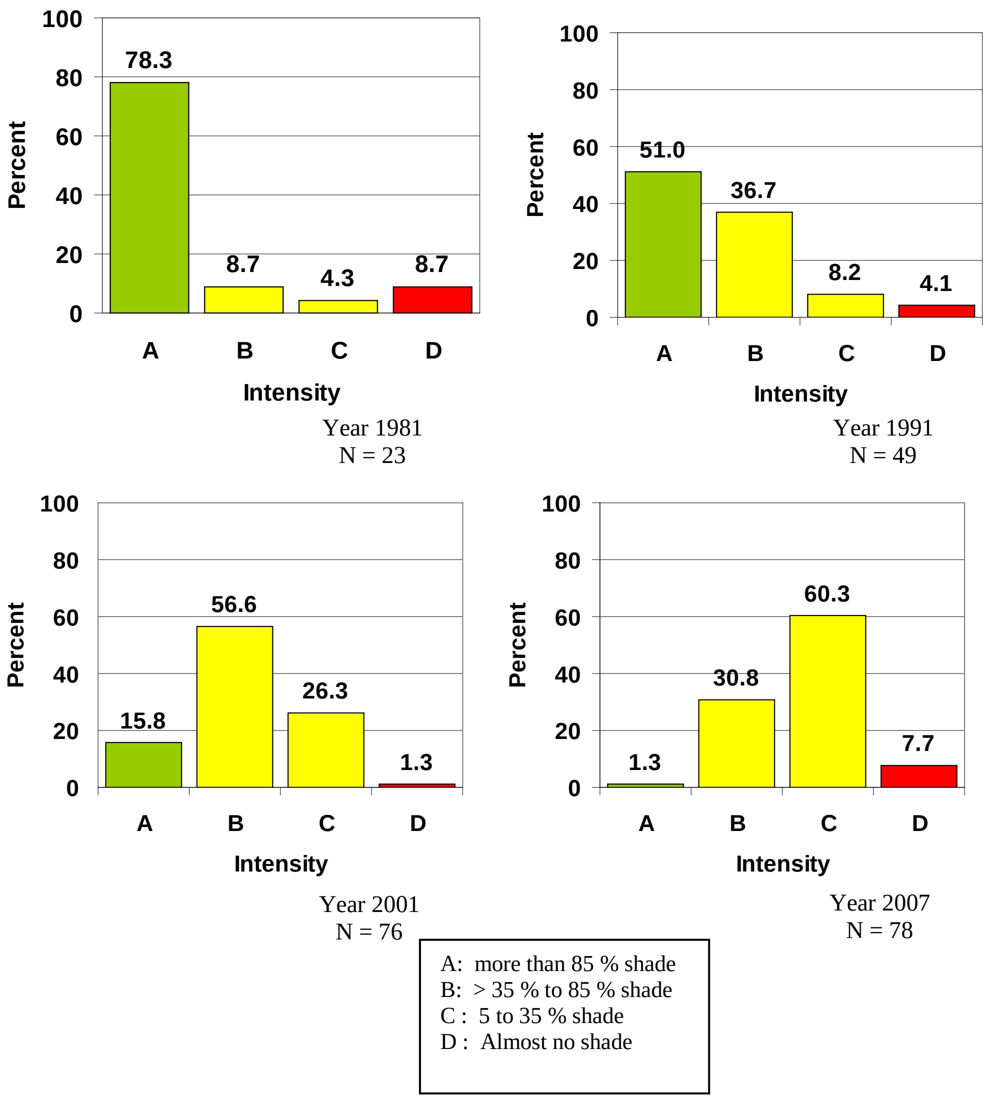
There are two chronologies of cacao expansion which lead to deforestation. The first form is the complete removal of forest trees to establish instantly new cacao plots. The second form is a gradual process of intensification, whereby wild trees and planted shade trees are periodically removed in order to cultivate more cacao trees, as shown in Figure 5 (Reetz, 2009). It is important to understand how the intensification of cacao cultivation has also contributed to deforestation processes in this region.

The spectrum of intensive cacao production systems from the lowest to the highest intensity has been classified as A to D. Type A represents systems where cacao is grown under a rich variety of forest and planted shade trees, giving over 85 percent shade cover. In contrast, type D is characterised by having almost no shade trees[11]. When cacao was first introduced, only a few farmers converted their land to intensive cacao production, and instead started to cultivate cacao on plots inside the forest due to a lower labour

[10] Appendix 3 provides a comparison of the land cover maps in 1983, 2001, and 2007
[11] See Appendix 4 for an illustration of different types of cacao agroforestry

requirement and so that they could continue to grow their usual and cash crops. This explains the high share of type A in 1981.

**Figure 5. Intensification of Cacao Agroforestry**

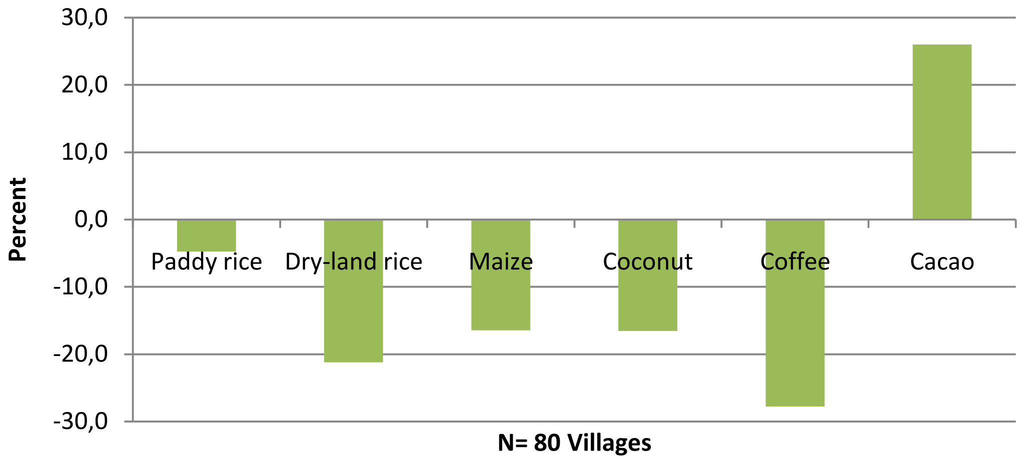



**Source: Village surveys own calculations**

By removing shade trees to intensify cacao production, farmers obtain higher yields and increased profitability. The intensification of cacao production significantly increases annual net returns from 285 Euro/ha (65-80 percent shade) to 780 Euro/ha (<5 percent shade) (Steffan-Dewenter et al., 2007), which is a driver for intensification and leads to deforestation.

In contrast to cacao, the area of all other important crops, namely paddy rice, dry land rice, maize, coconut and coffee, decreased considerably between 2001 and 2007 (Figure 6). Of all crops, cacao was the only one that has increased in area (by 26 percent), whilst coconut and coffee production have been reduced by 16.6 and 27.8 percent, respectively.

**Figure 6. Land Use Changes for the Most Important Crops from 2001 to 2007**




**Source: Village surveys and own calculations**

A comparison of the area of cacao cultivation according to the location and geophysical factors between 2001 and 2007 (Table 4), indicates that cacao plots are mainly located at steeper slopes from 6 to 12.4 degrees and at higher elevations between 700 and 900 metres above sea level.

**Table 4. Means Comparison of Location and Geophysical Aspects of Cacao Cultivation between 2001 and 2007**

| Geophysical Variable | Mean (2001) | Std Err. | Mean (2007) | | Std Err. |
|---|---|---|---|---|---|
| Slope (degree) | 6.000 | .460 | 12.400 | *** | .820 |
| Elevation (km) | .699 | .376 | .952 | *** | .471 |
| Distance to all-year road (km) | 3.951 | .721 | 5.519 | | .710 |
| Distance to river (km) | .863 | .920 | 1.167 | ** | .943 |
| Distance edge (km) | .09 | .014 | .491 | *** | .535 |

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

**Source: Interpretation of remotely sensed imagery and own calculations**

Furthermore, for the geographical aspects, cacao plots are located further away from all-year roads and rivers. Cacao plots have encroached almost half a kilometre more into the forest between 2001 and 2007. Table 4 describes the changes between 2001 and 2007, which indicate that cacao cultivation seems to be expanding into more remote areas (i.e.

areas with steeper slopes, at higher elevation and further away from roads and rivers) (Reetz, 2009).

## 3.3. Data and Methods

### 3.3.1. Data

The study uses data from a Landsat ETM+ scene, village surveys in 2001 and 2007, a Digital Elevation Model (DEM) and time series of cacao prices. The 80 villages[12] were selected from the total of 119 using a stratified random sample (Zeller et al., 2002). In each survey, a panel of village representatives was interviewed by a team consisting of two enumerators to obtain the socioeconomic data.

The dependent variable in our model is the area under cacao cultivation in a village. Using standardised questionnaires, we asked the villages' representatives about the allocation of land in their village with a particular focus on cacao.

A weekly time series of cacao prices at the farm gate was obtained from household surveys in 12 villages conducted by the A5 subproject of the STORMA project (Stability of Rainforest Margins) in 2007[13]. Since we do not have the complete time series of 80 villages, we used the price information from 10 villages[14] to predict the market integration parameters for the remaining villages. In addition to the prices at the farm gate level, we also obtained monthly cacao prices at the sub-district level from January 1996 until December 2007 from Statistics Indonesia (*BPS pusat*). For the same time period, we also obtained daily world market cacao prices which are based on the New York Futures from the International Cocoa Organisation (ICCO) in London.

### 3.3.2. Methods

We apply a number of econometric techniques to analyse the expansion of cacao in the study area. In the first part of the analysis, we apply price transmissions analysis to explain the integration between the domestic and the world market. All local cacao price data are converted from local currency to USD. Both local and the world

[12] We excluded villages without irrigated land and without cacao cultivation in a village in 2001 and 2007. Thus in our panel model we have only 135 observations instead of 160.

[13] Cacao price data were collected from 144 agroforestry cacao plots for 12 households per each of the 12 villages surveyed in the vicinity of LLNP.

[14] Two villages, Bulili and Pandere, were excluded from the GME estimation. Bulili was not within our villages sample. Pandere was excluded because the speed of adjustment value is larger than 1 whereas the other 10 villages have negative values.

cacao prices are expressed as logarithms. In this stage of analysis, we use prices at the sub-district level. In the second part of the analysis, we incorporate the price transmission elasticity obtained from the time series analysis into our panel econometric model to analyse determinants of cacao expansion. In the third part of the analysis, we attempt to improve our model by incorporating cacao prices at the village level. However, we only have farm gate cacao prices for 10 villages in 2007 and we use GME estimation to predict the speed of adjustments and price transmission elasticities for the remaining villages. In the last part of the analysis, we apply OLS estimation to identify the factors determining cacao expansion including the role of market integration between international and local markets.

#### 3.3.2.1. Market Integration and Price Transmission Analysis

Market integration analysis of agricultural products has been widely used to indicate their overall market performance (Faminow & Benson, 1990) and to measure whether markets function efficiently (Rapsomanikis et al., 2006). This information is important for policy makers to implement effective trade policies. Market integration is a measure of the flow of information, standard measures, trading habits and prices over form, space and time between markets linked directly or indirectly by trade (Barret, 1996). If markets are integrated, trade flows and price correlations are found (Barret, 1996). Specifically, the Law of One Price (Enke, 1951; Samuelson, 1952; Takayama & Judge, 1971) postulates that the price in the importing market will be equal to the price in the exporting market, plus transport and other transfer costs (Barrett & Li, 2002; Baulch, 1997). Thus, prices of homogenous commodities in two spatially separated markets should differ only by transfer costs. The difference between market integration and price transmission is that market integration is an exclusively long-run concept, whereas price transmission contains both long-run and short-run dynamics (Ihle et al., 2011). Most research on market integration and price transmission has covered spatial (Baulch, 1997; Dawson & Dey, 2002) and vertical market integration (Kinnucan & Forker, 1987; von Cramon-Taubadel, 1998). In this study, we focus on spatial market integration by analysing how changes in cacao prices in the world market are transmitted to the domestic market. There are number of factors that could impede the price transmission from the world market to the domestic market. The most well-known problem in developing countries is high transaction cost due to poor infrastructure, transport and communication services (Rapsomanikis et al., 2006).

Firstly, we applied the Augmented Dickey-Fuller (Dickey & Fuller, 1979) and the Kwiatkowski–Phillips–Schmidt–Shin (KPSS) tests (Kwiatkowski et al., 1992) to test for the presence of a unit root. Secondly, cointegration tests for the bivariate market pairs were conducted based on the Johansen procedure (Lütkepohl & Krätzig, 2004). If prices of two spatially separated markets ($p_{1t}$ and $p_{2t}$) are cointegrated, the Granger representation theorem (Engle & Granger, 1987) is applicable, and the system can be rewritten in error correction from. The resulting Vector Error Correction (VECM) is as follows:

$$\begin{pmatrix}\Delta p_{1t}\\ \Delta p_{2t}\end{pmatrix} = \begin{pmatrix}\mu_1\\ \mu_2\end{pmatrix} + \begin{pmatrix}\alpha_1\\ \alpha_2\end{pmatrix}(p_{1t-1} - \beta p_{2t-1}) + A_2\begin{pmatrix}\Delta p_{1t-1}\\ \Delta p_{2t-1}\end{pmatrix} + \cdots + A_k\begin{pmatrix}\Delta p_{1t-k}\\ \Delta p_{2t-k}\end{pmatrix} + \begin{pmatrix}v_{1t}\\ v_{2t}\end{pmatrix} \qquad (2)$$

where the operator Δ indicates first differences, the vector $\begin{pmatrix}\alpha_1\\ \alpha_2\end{pmatrix}$ is the parameter vector of the speed of adjustment coefficients, which describe the extent to which any deviation from the long run equilibrium is reduced. $\beta$ characterises this long-run equilibrium relationship between two prices whilst $A_k$ are the short-run effects. $v_{1t}$ and $v_{2t}$ are *iid* disturbances with zero mean and constant finite variance.

### 3.3.2.2. Linear Panel Data Models

There are several advantages of using panel data compared to cross sectional and time series data such as: controlling for individual heterogeneity, providing more information, enabling the study of the dynamic adjustment and allowing the construction and testing of more complex behavioural models. Nevertheless, there are some limitations, which include design and data collection problems, distortions of measurement errors and selectivity problems (Baltagi, 2008). The first aforementioned problem is the limitation in our study.

In our study we employ linear panel models with a short-time series of two periods. Our objective is to analyse factors such as socioeconomic, geophysical, geographic aspects that determined the area of cacao cultivation between 2001 and 2007. The price transmissions of cacao prices between the world and local markets at sub-district level have been incorporated as one of the explanatory variables in the panel model. Since in this stage the price transmissions only have variations across time but not across villages, the implementation of pure panel model is inappropriate. Any variable that varies only over time but not across villages will yield a significant estimated coefficient when it is included in our panel models. To overcome this

problem, we adjust our standard panel into a two-way effects panel model which includes time dummy variables, in this case 1 for year 2001 and 0 for year 2007. We assign two types of time dummies. Firstly, we introduce into the models an overall time dummy for the whole dataset. Secondly, after estimating the individual cross sections, we compare the estimated coefficients. Based on this comparison, we establish time dummies for explanatory variables that have changed either in their significances or their signs between those two cross section estimations. Time dummy is basically created as an interaction term between time dummy and explanatory variable.
We specify our two-way effects panel model as follows:

$$ln\, Y_{it} = X_{it}\beta + \mathrm{D}_{a\,it}\delta + \mathrm{D}_{b\,it}\gamma + \varepsilon_{it} \qquad \text{for } i = 1,\dots, n;\ t = 1, 2 \qquad (3)$$

$ln\, Y_{it}$ denotes the natural log of the cacao cultivation (ha), $X_{it}$ represents explanatory variables covering socioeconomic, geophysical and geographic aspects. Price transmission variables are categorised as socioeconomic factors in this model. $D_{a\,it}$ and $D_{b\,it}$ are time dummy variables. $\varepsilon_{it}$ represents the error component which consists of both random individual-specific effects ($\alpha_{it}$) and an idiosyncratic error ($v_{it}$). The $i$ denotes the villages and $t$ is time. To determine whether $\alpha_{it}$ is treated as a fixed or random effect, we test our fixed effect (FE) and random effect (RE) model using the Hausman test. The non-rejection of Hausman test indicates that the RE model provides consistent estimators and implies that $\alpha_{it}$ is purely random and uncorrelated with the explanatory variables ($X_{it}$) (Cameron & Trivedi, 2008).

#### 3.3.2.3. Generalised Maximum Entropy (GME)

Traditional methods that are based on general linear model including OLS have some shortcomings and yield unreliable estimates when dealing with ill-posed and/or ill-conditioned data. Ill-posed data occurs when the number of unknown parameters exceeds the number of data points, whereas ill-conditioned data relates to high correlation among variables. Even if data are under the aforementioned conditions, Generalised Maximum Entropy (GME) yields a consistent and robust estimation with lower mean-square errors in small samples (Golan et al., 2004; Golan et al., 2001). GME is an estimation technique based on the maximum entropy approach to inverse problems that is commonly used in engineering and physics studies (Akpalu et al., 2008). Nonetheless, the GME applications are also widely used in other fields of economic studies including agricultural economics (Fraser, 2000; Golan et al., 1996; Golan et al., 2004; Howitt & Msangi, 2006; Lence & Miller, 1998; Paris & Howitt, 1998). For general linear inverse problems, the regression parameters to be estimated and the error terms are reformulated in terms of probabilities (p and w) and so-called support matrices (Z and V), the latter capturing the range of admissible parameter values for the original model parameters. The objective of GME is to predict the unknown parameters using the sets of probabilities p and w. Golan et al. (1996) expressed the GME solution to the linear inverse problem with noise that selects p, w > 0 as follows:

$$maximize\ H\ (p_{ks} w_{ig}) = -\sum p_{ks} \ln(p_{ks}) - \sum w_{ig} \ln(w_{ig}) \quad (4)$$

subject to

$$y = \mathbf{X}\beta + e = \mathbf{XZ}p + \mathbf{V}w \quad (5)$$

$$\sum_{k=1}^{K} p_{ks} = 1 \quad s = 1, \ldots, M \quad (6)$$

$$\sum_{i=1}^{G} w_{ig} = 1 \quad j = 1, \ldots, J \quad (7)$$

Equation 4 is the objective function, Equation 5 is the model constraint, and the Equations 6 & 7 are the additivity constraints.

The advantages provided by adopting GME estimation allow us to predict price transmissions of the remaining villages. Although we face ill-posed data which includes 8 explanatory variables for price transmissions of 10 villages, the GME estimation produces unbiased estimated coefficients.

### 3.3.2.4. Ordinary Least Square (OLS)

We attempt to improve the estimation of price transmissions by incorporating price transmission variables that vary across villages using the predicted values from the GME estimation. Due to data limitation, however, we can only accomplish this for our 2007 cross section. We re-estimate our model using the standard OLS regression including the predicted price transmissions. In this estimation we exclude all variables that have been used to predict the speed of adjustments to avoid multicollinearity. However for geophysical variables, we re-integrate those variables into the OLS estimation because they have a significant influence on cacao cultivation.

## 3.4. Results and Discussion

The results section comprises three parts. Section 3.4.1 presents the results concerning the relationship between domestic and international cacao prices[15]. Section 3.4.2 examines the determinants of cacao cultivation in the study region applying a two-way effects panel model. Section 3.4.3 improves the analysis of the determinants of cacao cultivation by incorporating cacao prices at the village level.

### 3.4.1. Analysis of Price Transmission

As a standard procedure before implementing the market integration and price transmission analysis, the stationary properties of the cacao price series need to be checked. We begin with unit root tests using Augmented Dickey Fuller (ADF) and KPSS tests statistics to verify the order of integration and whether the cacao price series are stationary at I(1). The ADF, however, reveals that there is no cointegration between 1996 and 2001[16], which might be caused by the Asian financial crisis. We hence exclude the observations between January 1996 and July 1998 and[17] we can now reject the null hypothesis of a unit root. We have further conducted a stability test with a point of time break in December 2001. This test is to check whether statistically we may divide the cacao price series into two sub-periods[18]. The results of the stability test suggest that we can split the analysis into two time periods: August 1998 until December 2001 and the period from January 2002 until December 2007.

For the unit root tests for the aforementioned time division, Table 5 indicates that we cannot reject the null hypothesis neither for the ADF test nor the KPSS test. However, after first differencing both test statistics indicate stationarity of the price series.

[15] Appendix 5 provides the plot of cacao monthly price series between Donggala (sub-district market) and the world market.

[16] Appendices 6 and 7 present the results of a unit root test and Johansen cointegration test of the full period ($D_1$&$W_1$) and sub-periods ($D_2$&$W_2$ and $D_3$&$W_3$).

[17] During the economic crisis period, no relationship was also found between sugar domestic and world markets according to previous work by Reetz (2006).

[18] For the stability test, we have conducted a chow test. The results indicate that we can reject the null hypothesis that the full period of cacao price series has a stable parameter and variance structure. The bootstrapped and the asymptotic chi^2 p-values are respectively 0.031 and 0.004

**Table 5. Unit Root Tests of Monthly Cacao Prices (Donggala Sub-district and the World Market)**

| Price Series (log) | ADF test (with trend and intercept) | | | KPSS test (trend stationarity) | | |
|---|---|---|---|---|---|---|
| | Level ($P_t$) | First difference ($\Delta P_t$) | N of Lags[19] | Level ($P_t$) | First difference ($\Delta P_t$) | N of Lags[20] |
| | | | | Test statistic | Test statistic | |
| **Donggala prices** | | | | | | |
| $D_{1(1998\text{-}2007)}$ | – 2.5373 | – 12.4570 | (0;0) | 0.2374 | 0.0652 | 2 |
| $D_{2(1998\text{-}2001)}$ | – 1.3630 | – 7.8924 | (0;0) | 0.4420 | 0.0866 | 1 |
| $D_{3\ (2002\text{-}2007)}$ | – 2.4614 | – 9.0011 | (0;0) | 0.3072 | 0.0762 | 1 |
| **World Prices:** | | | | | | |
| $W_{1(1998\text{-}2007)}$ | – 2.4104 | – 8.2589 | (0;1) | 0.2494 | 0.1286 | 2 |
| $W_{2(1998\text{-}2001)}$ | – 0.5144 | – 4.1476 | (0;3) | 0.4749 | 0.0342 | 1 |
| $W_{3(2002\text{-}2007)}$ | – 2.1932 | – 7.2151 | (0;1) | 0.4005 | 0.0856 | 1 |

Note: The critical values in ADF test for rejecting the hypothesis of the presence of a unit root at the 1%, 5% and 10% levels are −3.96, −3.41 and −3.13, respectively.
The critical values in KPSS test for rejecting the hypothesis of stationarity at the 1%, 5% and 10% levels are 0.216, 0.146 and 0.119, respectively.

**Source: own calculations**

After conducting the unit root tests, we can proceed with the price transmission analysis of the domestic and international markets (Table 6).

**Table 6. Price Transmission Analysis of Monthly Cacao Prices (Donggala Sub-district and the World Market)**

| Period (price series) | Order of Integration | Cointegration test | Price transmissions | |
|---|---|---|---|---|
| | | $r \leq 1$ | Speed of adjustment | Long-run adjustment |
| **Full period:** | | | | |
| $D_{1(1998\text{-}2007)}$ | I (1) | yes | −0.339 | −0.818 |
| $W_{1(1998\text{-}2007)}$ | I (1) | | (−5.665)*** | (−7.801)*** |
| **Sub-period 2001:** | | | | |
| $D_{2(1998\text{-}2001)}$ | I (1) | yes | −0.370 | −0.565 |
| $W_{2(1998\text{-}2001)}$ | I (1) | | (−3.886)*** | (−4.828)*** |
| **Sub-period 2007:** | | | | |
| $D_{3\ (2002\text{-}2007)}$ | I (1) | yes | −0.504 | −0.632 |
| $W_{3(2002\text{-}2007)}$ | I (1) | | (−6.615)*** | (−8.507)*** |

Note: t-values are provided in parentheses
***Significant at the 1% level
**Source: own calculations**

The results show that each pair of price series is stationary after the first differencing or I(1). Furthermore, all price series both in full and sub-periods are also cointegrated. After fulfilling these conditions, we can estimate the price transmissions of the cacao price series for each period using the Johansen's VECM. The estimation provides values for the speed of adjustments and long-run adjustments which we report in the last

[19] The optimal endogenous lags from the Akaike Info Criterion (AIC), Hannan-Quin Criterion and Schwarz Criterion at the level and after first differenced.
[20]Kwiatkowski et al. (1992) suggested an optimal lag length between $l_4=4(T/100)^{0.25}$ or $l_{12}=12(T/100)^{0.25}$.

two columns of Table 6. The price transmission analysis during the full period from 1998 to 2007 indicates that the domestic market is well-integrated with the world market over the long-run. The long-run adjustment parameter or so-called price transmission (PT) elasticity indicates that 82 percent of long-run price shocks in the world market will be transmitted[21] to domestic prices. The speed of adjustment is relatively fast with about 34 percent of the divergence from the long-run equilibrium being corrected each month. If we compare between the sub-periods 2001 and 2007, there is a vastly increased speed of adjustments between the domestic and world market prices (from 0.370 to 0.504), and a more modest increase in the long-run adjustment (from 0.565 to 0.632).

### 3.4.2. Determinants of Cacao Cultivation

To investigate the effect of market integration on the expansion of cacao in this region, we incorporate the speed of adjustments and the long-run adjustments into our panel model. In the first attempt, we apply a standard panel model[22]. Although in this case the variable speed of adjustment yields a highly significant coefficient, this result is misleading because the inclusion of any variables that vary only across time but not across villages will yield significant results. We therefore apply a two-way effects panel model which includes time dummy variables. As described previously in the methods section, we assign two types of time dummies. The second type requires a comparison of the individual cross sections using an OLS estimation, in order to investigate which variables that are inconsistent in the significance or sign between the two cross sections. These variables are highlighted in Appendix 9. Results suggest that four variables necessitate time dummy variables, namely population density, number of chainsaws, share of irrigated land and slope.

Before describing the econometric estimation, we present the descriptive statistics for explanatory variables used in the panel model and also briefly explain the reasons for their selection (Table 7).

[21] A perfect market integration is achieved when the value is equal to 1
[22] Appendix 8 gives the detailed results of the RE panel estimation

**Table 7. Descriptive Statistics of Panel Model[b)]**

| Description: | 2001 | | 2007 | |
|---|---|---|---|---|
| | Mean | Std. Dev. | Mean | Std. Dev. |
| **Dependent Variable:** | | | | |
| Area of cacao cultivation (ha) | 226.93 | 623.95 | 245.13 | 287.41 |
| **Independent Variables:** | | | | |
| **Socioeconomic factors** | | | | |
| Population density (person/sq. km) | 3.25 | 1.43 | 3.46 | 1.52 |
| Number of motorcycles | 21.97 | 28.26 | 76.14 | 89.11 |
| Number of hand tractors | 5.32 | 8.63 | 9.81 | 13.00 |
| Number of chainsaws | 4.20 | 4.85 | 3.52 | 2.75 |
| Share of irrigated land (%) | 9.77 | 14.01 | 12.04 | 17.47 |
| Share of Buginese ethnic group (%) | 5.76 | 7.82 | 4.79 | 6.67 |
| Availability of agricultural lands (ha/person) | 0.68 | 0.58 | 0.58 | 0.34 |
| Cacao prices (USD per tonne) | 3,433.95 | 811.79 | 1,416.02 | 208.82 |
| Speed of adjustments | −0.37 | 0.00 | −0.50 | 0.00 |
| PT elasticity | −0.57 | 0.00 | −0.63 | 0.00 |
| **Geophysical factors** | | | | |
| Slope (°) | 5.92 | 3.88 | 4.84 | 3.82 |
| Elevation (km) | 0.74 | 0.31 | 0.71 | 0.34 |
| Average precipitation (ml/year) | 2,048.63 | 273.56 | 2,007.60 | 331.95 |
| **Geographical factors** | | | | |
| Distance to all-year roads (km) | 3.56 | 5.71 | 3.42 | 5.70 |
| Distance to river (km) | 0.85 | 0.85 | 0.83 | 0.77 |
| Distance to edge (km) | 0.01 | 0.01 | 0.01 | 0.01 |
| Distance to market (km) | 62.03 | 24.44 | 58.91 | 26.30 |
| Number of observations | 66 | | 69 | |

**Source: own calculation**

In much of the literature, population growth is well-known to have a strong effect on agricultural expansion, which we include as population density in our model. We select number of motorcycles as one of our explanatory variables because motorcycles are important means of transportation which are also commonly used for transporting agricultural products. Hand tractors and chainsaws are technologies used to preparing the land and clearing the forest respectively. We include the share of Buginese in a village because they are migrants from South Sulawesi who introduced cacao cultivation in this region. Geophysical and geographical aspects are chosen because they also influence cacao cultivation. Table 7 indicates that on average cacao cultivation increased almost 20 ha between 2001 and 2007, although the cacao price had dropped by almost 60 percent by 2007. The number of motorcycles increased more than three times by 2007 and the number of hand tractors almost doubled. Both speed of adjustment and price transmission elasticity were greater in 2007 than 2001.

Next, we estimate the area of cacao expansion using two-way effects panel econometric models. To select the best model, we conduct a Hausman test to compare between the fixed effects (FE) and random effects (RE) models. The Hausman test result indicates that RE provides a more consistent estimation than the FE model[23]. Table 8 reports the model estimation. The results suggest that population density, number of hand tractors, share of Buginese ethnic group and slope are highly significant determinants of the expansion of cacao cultivation. The variable for number of motorcycles is significant at the 10 percent level. Population density and the availability of agricultural land have positive effects on the cacao cultivation area. This region has an increasing population density, which means that more labour is available for the agricultural production, which in turn means that more land is converted to cacao production. To explain why the availability of agricultural land contributes to cacao expansion in this area, we should understand the way in which cacao plots are established. Aside from clearing forests to directly establish cacao plantations, another common practice is to convert existing agricultural plots to cacao production, as is common with ex-coffee cultivation since this is no longer profitable.

The only factor limiting the expansion of cacao cultivation is the share of irrigated land, which is typically used for paddy rice cultivation. The well-established irrigation systems are mainly found in villages in low land areas. These irrigation systems provide reliable water supply for rice cultivation, therefore pre-empting the need to establish new cacao plots. The high labour intensity of rice cultivation means that there is little excess labour to devote to other cropping systems. Furthermore, farmers are highly knowledgeable of rice production-related problems such as pest and diseases, improvements in productivity and management of harvests, whereas they have little to no knowledge about cacao production.

The high significance of the slope variable confirms that cacao plots are mainly located in steeper areas. Cacao provides a so-called forest rent and since forest is only left at higher elevations and steeper slopes, cacao cultivation takes place in these areas.

[23] The Hauman test Prob>chi2 = 0.4214 indicates the non-rejection of the null hypothesis that the RE estimator is fully efficient

Thus cacao expansion may result in other environmental problems such as an increase in the occurrence of landslides and erosions.

**Table 8. Determinants of Cacao Cultivation (Two-way RE Model Estimates)**

| Dependent variable: Area of cacao cultivation (ha) | | | |
|---|---|---|---|
| **Independent variables:** | **Estimated** | | |
| | **Coef.** | | **SE** |
| **Socioeconomic factors** | | | |
| Population density (person/sq. km) | 0.268 | ** | 0.112 |
| Number of motorcycles | 0.003 | * | 0.002 |
| Number of hand tractors | 0.022 | ** | 0.011 |
| Number of chainsaws | 0.000 | | 0.043 |
| Share of irrigated land (%) | -0.054 | *** | 0.010 |
| Share of Buginese ethnic group (%) | 0.072 | *** | 0.018 |
| Availability of agricultural lands (ha/person) | 1.245 | *** | 0.179 |
| Cacao prices (USD in ln) | -0.009 | | 0.238 |
| **Geophysical factors** | | | |
| Slope (°) | 0.118 | *** | 0.042 |
| Elevation (km) | -0.525 | | 0.746 |
| Average precipitation (ml/year) | 0.001 | | 0.001 |
| **Geographical factors** | | | |
| Distance to all-year roads (km) | -0.007 | | 0.027 |
| Distance to river (km) | -0.007 | | 0.165 |
| Distance to edge (km) | 0.876 | | 5.873 |
| Distance to market (km) | -0.001 | | 0.009 |
| **Dummy variables** | | | |
| Time dummy for population density | -0.217 | ** | 0.111 |
| Time dummy for number of chainsaws | 0.088 | ** | 0.044 |
| Time dummy for share of irrigated land | 0.040 | *** | 0.010 |
| Time dummy for slope | 0.018 | | 0.031 |
| The overall time dummy | -0.749 | | 0.458 |
| Cons | 1.192 | | 2.332 |
| Number of observations | 135 | | |
| R-sq within | 0.66 | | |
| R-sq between | 0.53 | | |
| R-sq overall | 0.52 | | |

*,**,*** Significant at the 10%, 5%, and 1% level, respectively.

**Source: own calculations**

Although the two-way RE panel model captures the socioeconomic and geophysical factors that contribute to cacao expansion, the application of this model eliminates our variable of interest, the speed of adjustment, since it varies across time but not across individual villages. However, we still use this model to elucidate that the prevailing prices have no influence on the decisions to expand the cultivation of cacao.

In order to investigate the effect of price transmissions on cacao expansion, we use village-level price data in the next section.

### 3.4.3. Determinants of the Cacao Expansion with the GME Applications and the OLS

At this stage, our objective is to detect the influence of market integration on cacao area. We use weekly cacao price series data from cacao growers in ten villages[24]. This price series data varies across individual villages. However, due to data limitation we cannot apply panel models which are comparable with the previous two-way effects model that we have estimated in section 3.4.2.

We repeat the procedure used to analyse price transmissions in section 3.4.1, for the village level prices. Appendix 11 reports results of the unit root tests (ADF and KPSS) on weekly cacao prices between the 10 local village markets and the international market. All data series are stationary after first-differencing I(1) as summarised in Appendix 12. Furthermore, the Johansen cointegration test indicates that all price series have long-run cointegration, which is indicated by 'yes' answers for $r \leq 1$. We obtain the speed of adjustments and PT elasticity between each village and the world market. We predict the speed of adjustments for the remaining 70 villages using a GME approach[25]. We use the same approach to estimate the PT elasticities in each village. However, results suggest that none of the variables used for the prediction are significant in either GME or OLS estimations. Thus, we can only utilise the speed of adjustment to represent market integration between local villages and the world market. Appendix 13 gives detailed results of the GME estimations[26]. After yielding values of estimated coefficients using the GME approach for parameters that are used to predict the speed of adjustments in each village, we incorporate these predicted values for the speed of adjustments into a cross section estimation with an OLS.

Please note that some variables; number of motorcycles, number of hand tractors, share of Buginese ethnic group, distance to river, distance to market, that were used in the GME to predict the speed of adjustment for the remaining villages are no

[24] Appendix 10 shows the plot series between the 12 villages and the world market. However, only 10 villages are later used in the GME estimations.

[25] We select the socioeconomic and geophysical variables that we have used in the two-way RE panel model to predict the market integration parameters.

[26] This is the results of the GME estimation after we transformed the speed of adjustments into log (-(speed of adjustments)).

longer included in the OLS estimation for cacao cultivation. This is to avoid perfect multicollinearity. This means that those aforementioned variables are now indirect influences on the expansion of cacao and are only transmitted via speed of adjustments variable. However, variables such as slope and elevation have direct influences on cacao cultivation in nature. Therefore we also include these variables in the OLS to estimate their effect on the area of cacao cultivation. In order to ascertain variables which are robust for use in the final OLS estimation for factors determining the area of cacao cultivation, we used the following procedure. We compared the OLS estimations that are different in a way the variable of speed of adjustments were predicted, and then checked that the estimated coefficients were consistent, in terms of having the same signs and significance (Appendix 14). Variables which showed inconsistency were not included in the next estimation. We then included the only consistent variable availability of agricultural land into an OLS estimation to estimate to which extent they affect the area under cacao cultivation. Table 9 presents the estimation results. The results suggest that population density, number of chainsaws, availability of agricultural land and slope are positive influences on the area of cacao cultivation in 2007. Once again, irrigated land has a negative influence which limits the expansion of cacao cultivation. These variables are highly significant (between 5 and 1 percent) except for the number of chainsaws variable (10 percent). Explanations for the estimated coefficients have been previously discussed in section 3.4.2. The availability of chainsaws facilitates the rapid removal of shade trees during the intensification process illustrated in Appendix 4 as well as to clear forest for cacao cultivation, and is thus an important factor influencing the cacao cultivation area.

Finally, the estimation results suggest that the speed of adjustments is a positive influence on the area of cacao cultivation in 2007, where values fall between –0.004 to –2.270[27]. A more negative value of speed of adjustment indicates an improvement in price transmission, whereas a high speed of adjustment transmits higher prices in the international market to the farm gate level. Therefore, this parameter strongly indicates that farmers receive recompensing prices to continue the expansion of cacao production. This evidence also shows that decisions to expand the cacao cultivation will depend

[27] The values greater than –1 indicate overshooting. We check the robustness of the estimation model by substituting the values that are greater than −1 with −1. The result is still significant.

much on farmers' expectations of cacao future prices rather than reacting to prevailing prices.

**Table 9. OLS Estimation of the Factors Influencing Cacao Cultivation**

| Dependent variable: Area of cacao cultivation (ha) | | | |
|---|---|---|---|
| **Independent variables:** | **Estimated** | | |
| | **Coef.** | | **Robust SE** |
| **Socioeconomic factors** | | | |
| Population density (person/sq. km) | 0.496 | *** | 0.175 |
| Number of chainsaws | 0.106 | * | 0.054 |
| Share of irrigated land (%) | – 0.045 | *** | 0.013 |
| Availability of agricultural lands (ha/person) | 2.115 | *** | 0.483 |
| ln cacao prices (USD) | 0.812 | | 0.969 |
| Short-run adjustments | –1.093 | ** | 0.458 |
| **Geophysical factors** | | | |
| Slope (°) | 0.133 | ** | 0.059 |
| Elevation (km) | 0.552 | | 0.915 |
| Average precipitation (ml/year) | 0.000 | | 0.001 |
| **Geographical factors** | | | |
| Distance to all-year roads (km) | –0.045 | | 0.030 |
| Distance to edge (km) | –15.011 | | 16.624 |
| Cons | –5.299 | | 7.758 |

*,**,*** Significant at the 10%, 5%, and 1% level, respectively.

**Source: own calculations**

## 3.5. Conclusions and Recommendation

This paper aims to contribute to studies on the drivers of cash crop expansion by explicitly addressing the role of market integration between international and local markets using price transmissions analysis. In this article, we apply a wide range of econometric techniques including panel model, cross section and time series analysis. To explore the integration between domestic and international markets, we apply a Vector Error Correction Model (VECM) with Johansen procedure. To examine the determinants of cacao expansion, we apply two-way RE models. To analyse the determinants of cacao expansion in a cross section in 2007, we used a combination of the GME approach and an OLS estimation.

The price transmission analysis suggests that between 1998 and 2007 the domestic market was well-integrated with the world market in the long-run. Almost 82 percent of the price shocks in the world market were transmitted to domestic prices. Furthermore, the fact that 34 percent of the divergence from the long-run equilibrium was corrected each month indicates a relatively fast speed of adjustment. Between 2001 and 2007, the degree of integration between domestic and world markets increased compared with the period 1999 to 2001. In particular the speed of adjustments increased more (from 0.370 to 0.504) than the long-run adjustment (from 0.565 to 0.632). This result confirms that short-run adjustments have stronger effects than the long-run adjustment on cacao price determination in local markets.

The Hausman test result indicates that the two-way RE panel model provides a more consistent estimation than the FE model. Results suggest that the following variables significantly positively influence the expansion of cacao cultivation: population density, number of hand tractors, share of Buginese ethnic group, number of motorcycles and slope. The only stabilising effect on cacao expansion is the share of irrigated land. The two-way RE panel model captures the socioeconomic and geophysical factors that contribute to cacao expansion and demonstrates that the prevailing prices have no influence on the decisions to expand the cultivation of cacao. However our variable of interest, the speed of adjustment, cannot be captured in this model due to lack of variation across individual villages.

To improve the analysis of the factors determining cacao cultivation expansion in this region, we use weekly cacao price series from ten villages. The GME method enables us to provide a consistent prediction of the speed of adjustments for prices in the remaining villages for 2007. However due to limited availability of data, we can only estimate a cross section analysis by applying an OLS estimation. The estimation results suggest that the variables population density, number of chainsaws, availability of agricultural lands and slope positively influence the area of cacao cultivation in 2007. In this cross section model the price transmission, represented by speed of adjustment, is a highly significant influence on the cacao cultivation area of cacao cultivation. A positive sign for the estimated speed of adjustments variable confirms that the high degree of integration between local and international markets contributes to the expansion of cacao production in the study region. The high speed of adjustment indicates that the higher prices in international market will be transmitted to the farm gate level. Therefore farmers still receive recompensing prices to continue the expansion of cacao production. Furthermore, the cacao expansion of all villages combined over the region gives a significant area of deforestation in this region.

Thus we can argue that the inclusion of the speed adjustment is an important parameter to understand the cacao expansion process because the decisions to expand the cultivation of cacao will depend much on cacao future prices rather than the prevailing prices. However, longer term price series which can be applied in panel models are more appropriate to capture the impact of cacao expansion.

The results of our study can suggest policy options which will better harmonise the goals of economic growth and environmental sustainability. Further expansion of irrigation schemes, which have so far been restricted mainly to the lowlands, might help to reduce cacao expansion. Cacao expansion is occurring mostly in the highlands, where there are low levels of investment in irrigation, yet which are fragile areas for forest conversions to agricultural use. Nevertheless for such implementation, policy makers need an accurate cost-benefit analysis to assess the viability of such investments. Due to the high transmission of high prices in the world market to the local markets, the economic incentives to intensify production by cutting shade trees from natural forests are high. Regardless of the fluctuating prices of cacao at farm gate level, the high prices in the world market are passed to cacao growers. Thus, improvements in market integration through improvement of physical, commercial, and institutional infrastructure provide an opportunity for farmers to remain engaged in existing non-cacao agricultural production. Improvement of physical (hard) infrastructure such as transportation and storage would reduce transport costs. Improvements in commercial and institutional (soft) infrastructure, such as the development of systems of market information, credit, and commercial law, would reduce overall transaction costs. The reduction of transport and transaction costs would therefore reduce farmers' reliability on further expansion of cacao production as the most favorable means to improve their livelihood.

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## *Chapter 4*

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

**Reetz, S., Schwarze, S., and Brümmer, B. 2011.**

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## Abstract

The negative impacts of climate change have made poverty and deforestation topics of heightened interest within global community discussions in recent years. The challenge remains for many developing countries to disconnect poverty reduction from negative environmental consequences such as deforestation. Our study contributes to the debate over the links between poverty and deforestation by providing an alternative approach from the village level perspective, whilst broadening the range of poverty measures based on poverty proxies and subjective well-being (SWB). The linkages are analysed in a tropical forest region in the vicinity of Lore Lindu National Park in Central Sulawesi, Indonesia. This park hosts many endemic species, however, this region is also characterised by high rates of poverty and deforestation. By exploring regional links between poverty and deforestation, we may be better able to protect ecosystem functioning and local livelihoods. Since poverty is a complex phenomenon, we include objective and subjective perspectives that are expressed by proxies of poverty from different dimensions, as well as an index of SWB at the village level. Our analysis applies geo-referenced land cover data and socioeconomic data from 2001 and 2007, obtained from Landsat ETM+ scenes and surveys of 80 randomly selected villages, respectively. We estimate the relationship between deforestation and a number of explanatory variables in a Beta regression framework. Our results suggest that there is a non-linear relationship between SWB, as well as other poverty proxies, and deforestation. The objective perspective of poverty shows an unclear pattern. No empirical evidence is found that poverty increases deforestation rates from the relative poverty assessment, although additional proxies derived from certain elements of poverty measures have mixed effects that might result in increased or decreased deforestation rates. The SWB perspective indicates that the extreme poor and rich villages have high deforestation rates. Furthermore, although initially wealthier villages showed higher rates of deforestation, from the subjective perspective, regional improvements in well-being have decreased the rates of deforestation within the period of study. Our results are used to suggest policies for reducing forest loss.


**Keywords:** *Poverty reduction, deforestation, subjective well-being, poverty proxies, beta regression*

## 4.1. 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). Indonesia had an average annual deforestation rate of 0.71 million hectares per year between 2000 and 2005, second only to Brazil during this period (World Research Institute, 2010). Here, the Indonesian agricultural sector, which is the driver of deforestation, has remained the backbone of the rural economy and contributed significantly to poverty alleviation (Tacconi & Kurniawan, 2006; Thorbecke & Jung, 1996). This further demonstrates the difficulties in disconnecting economic development from negative environmental effects, in this case deforestation.

The causes of deforestation are manifold and include logging, mining and the establishment of plantations or pastures. The agents of deforestation also vary depending on these activities. As an example, large land holders are responsible for the expansion of pasture land for beef production into previously forested areas in Brazil (Fearnside, 2005; Lele et al., 2000). Deforestation conducted by smallholders is the proximate cause of at least 50 percent of deforestation in tropical forests (Barraclough & Ghimire, 2000). Therefore, our study focuses on deforestation by smallholders, although later we aggregate the analysis up to the village level.

Two mainstreams can be identified within the growing literature that analyses the link between poverty and deforestation by smallholders. Some have perceived that agricultural expansion carried out by smallholders is triggered by poverty (Coxhead et al., 2002; Deininger & Minten, 1999; Dennis et al., 2005; Geist & Lambin, 2001; Godoy et al., 1997; Kerr et al., 2004; Maertens et al., 2006; Rudel & Roper, 1997) whilst other scholars have argued that poverty has no direct link to deforestation (Chomitz, 2007; Dasgupta et al., 2005; Khan & Khan, 2009; Wunder, 2001; Zwane, 2007). Accordingly, the question of whether poverty causes deforestation has been the subject of debate during the last decades.

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 existence of different theoretical approaches towards poverty, each of which utilise many methods to measure poverty. These different approaches and methods might explain why the existing literature regarding the poverty-deforestation link contains contradictory results. As an example, Khan and Khan (2009), using satellite imaging and poverty mapping in Swat district, Pakistan found that there is no empirical evidence that poverty is associated with forest degradation. Dasgupta et al. (2005), using absolute poverty indices from consumption expenditure, found that there are moderate correlations between poverty and deforestation rates in three developing countries (Cambodia, Lao PDR, and Vietnam), and that they are correlated at the district level for Cambodia, and at the provincial level for Lao PDR. Although poverty is a complex phenomenon, most studies have used generalised approaches towards poverty and, therefore, failed to distinguish the specific effects which different elements of poverty have on deforestation (Dasgupta et al., 2005; Deininger & Minten, 1999; Godoy et al., 1997). Moreover, most studies apply monetary measures or use consumption approaches to assess poverty at a household level (Dasgupta et al., 2005; Zwane, 2007).

Our study provides an alternative approach towards the poverty-deforestation link from the village level perspective. In our opinion, the drivers of deforestation will be more clearly observable at a higher level than households because deforestation is strongly associated with collective poverty and economic diversity at the village level (Angelsen & Wunder, 2003; Dewi et al., 2005), and many socio-demographic factors (e.g. population density, infrastructures) and geophysical factors (e.g. elevation, slope) have few variations across households.

The effects of different elements of poverty on deforestation have not previously been explored. In particular, very little research on subjective well-being (SWB) has been done in developing countries, and only a few studies have applied SWB as a proxy of poverty (Kingdon & Knight, 2006; Pradhan & Ravallion, 2000; Ravallion & Lokshin, 2002). Our study contributes to the debate over the links between poverty and deforestation. The use of poverty proxies including SWB assessments serves to capture the multidimensionality of poverty and therefore help to formulate improved policy suggestions to reduce future forest losses. However, there are some shortcomings of SWB assessments in terms of: accuracy, reliability (as a result of respondents interpreting questions differently), and different perceptions among the neighbouring respondents. The shortcomings of the objective approach are related to data availability and quality, as well as the issue of different perceptions of what constitute basic needs and minimum requirements (Angelsen & Wunder, 2003; Expert Group on Poverty Statistics, 2006).

This paper examines the relationship between poverty and deforestation in a region of tropical forest in the vicinity of Lore Lindu National Park in Central Sulawesi, Indonesia. This park hosts many collections of endemic species, however this region is also characterised by high rates of poverty and deforestation. Forest cover decreased by 4.8 percent from 2001 to 2007 whilst 59.1 percent of households were living below the international poverty line of 2 USD per capita per day in 2007 (Van Edig et al., 2010). Smallholders are the major agents of forest degradation in this area (Maertens et al., 2006; Steffan-Dewenter et al., 2007). The link between poverty and deforestation in this region, in particular the effects of different elements of poverty on deforestation, require consideration in order to devise sustainable development policies which simultaneously reduce poverty, preserve the long-term functioning of the forests and protect peoples' livelihoods.

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 an increase in the percentage of irrigated land reduces deforestation rates. Nevertheless, from the overall subjective perspective, between 2001 and 2007 the improvement of village well-being encouraged a reduction in the deforestation rate.

The remainder of the paper is organised as follows: Section 4.2 provides our conceptual framework which underlines the links between poverty and deforestation. Section 4.3 explains the data and methods, with particular attention to the data-collection process as well as coverage and accuracy of data. In Section 4.4, we provide and discuss our results, and Section 4.5 concludes the paper.

### 4.2. Conceptual Framework

Before discussing potential linkages between poverty and deforestation, we clarify the key terms. According to the definition of the Intergovernmental Panel on Climate Change (IPCC), deforestation is the permanent or temporary removal of forest cover and conversion to a non-forest land use. This includes natural events such as landslides and forest fires, as well as human activities such as shifting cultivation, clear-cut logging, and other types of land conversion from forest to non-forest use (Erasmi et al., 2004; Noble et al., 2000). Poverty, meanwhile, is a more multidimensional phenomenon, and its measurement is typically linked to many variables, including many dynamic components. One commonly accepted definition appropriately reflects the complexity of poverty; the World Bank describes poverty as a social condition of chronic insecurity resulting from malfunctioning of the economic, ecological, cultural, and social systems, which causes a group or class of people to lose the capacity to adapt and survive and to live below minimum levels required to satisfy their needs (World Bank, 2001). Thus, poverty relates to situations in which people are unable to meet economic, social, and other standards of well-being. However, the definition of poverty is incomplete without including gender inequality and environmental issues as well (OECD, 2001). Such a broad definition of poverty is open to subjective interpretation, because each case of poverty occurs within a particular context.

We adopt here the terms “objective approach” and “subjective approach”. For both approaches we must consider the technical issues involved in methods used to measure poverty. The objective approach has used some standard techniques to measure poverty. These techniques employ different indicators of well-being such as: poverty lines, head count indices with either a monetary approach or a food energy intake method (FEI), or the direct calorie intake method (DCI) with a consumption approach. These approaches have been used to estimate the incidence of poverty within a community, either at a regional or national level using a household as the unit of observation (Coudouel et al., 2002). To apply the aforementioned poverty measures analysis to our 80 sampled villages, however, would have been financially costly and research intensive for this project. As an alternative to monetary or consumption indicators of well-being, we employ poverty proxies and Subjective Well-Being (SWB). Subjective methods use a conceptual definition of poverty better suited to our specific research context, which will be explained further towards the end of this section. It is important that our outsiders’ view of poverty is informed also by the opinions of community members in order to define what they believe constitutes being poor. Perspectives of local people obtained using SWB have until now been left unexplored and only a few studies have applied SWB as a proxy of poverty in developing countries (Kingdon & Knight, 2005; Pradhan & Ravallion, 2000; Ravallion & Lokshin, 2002). Both the objective and subjective perspective approaches have some drawbacks. The shortcomings of SWB assessments are in terms of: accuracy, reliability (as a result of respondents interpreting questions differently), and different perceptions among the neighbouring respondents. The shortcomings of the objective approach are related to data availability and quality, as well as the issue of different perceptions of what constitute basic needs and minimum requirements (Angelsen & Wunder, 2003; Expert Group on Poverty Statistics, 2006).

Spatial overlap between high incidences of poor rural communities and forest cover areas have been found by some studies (Chomitz et al., 2007; Sunderlin et al., 2000) as well as potential links between poverty and deforestation (Coxhead et al., 2002; Deininger & Minten, 1999; Dennis et al., 2005; Geist & Lambin, 2001; Godoy et al., 1997; Kerr et al., 2004; Maertens et al., 2006; Rudel & Roper, 1997). There may be reciprocal causality between deforestation rates and their influencing factors. For example, villages which contain more motorcycles tend to have higher deforestation rates in the initial study period. However this does not mean that such communities have higher rates of deforestation as a result of their greater wealth. An alternative explanation might be that more villagers could afford motorcycles as a result of deforestation-derived wealth. In order to avoid reversal effects between deforestation and explanatory variables occurring in the model, we must set an assumption of unidirectional causal relationship. In practice, we circumvented the possibility of reciprocal causality by including factors that influenced deforestation from the initial period only. Here, we determine that the deforestation rate, as our dependent variable, has a unidirectional causal relationship to the explanatory variables.

Although our study focuses on a natural tropical forest in which deforestation is primarily caused by agricultural expansion of smallholders, we used the village as the unit of observation in order to link poverty and deforestation. We believe that this is advantageous because in our opinion drivers of deforestation will be more observable at a higher level than households. Furthermore deforestation is strongly associated with collective poverty and economic diversity at the village level (Angelsen & Wunder, 2003; Dewi et al., 2005). Meanwhile, many variables such as socio-demographic factors (e.g.

population density, infrastructures) and geophysical factors (e.g. elevation, slope) are largely uniform between households. Thus, the influence of poverty on deforestation rates should become more apparent at an aggregated level.

We aim to understand the relationship between various elements of poverty and deforestation, as well as to explore significant effects of particular aspects of poverty on the deforestation process at the village level. These particular aspects of poverty include; demographics, cultural and social systems, technology, health and sanitation, economy, education, gender inequality, environmental issues, and geophysical conditions. For each of the different elements, a set of proxies is required. For example the number of secondary schools and the illiteracy rate is used as a proxy for education. However, we must recognise that a given proxy might also simultaneously reflect other aspects of poverty. The SWB index is used to capture the respondents' view of their situation. Besides recognising the multidimensionality of poverty, the use of poverty proxies and SWB assessments helps to formulate improved policy implications to reduce future forest losses.

## 4.3. Data and Methodology

### 4.3.1. Study Area

The study area is located in central Sulawesi, Indonesia, and contains both lowland and mountainous forests with an altitude ranging from 200 to 2,610 meters above sea level. The study area is approximately 7,500 square kilometres, which includes 2,200 square kilometres of the Lore Lindu National Park (LLNP) (Erasmi & Priess, 2007). Most of the area is characterised by a humid tropical climate. 78 percent of the 80 villages surveyed lie within the largest portion of rainforest cover. The LLNP hosts many collections of endemic species that are of great biodiversity and natural conservation importance. However agricultural expansion threatens the integrity of the park's biodiversity.

From 2001 to 2007, the population increased by 14.1 percent, equivalent to a mean annual growth rate of 2.2 percent. Although this population growth rate is only slightly higher than at the provincial level (2.1 percent), it is significantly greater than the national level (1.3 percent). Such a high growth rate might indicate that this area is facing population pressure. The main indigenous groups residing in the area are the Kaili and Kulawi. However, the share of non-indigenous people is relatively high, comprising 32 percent of the total population. Furthermore the largest ethnic group is the Buginese, who originated from the South Sulawesi province.

Farming is the major occupation in the area with 86.8 percent of households completely dependent on agricultural activities. Earnings from non-agricultural activities are low, providing financial support for only 13.2 percent of households. In general, access to central markets has improved considerably since 2001, whilst the share of villages that are accessible by motorcycle has increased from 85 percent to 100 percent. Especially in the northern part of the region, the increase in the number of roads and road quality improvements has reduced the amount of time required for local people to reach the central market in the provincial capital Palu.

### 4.3.2. Data

Geo-referenced data were collected from various sources. These data include land use and topographic information for the study area. The land use information was derived from Landsat ETM+ scenes and was compiled into a 100 x 100 meter grid resolution in a GIS (Geography Information System) programme. For more details on the geo-referenced data see Erasmi and Priess (2007). We calculated the deforestation rate as the dependent variable in our model. Using village boundary data, we were able to determine the magnitude of deforestation for each village. The deforestation rate for each village was calculated by dividing the area of surrounding land that had been deforested between 2001 and 2007 by the total forest area in 2001. Furthermore, we included topographic information for each selected village obtained by calculating the average elevation and slope.

The 80 study villages were selected from the total of 119 using a stratified random sample (Zeller et al., 2002). Village socioeconomic data was obtained by conducting two surveys based on standardised questionnaires during the same year. We also obtained secondary data from village censuses and other documents. The survey comprised interviews in the form of a panel discussion, which were conducted by a team of two enumerators who interviewed the village leader and other village representatives in each of the selected villages. Each panel consisted of 4 to 6 representatives who were appointed due to their good knowledge of their village.

The questionnaires covered issues of village demographics, land use, agricultural technology and markets, land and labour, livestock, national park and conservation issues, infrastructure, income and wealth, El Nino-related drought, and future challenges. Moreover, to capture the multidimensionality of poverty, we generated data relating to poverty in three different ways. First, we assessed the relative poverty of the villages in the research area using a poverty assessment tool that was developed in a previous survey at the household level in 2005 (Van Edig et al., 2010). In that study, two sets of 15 poverty indicators were tested to provide a robust poverty tools assessment (PATs) that were used to predict households' daily per capita expenditures. Next, estimations of daily per capita expenditures were utilised to predict the distribution of poor households in the community. From those two sets of poverty indicators, we selected three indicators, namely education, health and sanitation and housing dimensions, that could be applicable at the village level. These three indicators were most applicable to and suitable for our village survey because they were easy to assess by enumerators and village representatives.

The first indicator education level for a given household was whether or not they include at least one family member who had graduated from high school. The second indicator, health and sanitation, characterises households based on whether or not they own a private pit toilet. The last indicator, housing, characterises households on the basis of whether or not they have exterior walls built from concrete. We define households as poor if they report favourable conditions for no more than one of these three poverty indicators, whereas we define better-off households as those benefitting from favourable ratings for at least two indicators. These classifications were chosen based on our field observations which suggested that households who possess two of these indicators are considered significantly better-off, while households considered to be poor possess one indicator and the poorest lack all three indicators. Questions about these aforementioned criteria were asked during the panel discussion with village representatives. By subtracting the percentage of better-off households from the total percentage of households, we estimated the percentage of poor households in the village.

Secondly, we assessed SWB as another proxy for poverty. SWB is measured by asking respondents to evaluate their livelihoods through self-completed reports which measure their emotional responses, domain satisfaction, and global judgements of life satisfaction (Diener & Seligman, 2004; Hoorn, 2008). SWB measurements vary from single-item scales to multi-item scales and more advanced measures (Hoorn, 2009), such as the so-called Experience Sampling Method (ESM) or Ecological Momentary Assessment (EMA) (Scollon et al., 2003) and Day Reconstruction Method (DRM) (Kahneman et al., 2004; Kahneman & Krueger, 2006). Using SWB allowed us to measure local peoples' perspectives on their own well-being. Despite the importance of SWB and its increasing prominence within economics literature, very little research on SWB has been done in developing countries. Previous SWB research has been done in (Pradhan & Ravallion, 2000) Nepal and Jamaica; (Lokshin et al., 2006; Ravallion & Lokshin, 2002)) Russia; (Bookwalter & Dalenberg, 2004; Kingdon & Knight, 2005; Neff, 2006)) South Africa; (Graham & Pettinato, 2001) Latin America and Russia; and (Appleton & Song, 2008) urban China. Moreover, only a few of these studies have applied SWB as a proxy of poverty aspects (Kingdon & Knight, 2006; Neff, 2006; Pradhan & Ravallion, 2000; Ravallion & Lokshin, 2002). While these studies apply SWB at the household level, we attempt to apply SWB at the village level. In our study, we asked village representatives to rate their village's welfare relative to that of their neighbouring villages on a single-item scale. Respondents were presented with an image of a ladder with 10 steps, of which the lowest step represents the poorest villages and the tenth step represents the wealthiest villages. Meanwhile our survey asked respondents to indicate the wealth of their village in comparison to these two extremes for 2001 and 2007 using the same ladder. We then calculated the changes between wealth ranks on the ladder over the 6 year interlude. A positive value indicates that the village became relatively wealthier, and vice versa. Lastly, we included selected variables to use as additional proxies of poverty: access to economic resources, agricultural technology, gender inequality, environmental issues, and income diversity[28].

Table 10 presents the descriptive statistics for study area. The deforestation rate in the research area was almost 7 percent between 2001 and 2007, which is equivalent to approximately, 1.2 percent annually. This rate is slightly lower than the national rate, which was 1.3 percent annually. On average, 1.63 square km of natural forests were cleared in each village, which represents an average of almost 5 percent of total village size. The average village population has increased by about one fifth over the last six years, although immigration of Buginese people is declining. We are particularly interested in including the Buginese ethnic group in our model because they migrated in early eighties from Southern Sulawesi and were the pioneers of cacao cultivation in this area. For the most part, they obtain access to land by purchasing it from local people, before introducing

[28] Although we sampled 80 villages, we observed only 52 in order to concentrate on the pure effects of poverty on deforestation. We therefore excluded villages with dependent variables (deforestation rate) less than zero which resulted by policy interventions such as local afforestation programs. We also excluded those villages with dependent variables with values greater than one because these deforestation rates were the result of changes in village size between 2001 and 2007 and therefore inaccurate. Moreover, since we used percentage change in irrigated land as one of our variables in a model, we excluded villages without irrigated land.

intensive cacao farming techniques. A previous study in three villages representative of the area has shown that cacao cultivation expansion has contributed to increased pressure for forest conversion (Steffan-Dewenter et al., 2007).

**Table 10. Descriptive Statistics[c)]**

| Description: | Mean | Std Dev. | Min | Max |
|---|---|---|---|---|
| **Dependent Variable:** | | | | |
| Deforestation rate (%) | 6.92 | 12.82 | .16 | 83.01 |
| **Other figures related to deforestation:** | | | | |
| Actual deforested area (square km) | 1.63 | 1.76 | .09 | 9.35 |
| Share of deforested area in village area (%) | 4.76 | 6.08 | .07 | 28.80 |
| **Independent Variables:** | | | | |
| Population growth | 19.68 | 32.03 | –50.90 | 189.14 |
| % change of share of Buginese | –.46 | 1.88 | –5.30 | 5.85 |
| % change of irrigated land | –.52 | 8.42 | –21.05 | 36.02 |
| % of HH with electricity | 56.47 | 33.81 | 0 | 100 |
| Number of hand tractors | 7.44 | 9.03 | 0 | 38 |
| Availability of phone connection either public or private (dummy) | .37 | .49 | 0 | 1 |
| Number of motorcycles in 2001 | 19.00 | 24.00 | 0 | 98 |
| Number of chainsaws in 2001 | 4.00 | 5.00 | 0 | 25 |
| Road accessibility by car (dummy) | .73 | .45 | 0 | 1 |
| Village health centre (dummy) | .12 | .32 | 0 | 1 |
| Distance to market (10 km) | 6.53 | 2.14 | 2.95 | 10.80 |
| % of HH that are members of informal rotating savings groups (arisan)[29] | 24.94 | 30.11 | 0 | 100 |
| % of HH with no land | 4.24 | 11.02 | 0 | 53.98 |
| % of HH with non-agricultural incomes | 11.29 | 7.81 | 1.15 | 43.02 |
| Number of secondary schools | .44 | .87 | 0 | 5 |
| % of illiteracy in the working age population | 4.02 | 6.99 | 0 | 35.50 |
| % of females in the village | 49.03 | 6.75 | 31.80 | 67.96 |
| Experiencing drought (dummy) | .75 | .44 | 0 | 1 |
| Averaged slope (degree) | 13.52 | 4.70 | 2.14 | 22.30 |
| Averaged elevation (000 m) | 1.11 | .31 | .35 | 1.64 |
| Forest size in 2001 (square km) | 60.65 | 60.73 | 1.53 | 267.76 |
| % of poor HH | 68.64 | 24.00 | 19.87 | 100 |
| SWB in year 2001 | 3.85 | 1.42 | 1 | 8 |
| Change of SWB from 2001 to 2007 | 1.19 | .72 | 0 | 3 |
| Number of observations | 52 | | | |

**Source: own calculations**

The study area is characterised by use of basic technologies and has limited access to public services. Over half of village households have electricity. Almost three quarters of roads within the observed villages are accessible by car, and over a quarter of villages have a phone connection either from a public phone, a mobile phone, or a fixed line. The average village has more than 90 motorcycles, which are the most important means by which people and agricultural goods are transported, and therefore they are used as the proxy for market access. More than 10 percent of the villages surveyed have health centres.

[29]Arisan is an example of a rotating savings or credit association which is a private lottery organized by several groups of friends or relatives. Each member of the group deposits a fixed amount of money, draws a lottery monthly, and the winner of the lottery takes home the cash. The cycle is complete after each member has won the lottery. These self-help groups play an important role for the informal financial sector in rural and urban areas in Indonesia. see: http://www.bwtp.org/arcm/indonesia/I_Country_Profile/Indonesia_country_profile.htm

Regarding economic properties, income diversification is low and only about 11 percent of households have non-agricultural income sources. Almost a quarter of the village population has access to an informal rotating credit association (arisan). Physical distances to the central markets vary between 30 and 110 kilometres, with most of the roads in poor condition. In terms of education, less than half the villages have a secondary school and 4 percent of working age people are illiterate. The gender demographic is almost balanced. Almost three quarters of the villages in this study area have experienced drought between 2001 and 2007, the occurrence of which might indirectly make people more vulnerable to poverty. Most lands are situated on steep slopes at high elevations, and remaining forest cover within villages varies from less than 2 to almost 270 square km. People defined as poor comprise, on average, more than two thirds of village populations. In regard to SWB measures, the average village in 2001 had a value greater than 3, on a scale of 1 to 10, with a range from 1 to 8 recorded. On average SWB scores improved between 2001 and 2007.

### 4.3.3. Econometric 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 values of 0 and 1. Since the dependent variable is a rate or proportion, OLS (Ordinary Least Squares) is inappropriate and inaccurate due to the skewed distribution of the residuals. Moreover, a rate or proportion dependent variable often violates the OLS' assumptions of normality and homoscedasticity as values tend to be concentrated within the middle range, and less so in the lower and upper limits. Therefore a beta distribution was considered for the analysis of the dependent variable (Cribari-Neto & Zeleis, 2010; Ferrari & Cribari-Neto, 2004; Smithson & Verkuilen, 2006).

Beta distribution is a flexible distribution which can accommodate a uniform, unimodal, or bimodal distribution of points that can either be symmetrical or skewed (Paolino, 2001). The standard beta density is expressed as:

$$f\ (y;p,q) = \frac{\Gamma(p+q)}{\Gamma(p)\Gamma(q)} y^{\,p-1}(1-y)^{q-1},\ \ 0 < y < 1 \qquad (8)$$

where p,q > 0 and Γ(.) denotes the gamma function. The mean and variance of y are, respectively,

$$E(y) = \frac{p}{(p+q)} \quad and \quad var\,(y) = \frac{pq}{(p+q)^2(p+q+1)}.$$

To obtain a regression structure that contains a precision parameter and the mean of response, Ferrari & Cribari-Neto (2004) proposed an alternative parameterisation with $\mu = p/(p+q)$ and $\phi = p+q$, which can be written as:

$$f\,(y;\mu,\phi) = \frac{\Gamma(\phi)}{\Gamma(\mu\phi)\Gamma((1-\mu)\phi)} y^{\,\mu\phi-1}(1-y)^{(1-\mu)\phi-1}, \;\; 0 < y < 1 \qquad (9)$$

where the mean and variance of y are, respectively:

$$E(y) = \mu \quad and \quad var\,(y) = \frac{V(\mu)}{1+\phi}.$$

The parameter $\phi$ is known as the precision parameter since, for fixed $\mu$, the larger the $\phi$ the smaller the variance of y; $\phi$–1 is a dispersion parameter. The precision parameter is assumed to be constant and the mean is related to a set of covariates through a linear predictor with unknown coefficients and a link function (Cribari-Neto & Zeileis, 2010). The link function for a beta regression is represented as follows:

$$g(\mu t) = \sum_{i=1}^{k} x_{ti}\beta_i = n_t \qquad (10)$$

where $\beta = (\beta_1, \ldots,\beta_k)^\top$ is a k x 1 vector of unknown regression parameters ($k < n$), $xt_{ti} = (x_{t1}, \ldots, x_{ik})^\top$ is the vector of k regressors (or independent variables or covariates) and $\eta_t$ is a linear predictor. Finally, $g(.) : (0,1) \rightarrow$ IR is a link function, which is strictly increasing and twice differentiable. There are two advantages in using a link function. First, both sides of the regression equation assume values in the real line when a link function is applied to $\mu_t$. Second, it gives practitioners flexibility in choosing the function that best fits. For instance, one can use some useful link functions $g(.)$ such as the logit specification, the probit function, and the log-log link (Cribari-Neto & Zeleis, 2010; Ferrari & Cribari-Neto, 2004). Further discussions of link functions can be found in McCullagh (1989).

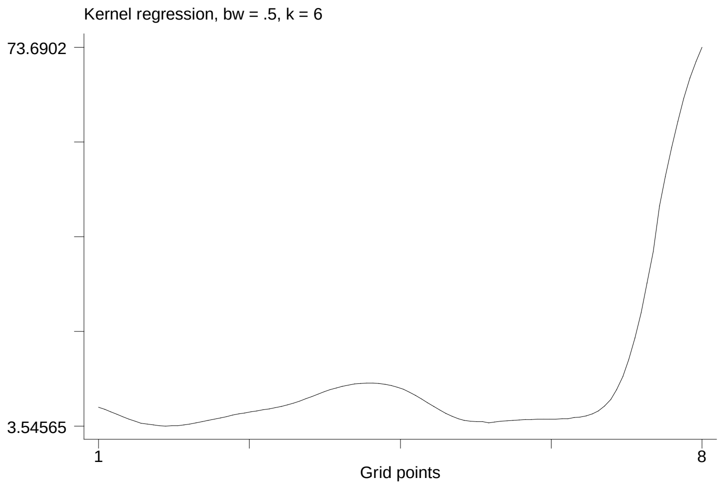
The estimation of beta regression is performed by maximum likelihood. The interpretation of the estimation results is less straightforward than normal linear models (*OLS*) but the regression parameters are interpretable in terms of the mean of y (the dependent variable). Nonetheless, maximum likelihood estimation using a beta distribution can yield more accuracy and precision than OLS or even GLM (Generalised Linear Model) when dealing with proportional data, as demonstrated by practitioners from other disciplines (Paolino, 2001; Ferrari & Cribari-Neto, 2004; Smithson & Verkuilen, 2006). Smithson and Verkuilen (2006) in particular have used comparisons of several alternative approaches to show that the beta regression model performs markedly better than potentially viable alternatives. Although GLM can be used as an alternative to beta regression, beta regression is the more appropriate because it can deal better with the distribution of our data (Paolino, 2001).

## 4.4. Empirical Results and Discussion

Before performing our analysis, we illustrated the relationship between SWB and the rate of deforestation using kernel density estimation (Figure 7).

**Figure 7. Subjective Well Being (SWB) vs. Deforestation Rates**

**Deforestation rate**




**SWB values in 2001**

**Source: own calculations**

The form of the kernel density estimation suggests that there is a non-linear relationship between both variables. Deforestation is low for SWB values between 1 and 2, rises to a moderate peak around 4, drops down at 5 and remains low until 6, after which it increases sharply. For this reason, we introduced the SWB variable as a polynomial in our model.[30]

[30]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.

**Table 11. Beta Regression Estimations**

| Variable: | Estimated Coef. | | Marginal Effects (Mfx) at x Coef.(Mfx) | | SE (Mfx) |
|---|---|---|---|---|---|
| Population growth | | | | | |
| % Change of share of Buginese | | | | | |
| % Change of irrigated land | – . 025 | *** | – .001 | *** | .000 |
| % of HH with electricity | .009 | *** | 3e-04 | *** | .000 |
| Number of hand tractors | | | | | |
| Availability of phone connection either public or private (dummy) | | | | | |
| Number of motorcycles in 2001 | | | | | |
| Number of chainsaws in 2001 | | | | | |
| Road accessibility by car (dummy) | | | | | |
| Village health service (dummy) | | | | | |
| 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 HH with non-agricultural incomes | | | | | |
| Number of secondary schools | | | | | |
| % of illiteracy in the working age population | .030 | *** | .001 | *** | .000 |
| % of females in the village | – .079 | *** | – .003 | *** | .000 |
| Experiencing drought (dummy) | | | | | |
| 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 | | | | |

*,**,*** Significant at the 10%, 5%, and 1% level, respectively.

**Source: own calculations**

The results of the beta regression model, which analyses the influence of poverty on deforestation, are presented in Table 11. Because the interpretation of the estimated coefficients is not straightforward compared normal linear models, we also present marginal effects. The marginal effect is the change in the deforestation rate resulting from a single unit change in the corresponding explanatory variable, keeping all other variables at the mean. 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[31], and therefore their inclusion did not improve the model. In the beta regression, the precision parameter with its identity link, showed as ln phi($\phi$), is presented on a logarithmic scale to ensure that it remains positive. The high significance (1%) of the ln phi($\phi$) variable in our model indicates that the precision coefficients can be treated as a full model parameter instead of a nuisance parameter (Zeleis et al., 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 model indicates that certain elements of poverty such as technology, economy, education, gender and geographical conditions significantly influence the rate of deforestation, while other elements such as demographics, cultural and social system and environmental issues have no significant influence on the deforestation rate. Closer inspection of technology reveals that each element of technology has a different influence on the deforestation rate. Increases in the percentage of irrigated land reduce the deforestation rate; between 2001 and 2007 a 1 percent increase led to a reduction of the deforestation rate by 0.001. The irrigated land is typically used for paddy rice cultivation, which requires a large amount of labour. As a result, it may be that less labour is available to encroach on forest lands. In contrast, a 10% increase in the percentage of households with electricity increases the deforestation rate by 0.002. Apparently, having electricity facilitates peoples’ access to technology and information via radio and television.

We found that greater distances to the market increase deforestation. The marginal effects show that a 10 kilometre increase in distance to market increases deforestation rates by 0.006. This suggests that physical barriers to market access do not impede deforestation activities. An increase in other socio-economic variables appear to lower the deforestation rate. For example if the share of village households in *arisan* and the share of landless households in a village increases by 10 percentage points, the rate of deforestation decreases by 0.01 and 0.003 respectively. As formal financial institutions are not available in most villages, becoming a member of an *arisan* gives rural people alternative means of obtaining cash than by cutting the surrounding forests. Cash received from an *arisan* could

[31] LR test (Prob> chi2) with $\rho$-value = 0.871

also be used to intensify agricultural production, which might in turn lead to lower forest conversion rates. The finding that a higher share of landless households is negatively correlated with deforestation suggests that poor households are not the direct actors who open up forests for agricultural uses.

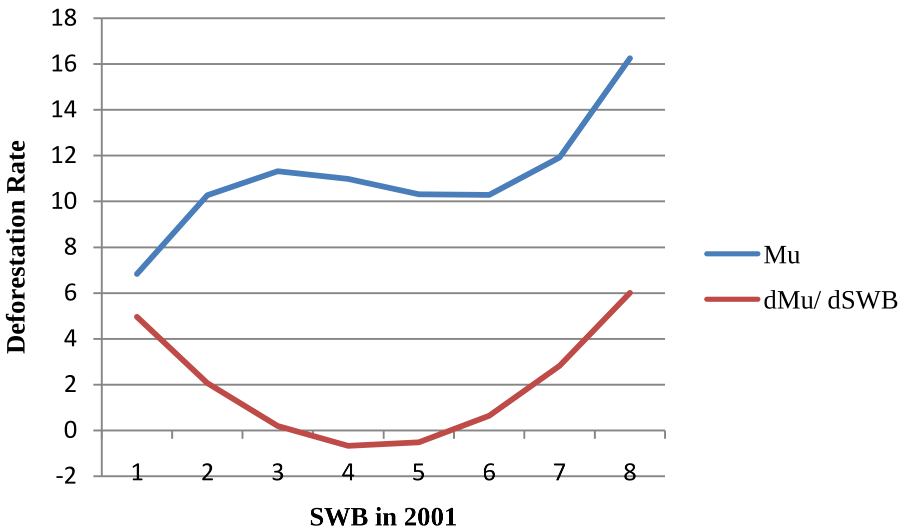
Our empirical model shows that the deforestation rate increases by 0.01 for every 10 percent rise in the share of illiterate working age people. Uneducated villagers are highly dependent on agricultural employment as they have few other work options. Moreover, the only chance to improve their well-being is to increase their share of agricultural land by encroaching into forests. A high proportion of female inhabitants negatively affects the deforestation rate. If the share of females in a village increases by 1 percentage point, the deforestation rate is reduced by 0.003. This confirms that forest margin agricultural expansion activities are dominated by male farmers.

Geophysical factors such as steep slopes and high elevation reduce the deforestation rate. The deforestation rate decreases by 0.007 for every 1 degree slope increase and decreases by 0.006 for every one hundred meter increase in elevation. Notice that the change in the deforestation rate is more responsive to elevation than slope. It is not possible to grow any agricultural crops above a certain elevation, although we found that farmers were still able to establish a number of cacao plots in extremely steep areas. This should be considered when formulating policy recommendations to promote land conservation in steep slope areas for the purpose of reducing instances of landslides and soil erosion. Forest size in 2001 was taken as a control variable in our model, and it was found that larger forests in 2001 had higher deforestation rates; for every 10 kilometre square increase, the deforestation rate increases by 0.002.

Other proxies that consider multiple aspects of poverty include: share of poor households in a village (objective approach), and the SWB, 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 8 to illustrate the impact of this variable on the deforestation rate. 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 8 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.

**Figure 8. Marginal Effects of SWB**




**Source: Study findings**

Additional objective poverty proxies have unclear patterns; variables might increase or decrease the deforestation rate. As we can see from the beta regression model, high illiteracy rates and less access to markets increase deforestation rates, although the availability of electricity in a village increases deforestation. On the contrary, the subjective assessment provides clear evidence that extreme poor and rich villages have high rates of deforestation.

## 4.5. Conclusions and Policy Implications

Although much previous research has investigated the link between poverty and deforestation, the majority used simplistic definitions of poverty and focused on the household level. Our study contributes to the debate on the link between poverty and deforestation by presenting multifaceted appraisals of poverty and thus more comprehensively considering links between particular aspects of poverty and their effects on deforestation. Further our approach towards the poverty-deforestation link uses the village level perspective, because few variations exist across households. Thus, the drivers of deforestation are more observable at a higher level than households. Moreover, by focusing on the village level, we are able to analyse a wider range of poverty dimensions, by using SWB, as well as other poverty proxies.

Our results suggest that there is a non-linear relationship between deforestation and SWB as well as other proxies of poverty. Moreover, the results show different linkages between deforestation and poverty depending on the poverty dimensions considered. A number of poverty proxies such as technology, economy, education, gender and geographical conditions were found to significantly influence the rate of deforestation. For other elements, related to demographics, or the cultural and social system, we found no significant impact on the deforestation rate. Nevertheless, among the identified drivers of deforestation, those related to technologies had contrasting effects on deforestation rates; an increase in the percentage of irrigated land had a negative impact, although electricity availability increases the deforestation rate. Regarding economic factors, we found that longer distances to the market increase deforestation, but other economic proxies such as higher proportions of village households which are members of rotation savings groups (arisan) and higher shares of landless households reduced the deforestation rate. Among the variables related to education, only the share of illiteracy in the working age population affected the rate of deforestation, where higher illiteracy rates led to higher deforestation. A higher proportion of female village inhabitants reduces the deforestation rate. Geophysical factors such as steep slopes and high elevation reduced the deforestation rate.

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 such trade-offs, 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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# *Chapter 5*

## General Conclusion

Reading through the large body of literature concerning tropical deforestation by smallholders, it becomes apparent that research that accommodates the complex inter linkages between various factors affecting the deforestation processes is lacking. Particularly lacking is research that gives special consideration to poverty and market factors. Such in-depth studies are required in order to formulate effective policy suggestions. This dissertation contributes to filling this gap by examining the deforestation problem in the vicinity of Lore Lindu National Park in Central Sulawesi, Indonesia. Tropical deforestation causes and processes are analysed from multi–perspectives, considering inter linkages between proximate and underlying causes based on the local context, which means the agricultural expansion by smallholders.

In order to attain this overall objective, this study used a rich variety of data types such as land cover, geophysical, socioeconomic and price time series data. Spatially explicit land cover data were obtained from satellite imagery. Images of land cover data were derived from the interpretation of a Landsat ETM+ scene. Rainfall and air temperature were recorded at ten weather stations, which were operated by the STORMA (*Stability of Rainforest Margins*) project. Slope and elevation were calculated using a Digital Elevation Model (DEM). The socioeconomic data was collected in 2001 and 2007 from surveys in 80 of the 119 villages, which were selected using a stratified random sampling method. Village socioeconomic data was obtained by conducting two surveys based on standardised questionnaires during the same year. We also obtained secondary data from village censuses and other documents. The survey comprised interviews in the form of a panel discussion, which were conducted by a team of two enumerators who interviewed the village leader and other village representatives in each of the selected villages. We obtained a weekly time series of cacao prices at the farm gate, which was collected via household surveys in 12 villages conducted by the A5 subproject of the STORMA project (Stability of Rainforest Margins) in 2007. In addition to the prices at the farm gate level, we also obtained monthly cacao prices at the sub-district level from January 1996 until December 2007 from Statistics Indonesia (*BPS pusat*). For the same time period, we also obtained daily world market cacao prices which are based on the New York Futures from the International Cocoa Organisation (ICCO) in London.

This dissertation poses three research questions, which have been analysed in three independent papers. First, what are the determinants of forest cover area? Second, what is the role of market integration between domestic and international markets in influencing agricultural expansion that leads to deforestation? Third, what is the relationship between poverty and deforestation? The objective of the first paper is to contribute to the advancement of an empirical methodology for land use studies, in particular between forest and non-forest use, by expanding on previously used methods. We apply the spatial panel econometric models with Hausman-Taylor application. This application has some advantages over conventional panel models since it accommodates the effects of time-invariant variables and possibly endogenous regressors. Furthermore, we can better examine the dynamics of forest cover change. The results indicate that high population growth reduces the probability of land being forest. Furthermore, deforestation occurred even in remote locations, and in areas with steeper slopes. The model suggests that factors- especially elevation, proximity to the forest land, setting of national park borders and high population density- strongly influence the probability of lands being forest.

In the second paper, the objective is to identify the factors determining cacao expansion, which is one of the drivers of deforestation in this area, including the role of market integration between international and local markets. Nevertheless, due to data limitation, we can only detect the influence of price transmission on cacao expansion in a cross section model. Results indicate that a high degree of integration between local and international markets is one of determinants of the area of land under cacao cultivation. The results confirm that decisions to expand the cultivation of cacao will depend more on expectations of future prices than prevailing prices. The only stabilising effect against cacao expansion is the presence of paddy rice fields in the village.

The last paper’s objective is to analyse the relationship between poverty and deforestation. The results reveal that some poverty factors positively influenced the deforestation rates, whilst others decreased it. A number of poverty proxies such as technology, economy, education, gender and geographical conditions were found to significantly influence the rate of deforestation. Factors derived from the subjective view clearly indicated that the villages which were initially poorest and wealthiest have higher deforestation rates than the moderately well-off villages with lower deforestation rates. In contrast, the objective view shows unclear patterns, whereby a given factor may increase or decrease the deforestation rate. Although during the initial period the wealthier villages have higher deforestation rates, overall between 2001 and 2007, the improvement of village well-being helped to reduce the deforestation rate in this region.

The use of the village as an observation unit to study deforestation confers several advantages. The drivers of deforestation are more observable at a higher level than households because few variations exist across households. To analyse the poverty-deforestation link, researchers can use a wide range of poverty dimensions to calculate subjective well-being SWB, or poverty proxies. The results of the study are consistent and highly complementary. The overall results indicate that population density corresponds to reduce forest cover via higher rates of agricultural expansion. People from the Buginese ethic group migrate primarily to areas with higher forest cover, in order to use the have more opportunities to profit from the expansion of cacao cultivation. Moreover, Buginese migrants have a positive influence on cacao expansion in this region.

Irrigated land which is typically used for paddy rice cultivation has a negative effect on deforestation rates. Three reasons explain how irrigated land helps to conserve forests. Firstly, where irrigated lands are available, increased profits may be more easily obtained by agricultural intensification rather than expansion, thereby discouraging deforestation. Secondly, irrigation systems facilitate reliable water supply for rice cultivation, therefore pre-empting the need to establish new cacao plots as an alternative source of income. Lastly, since the rice cultivation is highly labour intensive, there is little excess labour to devote to the conversion to and maintenance of other agricultural systems. The geophysical aspects elevation and slope influence the land cover. Forests are mostly concentrated at higher altitudes. Unlike elevation, steep slopes do not prevent farmers from expanding cacao production due to forest rent. Because forest remains intact only at higher elevations and on steeper slopes, and because high elevations are unfavorable for growing cacao, cacao cultivation takes place in the steeper areas. This finding has the further negative implication that ecosystems in such areas are destroyed, with consequent loss of habitat for endangered species populations.

Geographical factors also matter in shaping land for forest and non-forest use. However, unexpectedly, an analysis of distance to village centres and central markets confirm that deforestation occurred even in remote locations. This evidence shows that limited physical access to central markets does not impede deforestation activities in this area. This further supports the concept that deforestation must be studied within a local context. In contrast, most studies on processes in forest frontiers in Latin America show that road development and better access to central markets increases the deforestation rate. However in this study region, historical patterns of settlement are different from those of the forest frontier in the Amazon, most local people having settled inside the Lore Lindu National Park area long before the development of roads. Another profound finding, again emphasising the local context of deforestation, is that the extremely poor villages have higher deforestation rates compared to the moderate villages from the subjective perspective in poverty-deforestation link analysis. However, 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. This gives an insight that 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 existence of different theoretical approaches towards poverty, each of which utilise many methods to measure poverty.

Apart from population growth, market and technological forces influence the cacao expansion that leads to deforestation. The increasing number of hand tractors facilitates land preparation for new agricultural production. The increasing number of chainsaws facilitate the rapid removal of shade trees during the intensification process of cacao cultivation and forest clearance. The high speed of adjustment indicates that the higher prices in international markets will be transmitted to the farm gate level. Therefore farmers still receive recompensing prices to continue the expansion of cacao production. This market-oriented production is more favourable to cacao expansion than other agricultural productions. This drives another common practice whereby existing agricultural plots are converted to cacao production, for example ex-coffee or coconut systems which are no longer profitable. This explains why the availability of agricultural land in a village contributes to cacao expansion in this area.

This study accommodates the inter linkages between factors affecting tropical deforestation processes by smallholders and provides the more effective policy suggestions within a local context. From the analysis of spatially explicit modelling and study of determinants of cacao expansion, the results suggest that increasing population negative affects forest cover. Therefore the two child policy that keeps population growth rates low should be maintained. Furthermore, innovative programs such as community forest management provide an economically viable alternative to forest conversion. The results from the analysis of the poverty-deforestation link suggest that improvements in village well-being eventually lower rates of deforestation. 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 might balance trade-offs between forest conservation and poverty reduction. Our study on the role of market integration on cacao expansion suggests that an improvement in market integration covering physical, commercial, and institutional infrastructure will provide an opportunity for farmers to remain engaged with existing non-cacao agricultural production. Further improvements in physical (hard) infrastructure, such as transportation and storage, would reduce transport costs. Improvements in (soft) commercial and institutional infrastructure, involving the development of systems of market information, credit, and commercial law, would reduce overall transaction costs so that farmers would not be so reliant on further expansion of cacao production as the best means to improve their livelihoods. The results of our three independent papers reveal that further expansion of irrigation schemes, which have so far been restricted mainly to the lowlands, might help to reduce deforestation. Nonetheless for such implementation, policy makers need an accurate cost-benefit analysis to assess the viability of such investments. Overall, the economic incentives to intensify production by cutting shade trees from natural forests are high. Thus to balance the goals of poverty reduction and sustainable agricultural production, the implementation of the reduce emissions from deforestation and forest degradation (REED) program could create a win-win solution by which local people can benefit from the economic gains of cacao cultivation, without the need for further environmental damage. Payment for environmental services as in the proposed REDD carbon sequestration program urgently needs to be adopted in this area. The local government should actively propose the local implementation of such a carbon sequestration program under the national REDD agenda.

Some drawbacks in this study are as follows. Although we correct for spatial autocorrelation using regular sampling from grid and lagged slope variables in our spatially explicit modelling, we are unable to test how effective these *ad-hoc* applications are in solving the spatial autocorrelation problem. Moran I test is unfeasible to apply in our study due to the high number of observations, and in the context of a discrete dependent variable model. We also face the same problem in using spatially weighted matrices to counter spatial effects. This is a challenge for future research to develop a test for spatially lagged dependence in a spatially limited dependent model. Another drawback in this study is that we only estimate predictions of market integration parameters in a cross section analysis. Considering the characteristics of perennial crops, it would be preferable to use longer term price series data for application in panel models in order to better capture the impact of cacao expansion in future studies. In the study of the poverty-deforestation link, we apply only a simple SWB analysis and no monetary-based analysis for poverty assessment. Our findings highlight the need for a holistic consideration of poverty in order to improve future research on links between poverty and deforestation.

Finally, we consider our policy suggestion of further expansion of irrigation schemes in order to reduce deforestation. This will require different research to investigate negative externalities such as water pollution from chemical fertilisers, pesticides, etc. as well as sedimentation problems in the water catchment area. Concerning biodiversity aspects, the effect on wildlife habitat changes due to such intensification should also be taken into consideration. Furthermore, methane released from the vegetation decaying in the newly anaerobic conditions might affect payments for environmental services from REDD schemes. This implies that a careful assessment using a Cost Benefit Analysis is important to assess whether such investments will provide economical and social benefits as well as forest conservation.

## Appendices

## Appendix 1. Spatial Panel Binomial Logit Estimates of Forest Cover Change

| Dependent variable: Land use (1=Forest land; 0=Non-Forest land) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | OLS | | RE | | HT | | FE | |
| **Independent variables:** | | | | | | | | |
| **Socioeconomic factors:** | | | | | | | | |
| Population density (person/sq. km) | -0.059 | *** | -0.068 | *** | -0.008 | *** | -0.216 | ** |
| | (0.019) | | (0.025) | | (0.002) | | (0.088) | |
| Share of Buginese ethnic group (%) | 0.005 | | 0.006 | | 0.002 | *** | 0.068 | * |
| | (0.004) | | (0.005) | | (0.000) | | (0.036) | |
| Share of irrigated land (%) | -0.008 | *** | -0.009 | ** | 0.001 | ** | 0.029 | *** |
| | (0.003) | | (0.004) | | (0.000) | | (0.011) | |
| % of HH with non-agricultural incomes | -0.003 | | -0.004 | | -0.000 | ** | -0.012 | ** |
| | (0.003) | | (0.003) | | (0.000) | | (0.006) | |
| Frequency of extension worker visit per year | 0.003 | ** | 0.003 | * | -0.000 | | 0.001 | |
| | (0.001) | | (0.002) | | (0.000) | | (0.004) | |
| Village Border (1=yes) (0=No) | 0.106 | * | 0.126 | * | 0.037 | *** | | |
| | (0.059) | | (0.068) | | (0.007) | | | |
| **Location:** | | | | | | | | |
| Distance to village centre (km) | 0.299 | *** | 0.310 | *** | -0.039 | *** | | |
| | (0.048) | | (0.043) | | (0.011) | | | |
| Distance to edge (km) | 10.580 | *** | 11.621 | *** | 0.145 | *** | | |
| | (0.488) | | (0.313) | | (0.013) | | | |
| Distance to river (km) | 0.073 | *** | 0.097 | *** | 0.022 | *** | | |
| | (0.023) | | (0.027) | | (0.004) | | | |
| Distance to market (km) | -0.011 | *** | -0.013 | *** | -0.002 | *** | | |
| | (0.001) | | (0.001) | | (0.000) | | | |
| Distance to all-year roads (km) | 0.038 | *** | 0.048 | *** | 0.010 | *** | | |
| | (0.005) | | (0.006) | | (0.001) | | | |
| **Geophysical factors:** | | | | | | | | |
| Elevation (km) | 2.944 | *** | 3.667 | *** | 0.331 | *** | | |
| | (0.083) | | (0.123) | | (0.024) | | | |
| Temperature (° Celsius) | 0.110 | *** | 0.129 | *** | -0.009 | *** | 0.634 | |
| | (0.021) | | (0.026) | | (0.003) | | (0.490) | |
| Average precipitation (ml/year) | -0.001 | *** | -0.001 | *** | -0.000 | *** | -0.001 | *** |
| | (0.000) | | (0.000) | | (0.000) | | (0.000) | |
| Slope (°) | -0.033 | *** | -0.040 | *** | -0.004 | *** | | |
| | (0.009) | | (0.009) | | (0.000) | | | |
| Slope lag (°) | 0.179 | *** | 0.217 | ** | 0.022 | *** | | |
| | (0.010) | | (0.011) | | (0.001) | | | |
| Aspect (°) | -0.000 | | -0.000 | *** | 0.000 | | | |
| | (0.000) | | (0.000) | | (0.000) | | | |
| cons | -5.205 | *** | -6.260 | | 0.451 | *** | | |
| | (0.544) | | (0.671) | | (0.089) | | | |
| N observation | 54,954 | | 54,954 | | 54,954 | | 3,204 | |
| Pseudo $R^2$ | 0.662 | | | | | | | |
| Wald $Chi^2$ / LR $chi^2$ | 4,229.380 | | 2,979.700 | | 14,809.590 | | 172.950 | |
| Probability > Wald $Chi^2$ / $Chi^2$ | 0.000 | | 0.000 | | 0.000 | | 0.000 | |
| Hausman test against FE (ρ-value) | | | 0.000 | | | | | |

*,**,*** Significant at the 10%, 5%, and 1% level, respectively.
Notes: Coefficient estimates are shown with standard errors in parentheses. OLS refers to pooled logit, RE to random effects, HT to Hausman-Taylor (1981), and FE to fixed effects.

**Source: Own calculation**

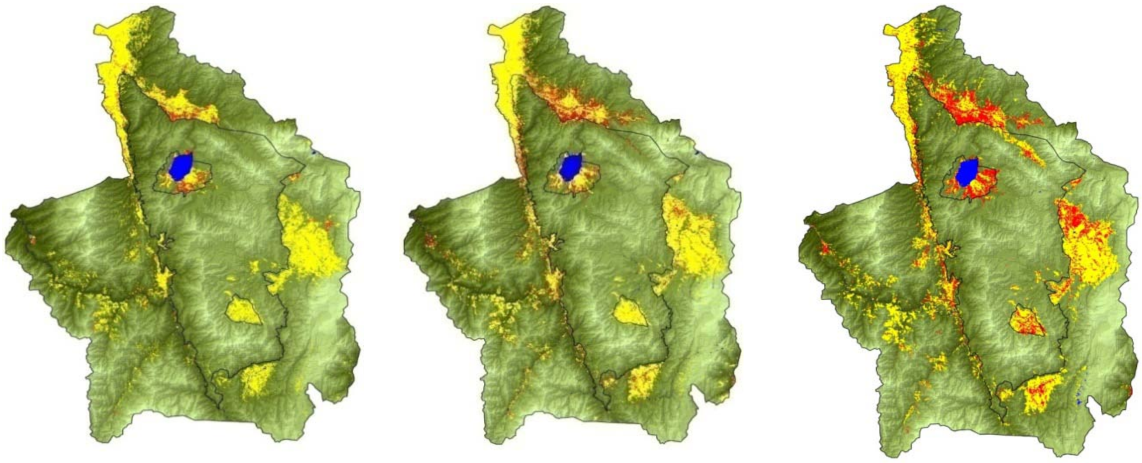
## Appendix 2. Correlation between Unobserved Individual Effects and Explanatory Variables

| | FE | |
|---|---|---|
| FE | 1.000 | |
| Socioeconomic factors: | | |
| Population density (person/sq. km) | -0.231 | |
| Share of Buginese ethnic group (%) | -0.125 | |
| Share of irrigated land (%) | -0.329 | + |
| % of HH with non-agricultural incomes | -0.080 | |
| Frequency of extension worker visit per year | -0.148 | |
| Village Border (1=yes) (0=No) | -0.082 | |
| Location: | | |
| Distance to village centre (km) | 0.416 | + |
| Distance to edge (km) | 0.401 | |
| Distance to river (km) | 0.203 | |
| Distance to market (km) | 0.170 | |
| Distance to all-year roads (km) | 0.305 | |

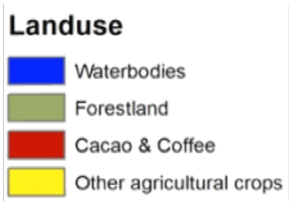
+ the highest correlation

**Source: Own calculation**

## Appendix 3. Land Cover Maps Showing Cacao Expansion over the Last Two Decades

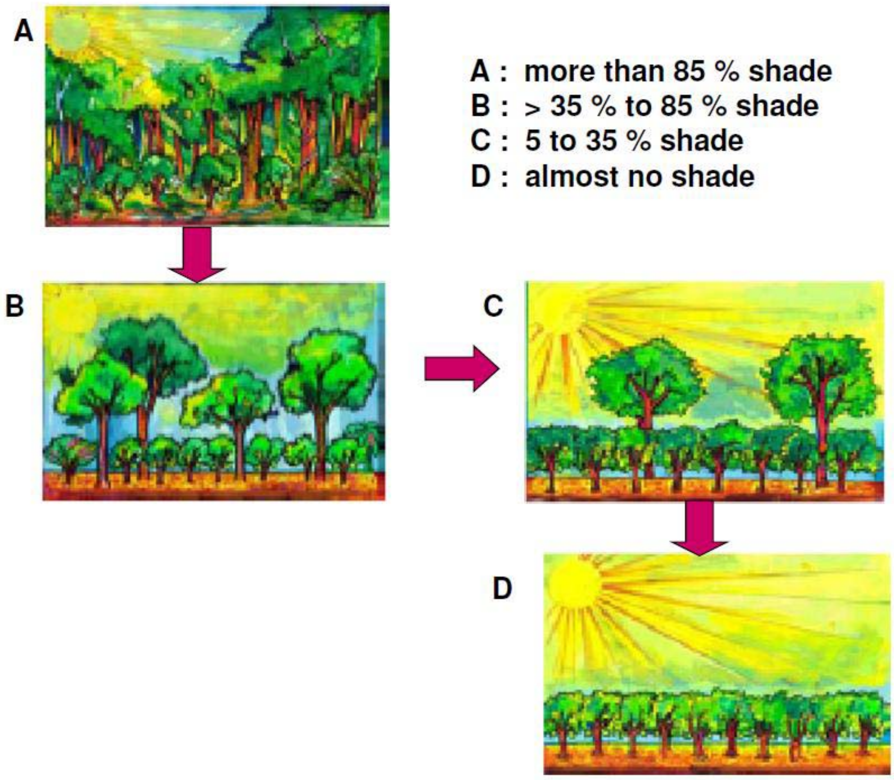


**Year 1983** **Year 2001** **Year 2007**



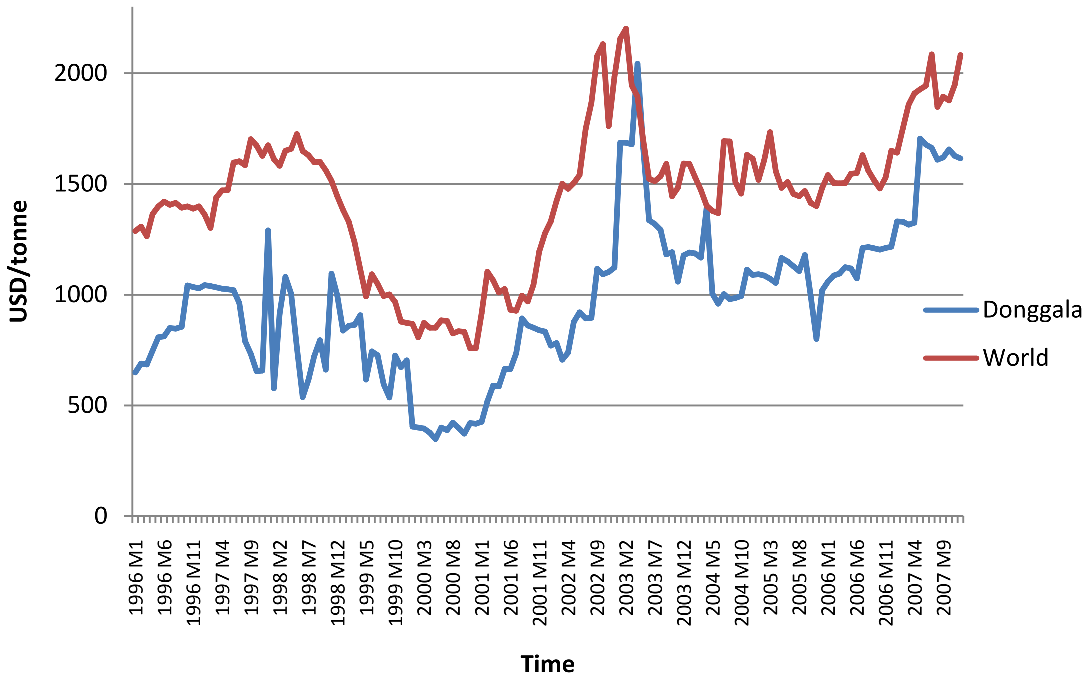

**Source: STORMA D6 sub-project derived from the satellite image interpretation, Landsat ETM+ scene**

**Appendix 4. Illustration of Different Types of Cacao Agroforestry**




**Source: STORMA project**

**Appendix 5. Monthly Cacao Prices from 1998-2007 in the Donggala and World Markets**




**Source: own result from BPS, Jakarta and ICCO, London**

## Appendix 6. Unit Root Tests for Cacao Prices of the Whole Regime

| Price Series (log) | ADF test (Nonzero mean and time trend) | | | KPSS test (trend stationarity) | | |
|---|---|---|---|---|---|---|
| | Level ($P_t$) | First differenced ($\Delta P_t$) | N of Lags | Level ($P_t$) | First differenced ($\Delta P_t$) | N of Lags |
| **Donggala Prices:** | | | | Test statistic | Test statistic | |
| $D_{1(1996\text{-}2007)}$ | – 2.2663 | – 10.7754 | (1;1) | 0.4576 | 0.0433 | 2 |
| $D_{2(1996\text{-}2001)}$ | – 2.1075 | – 11.6340 | (1;0) | 0.2597 | 0.0732 | 1 |
| $D_{3\ (2002\text{-}2007)}$ | – 2.4614 | – 9.0011 | (0;0) | 0.3072 | 0.0762 | 1 |
| **World Prices:** | | | | | | |
| $W_{1(1996\text{-}2007)}$ | – 1.7004 | – 6.1908 | (3;2) | 0.4650 | 0.0800 | 2 |
| $W_{2(1996\text{-}2001)}$ | – 1.2841 | – 3.5370** | (3;3) | 0.4352 | 0.2196 | 1 |
| $W_{3(2002\text{-}2007)}$ | – 2.1932 | – 7.2151 | (0;1) | 0.4005 | 0.0856 | 1 |

Note: The critical values in ADF test for rejecting the hypothesis of the presence of a unit root at the 1%, 5% and 10% levels are −3.96, −3.41 and −3.13, respectively.
The critical values in KPSS test for rejecting the hypothesis of stationarity at the 1%, 5% and 10% levels are 0.216, 0.146 and 0.119, respectively.

**Source: own result**

## Appendix 7. Johansen Cointegration Test of Monthly Cacao Prices between the World and Donggala Markets for the Whole Period

| Period of price series | Cointegration | Rank | p-value | Trace statistic | Critical value | | |
|---|---|---|---|---|---|---|---|
| | | | | | **10%** | **5%** | **1%** |
| Donggala-World $_{(1996\text{-}2007)}$ | No | 0 | 0.0092 | 24.92 | 17.98 | 20.16 | 24.69 |
| | Yes | 1 | 0.0092 | 1.68 | 7.60 | 9.14 | 12.53 |
| Donggala-World $_{(1996\text{-}2001)}$ | No | 0 | 0.2384 | 14.88 | 17.98 | 20.16 | 24.69 |
| | No | 1 | 0.9378 | 0.99 | 7.60 | 9.14 | 12.53 |
| Donggala-World $_{(2002\text{-}2007)}$ | No | 0 | 0.0045 | 26.76 | 17.98 | 20.16 | 24.69 |
| | Yes | 1 | 0.1158 | 7.26 | 7.60 | 7.60 | 12.53 |

**Source: own result**

## Appendix 8. Random Effects Panel Model

| **Dependent variable: Area of cacao cultivation (ha)** | | | |
|---|---|---|---|
| **Independent variables:** | **Estimated Coef.** | | **SE** |
| **Socioeconomic factors** | | | |
| Population density (person/sq. km) | 0.189 | * | 0.108 |
| Number of motorcycles | 0.002 | | 0.002 |
| Number of hand tractors | 0.013 | | 0.011 |
| Number of chainsaws | 0.066 | *** | 0.022 |
| Share of irrigated land (%) | –0.038 | *** | 0.009 |
| Share of Buginese ethnic group (%) | 0.071 | *** | 0.019 |
| Availability of agricultural lands (ha/person) | 1.245 | *** | 0.191 |
| Cacao prices (USD in ln) | 0.019 | | 0.251 |
| Speed of adjustments | –2.762 | *** | 0.937 |
| Long-run adjustment | (dropped) | | |
| **Geophysical factors** | | | |
| Slope (°) | 0.114 | *** | 0.039 |
| Elevation (km) | –0.452 | | 0.766 |
| Average precipitation (ml/year) | 0.001 | | 0.001 |
| **Geographical factors** | | | |
| Distance to all-year roads (km) | –0.009 | | 0.028 |
| Distance to river (km) | –0.045 | | 0.169 |
| Distance to edge (km) | 2.029 | | 6.068 |
| Distance to market (km) | –0.002 | | 0.009 |
| cons | –0.256 | | 2.827 |
| Number of Observations | 135 | | |
| Hausman test | 0.421 | | |
| R-sq within | 0.55 | | |
| R-sq between | 0.51 | | |
| R-sq overall | 0.49 | | |

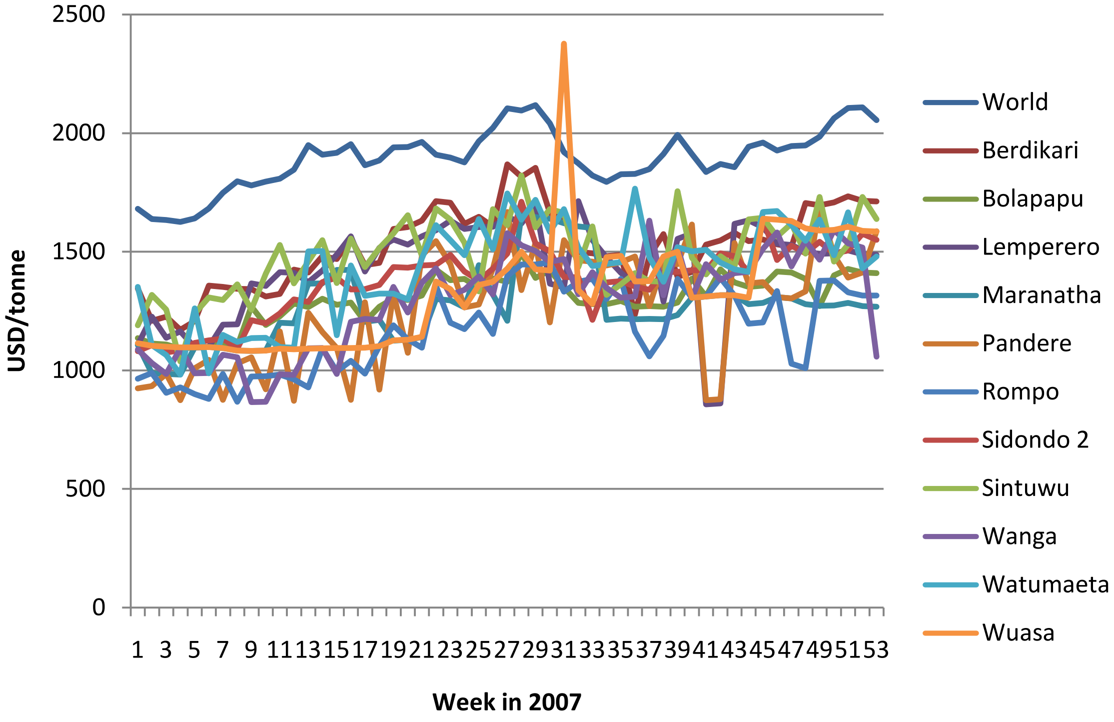
*,**,*** Significant at the 10%, 5%, and 1% level, respectively.
**Source: own calculations**

## Appendix 9. Comparison of Cross Sections in 2001 and 2007 with OLS

| **Dependent variable: Area of cacao cultivation (ha)** | | | | | | |
|---|---|---|---|---|---|---|
| | **Cross section 2001** | | | **Cross section 2007** | | |
| **Independent variables:** | **Coef.** | | **SE** | **Coef.** | | **SE** |
| **Population density (person/sq. km)** | **-0.017** | | **0.174** | **0.381** | ** | **0.167** |
| Number of motorcycles | 0.009 | | 0.007 | 0.003 | | 0.002 |
| Number of hand tractors | 0.016 | | 0.029 | 0.010 | | 0.014 |
| **Number of chainsaws** | **0.122** | *** | **0.039** | **0.056** | | **0.063** |
| **Share of irrigated land (%)** | **-0.020** | | **0.019** | **-0.047** | *** | **0.014** |
| Share of Buginese ethnic group (%) | 0.064 | *** | 0.023 | 0.074 | *** | 0.025 |
| Availability of agricultural lands (ha/person) | 1.078 | *** | 0.299 | 2.094 | *** | 0.497 |
| Cacao prices (USD in ln) | 0.114 | | 0.394 | 0.734 | | 1.002 |
| **Slope (°)** | **0.086** | | **0.055** | **0.171** | *** | **0.050** |
| Elevation (km) | -0.591 | | 0.961 | -0.050 | | 0.949 |
| Distance to all-year roads (km) | 0.012 | | 0.035 | -0.020 | | 0.031 |
| Distance to river (km) | 0.021 | | 0.195 | -0.073 | | 0.207 |
| Distance to edge (km) | -1.980 | | 12.668 | -19.962 | | 12.625 |
| Distance to market (km) | 0.002 | | 0.011 | -0.007 | | 0.010 |
| Average precipitation (ml/year) | 0.000 | | 0.001 | 0.001 | | 0.001 |
| Short-run adjustments | (dropped) | | | (dropped) | | |
| Long-run adjustments | (dropped) | | | (dropped) | | |
| Cons | 1.785 | | 4.034 | -6.142 | | 7.517 |
| N observations | 66 | | | 69 | | |
| R-squared | 0.565 | | | 0.574 | | |
| Adj R-squared | 0.434 | | | 0.454 | | |

*,**,*** Significant at the 10%, 5%, and 1% level, respectively.
**Source: own calculations**

**Appendix 10. Weekly Cacao Prices in 2007 for Specific Villages and the World Market**




**Source: ICCO, London and the A5 STORMA sub-project**

## Appendix 11. Unit Root Test of Weekly Cacao Prices between 10 Villages and the World Market

| Price Series (log) | ADF test (with trend and intercept) | | | KPSS test (trend stationarity) | | |
|---|---|---|---|---|---|---|
| | **Level ($P_t$)** | **First differenced ($\Delta P_t$)** | **N of Lags** | **Level ($P_t$)**<br>Test statistic | **First differenced ($\Delta P_t$)**<br>Test statistic | **N of Lags** |
| Berdikari | – 2.6360 | – 9.0505 | (0;0) | 0.3445 | 0.0514 | 1 |
| Bolapapu | – 3.0707 | – 10.8961 | (0;0) | 0.3633 | 0.0432 | 1 |
| Lemperero | – 2.6168 | – 5.9856 | (2;3) | 0.2749 | 0.0201 | 1 |
| Maranatha | – 2.5140 | – 8.0396 | (0;0) | 0.3146 | 0.0365 | 1 |
| Rompo | – 2.8728 | – 7.9932 | (1;0) | 0.3721 | 0.0293 | 1 |
| Sidondo 2 | – 2.9765 | – 10.5207 | (0;0) | 0.3817 | 0.0444 | 1 |
| Sintuwu | – 3.0231 | – 8.3495 | (1;1) | 0.3087 | 0.0289 | 1 |
| Wanga | – 1.3772 | – 5.7472 | (1;0) | 0.3442 | 0.0883 | 1 |
| Watumaeta | – 2.5826 | – 7.8236 | (0;0) | 0.3822 | 0.0485 | 1 |
| Wuasa | – 2.4703 | – 9.0918 | (2;1) | 0.1451 | 0.0255 | 1 |
| World | – 2.7911 | – 4.4747 | (1;0) | 0.3088 | 0.0597 | 1 |

Note: The critical values in ADF test for rejecting the hypothesis of the presence of a unit root at the 1%, 5% and 10% levels are −3.96, −3.41 and −3.13, respectively.
The critical values in KPSS test for rejecting the hypothesis of stationarity at the 1%, 5% and 10% levels are 0.216, 0.146 and 0.119, respectively.

**Source: own calculations**

## Appendix 12. Price Transmission of World Weekly Cacao Prices to 10 Villages

| Village | Order of Integration | Cointegration test | Price transmissions | |
|---|---|---|---|---|
| | | $r \leq 1$ | **Speed of adjustment** | **Long-run adjustment** |
| Berdikari | I (1) | yes | –0.528 | –1.617 |
| Bolapapu | I (1) | yes | –0.573 | –1.105 |
| Lemperero | I (1) | yes | –0.658 | –1.341 |
| Maranatha | I (1) | yes | –0.397 | –1.269 |
| Rompo | I (1) | yes | –0.427 | –1.681 |
| Sidondo 2 | I (1) | yes | –0.483 | –1.576 |
| Sintuwu | I (1) | yes | –1.245 | –1.306 |
| Wanga | I (1) | yes | –0.278 | –1.403 |
| Watumaeta | I (1) | yes | –0.634 | –1.767 |
| Wuasa | I (1) | yes | –0.409 | –1.731 |

*,**,*** Significant at the 10%, 5%, and 1% level, respectively.

**Source: own calculations**

## Appendix 13. The Generalised Maximum Entropy Estimations

| **Dependent variable: The speed of adjustments** | |
|---|---|
| **Independent variables:** | **Coefficient** |
| Number of motorcycles | 0.000 |
| Share of Buginese ethnic group (%) | 0.052 |
| Distance to river (km) | -0.957 |
| Elevation (km) | -1.150 |
| Slope (°) | 0.012 |
| Number of hand tractors | 0.000 |
| Availability of agricultural lands (ha/person) | -0.000 |
| Distance to market (km) | 0.015 |
| Cons | -0.814 |
| N observations | 10 |
| N parameters | 9 |
| Mean (The speed of adjustments) | -0.653 |
| Var (The speed of adjustments) | 0.143 |

Support matrices: We use uninformative support matrices for the beta coefficients (-8, -4, 0, 4, 8), and apply the three-sigma-rule for the error.

**Source: own calculations**

## Appendix 14. Comparison of the OLS Estimations to Select the Consistent Variables for the Final OLS Model

| **Dependent variable: Area of cacao cultivation (ha)** | | | | | | |
|---|---|---|---|---|---|---|
| **Independent variables:** | | | | | | |
| | **OLS 1** | | **OLS 2** | | **OLS 3** | |
| | **OLS[a)]** | | **OLS[b)]** | | **GME[a)]** | |
| | Coef. | | Coef. | | Coef. | |
| Population density (person/sq. km) | 0.381 | ** | 0.337 | * | 0.293 | * |
| Number of motorcycles | 0.003 | | 0.003 | | -0.005 | |
| Number of hand tractors | 0.010 | | -0.257 | | -0.275 | *** |
| Number of chainsaws | 0.055 | | 0.051 | | -0.005 | |
| Share of irrigated land (%) | -0.047 | ** | -0.046 | | -0.039 | ** |
| Share of Buginese ethnic group (%) | 0.076 | *** | -0.386 | | -0.587 | *** |
| Availability of agricultural lands (ha/person) | 2.088 | *** | 2.068 | *** | 1.096 | ** |
| Cacao prices (USD in ln) | 0.729 | | 0.576 | | 0.404 | |
| Slope (°) | 0.170 | ** | 0.176 | *** | 0.364 | *** |
| Elevation (km) | -0.067 | | 13.581 | | 20.168 | *** |
| Distance to all-year roads (km) | -0.020 | | -0.025 | | -0.030 | |
| Distance to river (km) | -0.069 | | 18.271 | | 23.923 | *** |
| Distance to edge (km) | -20.039 | | -19.858 | | -14.501 | |
| Distance to market (km) | -0.007 | | -0.270 | | -0.378 | *** |
| Average precipitation (ml/year) | 0.001 | | 0.001 | | 0.001 | |
| Short-run adjustments | 0.000 | | -7.012 | | -11.221 | *** |
| cons | -6.077 | | -4.263 | | -3.146 | |
| R-squared | 0.574 | | 0.590 | | 0.658 | |
| N observations | 69 | | 69 | | 69 | |

*,**,*** Significant at the 10%, 5%, and 1% level, respectively.
Note: In OLS 1&2, the speed of adjustments are predicted using an OLS estimation whilst in OLS 3 is with the GME estimation.
[a)] The estimation includes all candidate variables.
[b)] The estimation includes only the significant variables

**Source: own calculations**

## Appendix 15. The Full Model Estimations

| Variable: | Full Model | | |
|---|---|---|---|
| Population growth | | .001 | |
| % Change of share of Buginese | | .013 | |
| % Change of irrigated land | – | .030 | *** |
| % of HH with electricity | | .008 | *** |
| Number of hand tractors | | .006 | |
| Availability of phone connection either public or private (dummy) | | .148 | |
| Number of motorcycles in 2001 | | .005 | |
| Number of chainsaws in 2001 | – | .007 | |
| Road accessibility by car (dummy) | – | .371 | |
| Village health service (dummy) | | .019 | |
| Distance to market (10 km) | | .193 | *** |
| % of HH that are members of informal rotating savings groups (arisan) | – | .021 | *** |
| % of HH with no land | – | .015 | *** |
| % of HH in non-agriculture incomes | – | .003 | |
| Number of secondary schools | | .046 | |
| % of illiteracy in the working age population | | .003 | *** |
| % of females in the village | – | .070 | *** |
| Experiencing drought (dummy) | – | .028 | |
| Averaged slope (degree) | – | .227 | *** |
| Averaged elevation (000 m) | – | 1.838 | *** |
| Forest size in 2001 ($km^2$) | | .005 | * |
| % of poor HH | – | .027 | *** |
| SWB in 2001 cubic | | .202 | *** |
| SWB in 2001 squared | – | 2.642 | *** |
| SWB in 2001 | | 10.442 | *** |
| Change of SWB from 2001 to 2007 | – | .295 | *** |
| Constant | – | 6.650 | *** |
| /ln phi(ϕ) | | 5.248 | *** |
| Number of observed villages | 52 | | |
| Prob> chi2 | 0.00 | | |
| Phi(ϕ) | 190.287 | | |
| Log Likelihood | 153.543 | | |
| Parameter | 28 | | |

*,**,*** Significant at the 10%, 5%, and 1% level, respectively.
**Source: own calculations**

**Appendix 16. Village Survey**

# STORMA

## Stability of Rainforest Margin Areas
## University of Goettingen/Kassel/IPB-Bogor/UNTAD–Palu

## Socioeconomic Village Survey

---

Sub-district: ____________ Village: ____________

Name of the 1st Enumerator: ____________ Name of the 2nd Enumerator: ____________

| Respondent Number | | Function in the village | | Respondent Number | | Function in the village | |
|---|---|---|---|---|---|---|---|
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |

| Date of interview: | | | | | |
|---|---|---|---|---|---|
| | From | day | | date | |
| | until | day | | date | |

Duration of the interview: ________ hours

Supervisor name: ____________ Supervisor signature:

## SECTION 1: DEMOGRAPHY

1. Was there any change in the village border since 2001? YES=1; NO=2 [ ]

IF YES : Please explain_____________________________________

2. In 2001 the village had ___________________ inhabitants.

| | |
|---|---|
| What is the total population of this village now? | |
| What is the total number of households in this village? | |
| What is the number of women living in this village? | |
| How many adults (19-60 years old) died in the previous 12 months? | |
| How many elderly (>60 years old) died in the previous 12 months? | |
| How many children were born in the previous 12 months? | |
| How many of these infants are still alive? | |

3. What is the current composition of the village community in each age group below?

| Unit (specify) | | 0 – 6 years | 7 – 12 years | 13 -18 years | 19- 45 years | 46- 60 years | Over 60 years |
|---|---|---|---|---|---|---|---|
| % of people | # persons | | | | | | |

(%): please check whether the total is 100. (# person): please check whether the number corresponds with the total population (question no.2, on this page)]

4. What is the current composition of the village community in each religion group below?

| Unit (specify) | | | Moslem | Hindu | Buddhist | Protestant | Catholic | Other |
|---|---|---|---|---|---|---|---|---|
| % of people | # persons | # households | | | | | | |

(%): please check whether the total is 100. (# person): please check whether the number corresponds with the total population (question no.2, on this page)]

5. What is the current composition of the village community according to ethnic group?

| Unit (specify) | | 1. | 2. | 3. | 4. | 5. | 6. | 7. |
|---|---|---|---|---|---|---|---|---|
| % of people | # households | | | | | | | |

(%): please check whether the total is 100. (# person): please check whether the number corresponds with the total population (question no.2, on this page)]

6. How many of these ethnic group members are migrants (household head was not born in the village)?

| Unit (specify) | | 1. | 2. | 3. | 4. | 5. | 6. | 7. |
|---|---|---|---|---|---|---|---|---|
| % of people | # households | | | | | | | |

(%): please check whether the total is 100. (# person): please check whether the number corresponds with the total population (question no.2)]

[If there are no immigrants, please continue to no. 8, page 3]

7. Since 2001, how many households in this village have come from the following places:

| | | | | | |
|---|---|---|---|---|---|
| - Another province of Sulawesi island? | Spontaneous migration | | HH | Transmigrant | | HH |
| - Another island in Indonesia? | Spontaneous migration | | HH | Transmigrant | | HH |

8. Since 2001, how many households and/or people have moved away from this village permanently?

| | | | |
|---|---|---|---|
| | # HH | | # persons |

9. Are there any people temporarily leaving this village to work in another place? YES=1; NO=2 [ ]

<u>IF YES:</u> How many people in total do this annually? [ ]

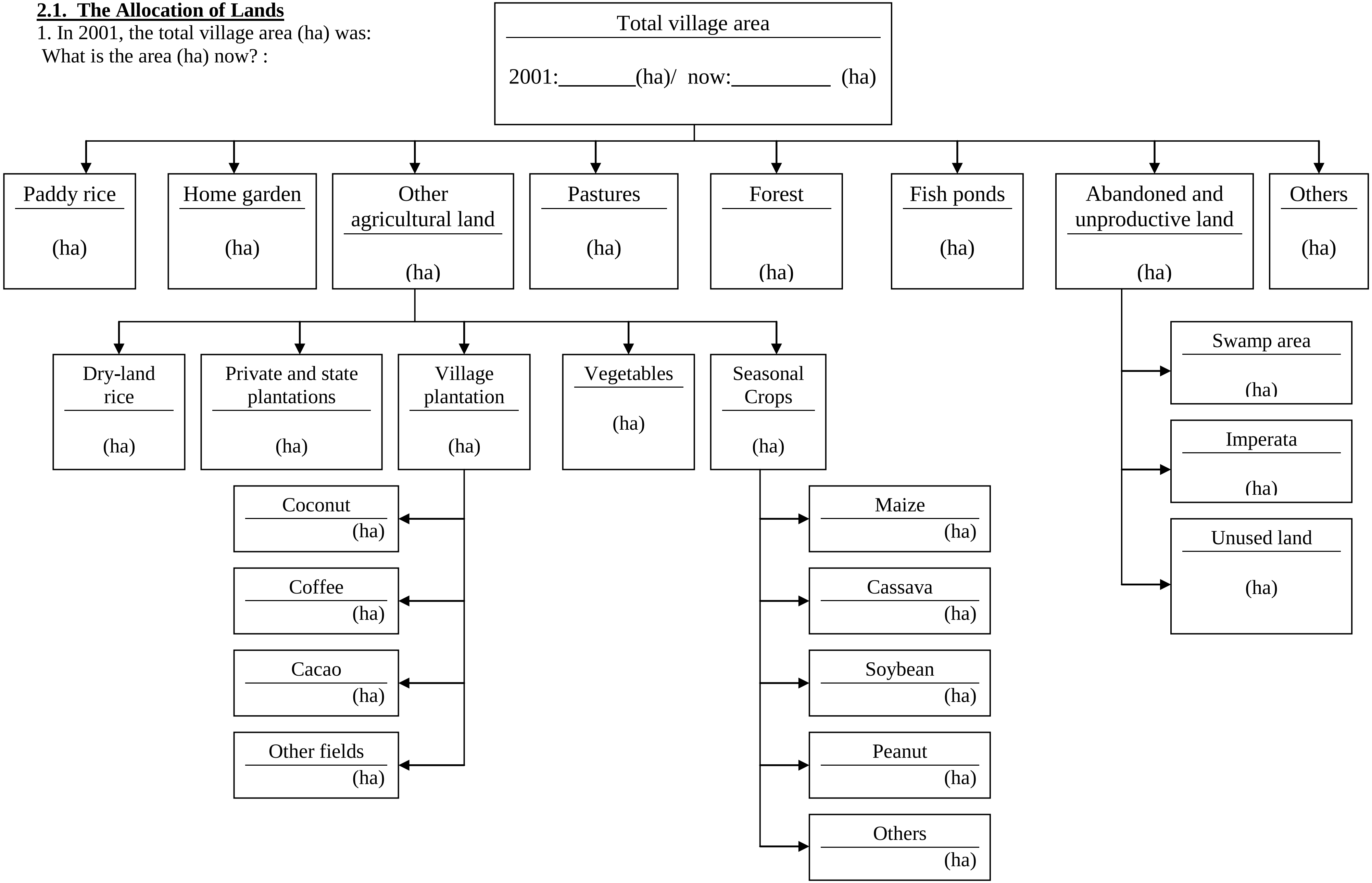
<u>IF YES:</u> How many of them work outside Sulawesi? [ ]

<u>IF YES:</u> How many of them work outside Indonesia? [ ]

## SECTION 2: LAND USE

**2.1. The Allocation of Lands**

1. In 2001, the total village area (ha) was:
What is the area (ha) now? :



## 2.2. Paddy Rice Field

1. At present, there are (XX) ha paddy rice. In the next 15 years, how much area do you think will be cultivated for paddy rice? [ ] ha

[XX =total area of paddy rice, page 4.]

2. In 2001, the following irrigation types were found:

| | Technical irrigation | | Semi-technical irrigation | | Simple irrigation | |
|---|---|---|---|---|---|---|
| In 2001 | Technical irrigation | (ha) | Semi-technical irrigation | (ha) | Simple irrigation | (ha) |
| How is it now? | Technical irrigation | (ha) | Semi-technical irrigation | (ha) | Simple irrigation | (ha) |

[Check whether the total corresponds to the total area of rice field, page 4).]

3. How many times per year is the paddy rice harvested? [ ]

Do villagers grow other crops after harvesting the paddy rice? YES=1 NO=2 [ ]

IF YES : What type of crops? YES=1; NO=2

| | | | | | |
|---|---|---|---|---|---|
| Peanut | | Cassava | | Soybean | |
| Maize | | Sweet Potatoes | | Other (specify) | |

4. In 2001, the yield of paddy rice per hectare for one harvest was:

What is the yield now?

| | | | | | |
|---|---|---|---|---|---|
| In 2001 | | Unit (specify) | Kg | Ton | Others (specify) |
| Now | | Unit (specify) | Kg | Ton | Others (specify) |

5. How is the land prepared before the rice cultivation?

| | | | | | | |
|---|---|---|---|---|---|---|
| By hand with hoe | YES=1; NO=2 | | | Unit (specify) | ha | in (%) area |
| By cattle/ buffalo | YES=1; NO=2 | | | Unit (specify) | ha | in (%) area |
| By hand-tractor | YES=1; NO=2 | | | Unit (specify) | ha | In (%) area |

6. Do farmers use HYVs (High Yielding Varieties)? YES=1; NO=2 [ ]

| | | | |
|---|---|---|---|
| | Unit (specify) | ha | in (%) area |
| | Unit (specify) | ha | in (%) area |

- In 15 years time, what will the share area of HYVs be?
- Do the farmers use a variety of paddy rice that can be grown directly without seedling it in a nursery? YES=1; NO=2 [ ]

7. Do farmers use fertiliser? YES=1; NO=2 [ ] | [ ] Unit (specify) | ha | In (%) area

- On average, what is the price of urea and how much do farmers use per ha? [ ] Kg Price Rp.
- In 15 years time, what will the fertilised area be? [ ] Unit (specify) | ha | In (%) area
- On average, what is the price of urea and how much do farmers use per ha? [ ] Kg Price Rp.

8. Do farmers use pesticides? YES=1; NO=2 [ ] | [ ] Unit (specify) | ha | in (%) area

- In 15 years time, how much land will be sprayed with pesticides? [ ] Unit (specify) | ha | in (%) area

**2.3. Dry-land Rice**

1. At present, there are XX hectares of dry-land rice in this village.
[XX = the total area of dry land paddy, page 4.]

2. Do villagers grow other crops in between or after harvesting dry-land rice? YES=1; NO=2 [ ]

IF YES: What type of crops? YES=1; NO=2

| | | | | | |
|---|---|---|---|---|---|
| Peanut | | Cassava | | Soybean | |
| Maize | | Sweet potato | | Others (specify) | |

3. In 2001, the the yield of dry-land rice per hectare for one harvest was:

What is the yield now?

| | | | | |
|---|---|---|---|---|
| In 2001 | | Unit (specify) | Kg | Ton |
| Now | | Unit (specify) | Kg | Ton |

4. Do farmers use fertiliser? YES=1; NO=2 [ ] | [ ] Unit (specify) | ha | In (%) area

- On average, what is the price of urea and how much do farmers use per ha? [ ] Kg Price Rp.

5. Do farmers use pesticides? YES=1; NO=2 [ ] | [ ] Unit (specify) | ha | in (%) area

**2.4. Home Garden**

1. Do villagers grow the estate crops in their home garden? YES=1; NO=2 [ ]

IF YES: What type of crops? YES=1; NO=2

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Coconut | | Coffee | | Cacao | | Clove | |
| Candle nut | | Vanilla | | Rubber | | Others (specify) | |

Do villagers grow the seasonal crops in their home garden? YES=1; NO=2 [ ]

IF YES: What type of crops? YES=1; NO=2

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Soybean | | Peanut | | Maize | | Cassava | |
| Green beans | | Others (specify) | | | | | |

Do villagers grow vegetables in their home garden? YES=1; NO=2 [ ]

Do villagers grow fruit trees in their home garden? YES=1; NO=2 [ ]

**2.5. Coconut**

1. At present, there are (XX) ha coconut plots in this village. In the next 15 years, how much area do you think will be cultivated for coconut? [ ] ha

[XX =total area of coffee, page 4.]

2. Do villagers grow other crops between the coconut trees (intercropping)? YES=1; NO=2 [ ]

IF YES: What type of crops? YES=1; NO=2

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Coffee | | Cacao | | Clove | | Candle nut | |
| Cassava | | Soybean | | Green beans | | Vegetables | |
| Fruit trees | | Others (specify) | | | | | |

3. What is the average number of coconut trees grown per hectare in this village? Minimum [ ] Maximum [ ]

4. What is the frequency of coconut harvests in this village? [ ] Times per | Unit (specify) | week | month | year |

The yield per hectare for the average harvest in 2001 was: [__________] fruits per hectare

What is the yield per hectare for the average harvest now? [ ] fruits per hectare

5. Do farmers use HYVs? YES=1; NO=2 [ ]

- In 15 years time, what will the area HYVs be?

| | | | |
|---|---|---|---|
| | Unit (specify) | ha | in (%) area |
| | Unit (specify) | ha | in (%) area |

6. Do farmers use fertiliser? YES=1; NO=2 [ ]

- On average, what is the price of urea and how much do farmers use per ha? [ ] Kg Price Rp.
- In 15 years time, how much land will be fertilised?
- On average, what is the price of urea and how much do farmers use per ha?

| | | | |
|---|---|---|---|
| | Unit (specify) | ha | In (%) area |
| Rp. | | | |
| | Unit (specify) | ha | In (%) area |
| | Kg | Price | Rp. |

**2.6. Coffee**

1. At present, there are (XX) ha coffee in this village. In the next 15 years, how much area do you think will be cultivated for coffee? [ ] ha

[XX =total area of coffee, page 4.]

[**The questions no. 2 and 3 only have to be asked if there was no coffee in 2001.**]

2. Who introduced the coffee plant in this village?

1. Government [ ] 2. NGOs [ ] 3. Immigrants [ ] 4. Traders [ ] 5. Neighbouring villagers [ ] 6. Others (specify) [ ]

3. From whom did the villagers learn the techniques to grow coffee?

1. Government [ ] 2. NGOs [ ] 3. Immigrants [ ] 4. Traders [ ] 5. Neighbouring villagers [ ] 6. Others (specify) [ ]

4. Do villagers intercrop their coffee? YES=1; NO=2 [ ]

<u>IF YES:</u> What type of crops? YES=1; NO=2

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Coconut | | Cacao | | Clove | | Candle nut | |
| Rubber | | Vanilla | | Maize | | Peanut | |
| Cassava | | Soya | | Green Beans | | Vegetables | |
| Fruit trees | | Others (specify) | | | | | |

IF YES: How much are the intercropping areas (in %) ?

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Coconut | | Cacao | | Clove | | Candle nut | |
| Rubber | | Vanilla | | Maize | | Peanut | |
| Cassava | | Soya | | Green Beans | | Vegetables | |
| Fruit trees | | Others (specify) | | | | | |

5. Of XX hectares of coffee plots, how many are planted with the following varieties:

| | | | | | |
|---|---|---|---|---|---|
| Robusta | | Arabica | | Kopi Kate (Local variety) | |

6. How many coffee trees are planted per hectare in this village?

| | | | | |
|---|---|---|---|---|
| Robusta | Minimum | | Maximum | |
| Arabica | Minimum | | Maximum | |
| Local variety | Minimum | | Maximum | |

7. From the number of XX hectares of coffee, how much area is unproductive in this village?

| | | | | |
|---|---|---|---|---|
| From the number of XX hectares of coffee, how much area is unproductive in this village? | | Unit (specify) | ha | In % |
| Is still productive? | | Unit (specify) | ha | In % |
| Is no longer productive? | | Unit (specify) | ha | In % |

8. In the case without intercropping practice:

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| What is the fequency of coffee harvest in this village ? | Robusta | | times per | Unit (specify) | week | month | year |
| What is the yield per hectare for the average harvest? | Robusta | | | Unit (specify) | Kg | Ton | |
| What is the frequency of coffee harvest in this village? | Arabica | | times per | Unit (specify) | week | month | year |
| What is the yield per hectare for the average harvest? | Arabica | | | Unit (specify) | Kg | Ton | |
| What is the frequency of coffee harvest in this village ? | Kopi Kate | | times per | Unit (specify) | week | month | year |

What is the yield per hectare for the average harvest? Kopi Kate [ ] | Unit (specify) | Kg | Ton |

9. Do farmers use fertiliser? YES=1; NO=2 [ ]

| | Unit (specify) | ha | In (%) area |
|---|---|---|---|

- On average, what is the price of urea and how much do farmers use per ha? [ ] Kg Price | Rp. |
- In 15 years time, what will the area of fertilised land be?

| | Unit (specify) | ha | In (%) area |
|---|---|---|---|

- On average, what is the price of urea and how much do farmers use per ha?

| | Kg | Price | Rp. |
|---|---|---|---|

10. Do farmers use pesticides? YES=1; NO=2 [ ]

| | Unit (specify) | ha | in (%) area |
|---|---|---|---|
| | Unit (specify) | ha | in (%) area |

- In 15 years time, how much will be sprayed with pesticides?

**2.7. Cacao Plots**

1. At present, there are XX hectares of cacao plots in this village.
[XX = total area of cacao plots, page 4.]

Ennumerators show the card to the respondents. Please ask only if cacao has been introduced in the village.

How much area of the cacao in your village is grown as shown on the cards?

| | A | B | C | D |
|---|---|---|---|---|
| Area now | | | | |
| Area in 2001 | | | | |
| Area in 1996 | | | | |
| Area in 1991 | | | | |
| Area in 1981 | | | | |
| Area in the next 15 years | | | | |

**The questions no. 2 and 3 have only to be asked if there was no coffee in 2001:**

2. Who introduced the cacao plant?

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1. Government | | 2. NGOs | | 3. Immigrants | | 4. Traders | | 5. Neighbouring villagers | | 6. Others (specify) | |

3.From whom did the farmers learn the techniques to grow cacao?

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1. Government | | 2. NGOs | | 3. Immigrants | | 4. Traders | | 5. Neighbouring villagers | | 6. Others (specify) | |

4. Do the villagers intercrop the cacao with other crops? YES=1; NO=2 [ ]

IF YES: What type of crops?
YES=1; NO=2

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Coffee | | Coconut | | Clove | | Nutmeg | |
| Rubber | | Vanilla | | Maize | | Peanut | |
| Cassava | | Soybean | | Green Beans | | Vegetables | |
| Fruit trees | | Others (specify) | | | | | |

5. What is the minimum and maximum average number of cacao trees planted per hectare in this village?

| | | | |
|---|---|---|---|
| | Minimum | | Maximum |

6. In what age range do the cacao plants reach their optimal production? From age [ ] To age [ ]

| | | | | |
|---|---|---|---|---|
| From the number of XX hectares of cacao in this village, how much area is unproductive? | | Unit (specify) | ha | In % |
| is still productive? | | Unit (specify) | ha | In % |
| is no longer productive? | | Unit (specify) | ha | In % |

[XX = the total area of cacao plots, page 4.]

| | | | | | | |
|---|---|---|---|---|---|---|
| 7. In 2001, the frequency of cacao harvests in this village was: | ________ | times per | Unit (specify) | week | month | year |
| and the yield per hectare of cacao for the average harvest was: | ________ | | Unit (specify) | Kg | Ton | |
| What is the frequency of cacao harvest in this village now? | | times per | Unit (specify) | week | month | year |
| What is the yield per hectare of cacao for the average harvest now? | | | Unit (specify) | Kg | Ton | |

8. Do farmers use fertiliser? YES=1; NO=2 [ ]

| | Unit (specify) | ha | In (%) area |
|---|---|---|---|

- On average, what is the price of urea and how much do farmers use per ha? [ ] Kg Price Rp.
- In 15 years time, how much will the share area of fertiliser be?

| | Unit (specify) | ha | In (%) area |
|---|---|---|---|
| | Kg | Price | Rp. |

- On average, what is the price of urea and how much do farmers use per ha?

9. Do farmers use pesticides? YES=1; NO=2 [ ]

- In 15 years time, how much will the share area of pesticides be?

| | | | |
|---|---|---|---|
| | Unit (specify) | ha | in (%) area |
| | Unit (specify) | ha | in (%) area |

**2.8. Vegetables**

1. At present, there are XX hectares vegetables in this village. [XX = the total area of vegetables, page 4.]

**The questions no. 2 and 3 have only to be asked if there was no vegetable production in 2001**

2. Who introduced vegetables to the farmers?

1. Government [ ] 2. NGOs [ ] 3. Immigrants [ ] 4. Traders [ ] 5. Neighbouring villagers [ ] 6. Others (specify) [ ]

3. From whom the farmers learn the techniques to grow vegetables?

1. Government [ ] 2. NGOs [ ] 3. Immigrants [ ] 4. Traders [ ] 5. Neighbouring villagers [ ] 6. Others (specify) [ ]

4. What type of vegetables grown are common in this village?

1. Shalot [ ] 2. Bean [ ] 3. Long bean [ ] 4. Cucumber [ ] 5. Tomato [ ] 6. Others (specify) [ ]

**2.9. Maize**

1. At present, there are (XX) ha maize in this village. In the next 15 years, how much area do you think will be cultivated for maize? [ ] ha
[XX =total area of maize, page 4.]

2. How many times per year is the maize harvested? [ ]

Do the farmers grow other crops in between or after harvesting maize? YES=1; NO=2 [ ]

In 2001, the yield of maize per hectare for the average harvest was: | ___________ | Unit (specify) | Kg | Ton

What is the yield of maize per hectare for the average harvest now? | | Unit (specify) | Kg | Ton

3. Do farmers use HYVs? YES=1; NO=2 [ ] | | Unit (specify) | ha | in (%) area

- In 15 years time, how much land will be cultivated with HYVs? | | Unit (specify) | ha | in (%) area

6. Do farmers use fertiliser? YES=1; NO=2 [ ] | | Unit (specify) | ha | In (%) area

- On average, what is the price of urea and how much do farmers use per ha? [ ] Kg Price Rp.

- In 15 years time, how much will the share area of fertiliser be? | | Unit (specify) | ha | In (%) area

- On average, what is the price of urea and how much do farmers use per ha? [ ] Kg Price Rp.

9. Do farmers use pesticides? YES=1; NO=2 [ ] | | Unit (specify) | ha | in (%) area

**2.10. Abandoned Lands**

[If there is no swamp area please continue to question no. 2, on this page]

1. Has a number of XX hectares of swamp area been cultivated with any productive crops? YES, all of them=1; YES, part of them=2; NO, none =3 [ ]

IF YES: When did it happen? year

[XX = total area of swamp, page 4.]

[If there are no coverage areas of imperata please continue to question no. 3, page 13]

2. Has a number of XX hectares of coverage area of imperata been cultivated with any productive crops? YES, all of them=1; YES, part of them=2; NO, none=3 [ ]

IF YES: When did it happen? year

[XX = total coverage area of imperata, page 4.]

[If there are no areas of unused land please continue to section 2.11, page 13]

3. Has a number of XX hectares of unused land been planted with any productive crops? YES, all of them=1; YES, part of them=2; NO, none=3 [ ]

IF YES: When did it happen? year

Why this is area abandoned? ____________________

[XX = total of abandoned area, page 4.]

**2.11. The availability of land**

1. At present, are there any possibilities to expand the agricultural land? YES=1; NO=2 Paddy rice [ ] Other agricultural land [ ]

In the next 15 years, do you think there will be any possibilities to expand the agricultural land in this village? YES=1; NO=2 Paddy rice [ ] Other agricultural land [ ]

2. Is there any forest from which to collect timber for home construction use? YES=1; NO=2 [ ]

In the next 15 years, do you think there will be any forest to collect timber for home construction use? YES=1; NO=2 [ ]

3. How many households have cleared the forest for agricultural land since 2001? [ ]

| Unit (specify) | In ( %) | # HH |
|---|---|---|

How many hectares were cleared approximately? [ ]

4. Has any land in the forest of this village been sold to immigrants since 2001? YES=1; NO=2 [ ]

IF YES: Approximately how many hectares have been sold in total? [ ]

5. Has any land in the forest of this village been sold to people who live in the city since 2001? YES=1; NO=2 [ ]

IF YES: How many hectares were sold approximately? [ ]

6. Has the village leader facilitated the sale of land in the forest to immigrants or people coming from the city since 2001? YES=1; NO=2 [ ]

IF YES: Have any benefits been offered to the village leader or other village members as part of the forest sales? YES=1; NO=2 [ ]

IF YES: (please explain) ____________________

## SECTION 3: AGRICULTURAL TECHNOLOGY AND MARKETING

### 3.1. Shifting Cultivation

1. At present is shifting cultivation used in this village? YES=1; NO=2 [ ]

| | | | | | | |
|---|---|---|---|---|---|---|
| IF NO: | When was this system abandoned (0000= never practiced)? | | year | | | |
| IF YES: | Currently, how much land is culivated under shifting cultivation? | | ha | | | |
| | How much land under shifting cultivation is fallowed? | | ha | | | |
| | How long are the cultivation periods before the fallow period? | | years | | | |
| | How long is the fallow period? | | years | | | |
| | How many households practice shifting cultivation? | | Unit (specify) | In ( % ) | # HH | |

### 3.2. Agricultural Inputs

1. Do the farmers use pesticides in this village? YES=1; NO=2 [ ]

IF NO, Why not:

1. No knowledge of use [ ] 2. Not necessary [ ] 3. Expensive [ ] 4. Difficult to acquire [ ] 5. Others (specify) [ ]

IF YES: Since when have pesticides been used in this village? [ ] year

If after 2000: Who introduced pesticides to the farmers?

1. Government [ ] 2. NGOs [ ] 3. Immigrants [ ] 4. Traders [ ] 5. Other neighbouring villagers [ ] 6. Others (specify) [ ]

2. Do the farmers use chemical fertilisers in this village? YES=1; NO=2 [ ]

IF NO, Why not:

1. No knowledge of use [ ] 2. Not necessary [ ] 3. Expensive [ ] 4. Difficult to acquire [ ] 5. Others (specify) [ ]

IF YES: What types of fertilisers? YES=1; NO=2

| Urea | TSP | KCl | Others (specify) | |
|---|---|---|---|---|
| | | | | |

Since when have chemical fertilisers been used in this village? [ year ]

If after 2000: Who introduced chemical fertilisers in this village?

1. Government [ ] 2. NGOs [ ] 3. Immigrants [ ] 4. Traders [ ] 5. Other neighbouring villagers [ ] 6. Others (specify) [ ]

3. Do the farmers use high yielding varieties in this village? YES=1; NO=2 [ ]

IF NO, Why not:

1. No knowledge of use [ ] 2. Not necessary [ ] 3. Expensive [ ] 4. Difficult to acquire [ ] 5. Others (specify) [ ]

IF YES: Since when have high yielding varieties been used in this village? [ ] year

If after 2000: Who introduced the high yielding varieties to the farmers?

1. Government [ ] 2. NGOs [ ] 3. Immigrants [ ] 4. Traders [ ] 5. Other neighbouring villagers [ ] 6. Others (specify) [ ]

4. How do the farmers obtain the agricultural inputs?

1= buying in local shops ; 2= buying from the town; 3= buying from traders
4= buying from extension services; 5= buying from NGOs 6= receiving from extension services
7= others

Are the agricultural inputs available in sufficient quantities ? YES=1; NO=2

Did government give money to support the farmers buying those inputs? YES=1; NO=2

Do NGOs give money to the farmers to buy those inputs? YES=1; NO=2

| HYV | Chemical fertilisers | Pesticides |
|---|---|---|
| | | |
| | | |
| | | |
| | | |
| | | |

5. What is the current price of urea? Rp ____ per ____ Kg

What is the minimum price during the last 12 months? Rp ____ per ____ Kg

What is the maximum price during the last 12 months? Rp ____ per ____ Kg

6. How many extension service workers are there in this village? [ ] persons

How many times do they give their services to the farmers? [ ] times per

| Unit (specify) | week | month | year | others (specify) |
|---|---|---|---|---|

How much area is covered by the work? [ ] Persons per [ ]

| Unit (specify) | ha | village | others (specify) |
|---|---|---|---|

**3.3. Agricultural Equipment and Machinery**

| | | Plough | Hand-tractor | Tractor | Rice Mill | Other Mills | Chain-saw |
|---|---|---|---|---|---|---|---|
| How many of the following equipment types are available in this village? | | | | | | | |
| Are there any possibilities to rent equipment from: YES=1; NO=2 | other households in this village? | | | | | | |
| | village community ? | | | | | | |
| | other households in the other villages? | | | | | | |
| | Others (specify) | | | | | | |

**3.4. Soil Fertility and Conservation**

1. Is there an erosion problem in this village? YES=1; NO=2 [ ]

IF YES: What is the level of the erosion? Heavy=1; Moderate=2; Light=3 [ ]

Since the year 2001, has the erosion changed? Code 3a [ ]

Code 3a
Change in erosion
Increased a lot ……………. 1
Increased slightly ………… 2
No change ………………... 3
Decreased slightly ………... 4
Decreased a lot …………… 5

2. Are there plots/fields located on the steep slope areas in this village? YES=1; NO=2 [ ]

IF YES: What is the area in hectares? [ ] ha

3. Since 2001, did the farmers build ditches, drainage, fences, barriers, etc. on their plots to prevent the erosion? YES=1; NO=2 [ ]

IF YES: How many farmers carry out these techniques? [ ]

| Unit (specify) | In % | # HH |
|---|---|---|

When were these techniques first practiced? [ ]

Who introduced the techniques to the farmers?

1. Government [ ] 2. NGOs [ ] 3. Immigrants [ ] 4. Traders [ ] 5. Neighbouring villagers [ ] 6. Others (specify) [ ]

4. Since 2001, have farmers built terraces on their steep plots to prevent the erosion? YES=1; NO=2 [ ]

| | | | | |
|---|---|---|---|---|
| IF YES: How many farmers perform these techniques? | | Unit (specify) | In % | # HH |
| When were these techniques first practiced? | | | | |

Who introduced the techniques to the farmers?

1. Government [ ] 2. NGOs [ ] 3. Immigrants [ ] 4. Traders [ ] 5. Neighbouring villagers [ ] 6. Others (specify) [ ]

**3.5. Marketing**

| | Paddy | Maize | Coconut | Cacao | Coffee | Vegetables |
|---|---|---|---|---|---|---|
| 1. Do the farmers sell their harvest? YES=1; NO=2 | | | | | | |
| IF YES: What percentage of their harvest do the farmers sell? | | | | | | |
| How do the farmers sell their harvest? | | | | | | |

1= to village traders ; 2= to village market ; 3= to the market in other villages
4= to the market in the city ; 5= village cooperative ; 6= others

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2. What is the price of rice? | now | Rp. | The last 12 months | Min | Max | per | Unit (specify) | Kg | ton | liter | Others: |
| What is the price of stick maize | now | Rp. | The last 12 months | Min | Max | per | Unit (specify) | Kg | ton | liter | Others: |
| What is the price of coconut? | now | Rp. | The last 12 months | Min | Max | per | Unit (specify) | Kg | ton | liter | Others: |
| What is the price of dried-coconut? | now | Rp. | The last 12 months | Min | Max | per | Unit (specify) | Kg | ton | liter | Others: |
| What is the price of cacao? | now | Rp. | The last 12 months | Min | Max | per | Unit (specify) | Kg | ton | liter | Others: |
| What is the price of coffee? | now | Rp. | The last 12 months | Min | Max | per | Unit (specify) | Kg | ton | liter | Others: |

## SECTION 4: LAND AND LABOR

### 4.1. Land Rights

| 1. Who are the owners of the following lands in this village?: | Unit (specify) | | Native households dwelling in this village | Migrant households dwelling in this village | The village community | Households living in another village | Households living in the city (Palu/ Poso) | The Government | Others(specify) |
|---|---|---|---|---|---|---|---|---|---|
| AA hectares of paddy rice fields | In % | Hectares | | | | | | | |
| BB hectares of home garden | In % | Hectares | | | | | | | |
| CC hectares of other agricultural land | In % | Hectares | | | | | | | |
| CC(1) hectares of cacao | In % | Hectares | | | | | | | |
| DD hectares of pastures | In % | Hectares | | | | | | | |
| EE hectares of abandoned land | In % | Hectares | | | | | | | |
| FF hectares of forest | In % | Hectares | | | | | | | |
| GG hectares of fish ponds | In % | Hectares | | | | | | | |

[AA = total area of paddy rice field (page 4); BB= total area of home garden(page 4); CC = total area of other agricultural land (page 4); CC(1) = total area of cacao (page 4) DD = total area of pastures (page 4); EE = total area of abandoned land (page 4); FF = total area of forest (page 4); GG = total area of fish ponds (page 4).]

| | | For housings | For paddy rice fields | For other agricultural lands | For cacao |
|---|---|---|---|---|---|
| 2. In 2001, did legal land rights already exist in your village? | YES=1; NO=2 | | | | |
| IF NO: Do the people have legal certificates of their land property now? | YES=1; NO=2 | | | | |
| | | | | | |
| IF ANY YES: How many households have legal certificates? | Unit \| In % \| # HH | | | | |
| Was this legalised land obtained from *PRONA* or *PRODA*? | All=1 ; Some=2 ; None=3 | | | | |

3. Do any written documents of customary land exist? YES=1; NO=2 [ ]

4. Are there villagers who own agricutural land in other villages? YES=1; NO=2

1. Paddy rice [ ] 2. Other agricultural land [ ] 3. Cacao [ ]

IF YES: How many households have land outside this village?

| | Unit (specify) | In % | # HH |
|---|---|---|---|
| | | | |

5. Are there conflicts over land rights in this village?

| | | |
|---|---|---|
| - among the native people in this village | YES=1; NO=2 | |
| - between the native people and migrants | YES=1; NO=2 | |
| - with members of neighbouring villages | YES=1; NO=2 | |
| - with the government or other institutions | YES=1; NO=2 | |

Have the people ever brought their conflicts into court? YES=1; NO=2 [ ]

IF NO, could you explain how the people solve the conflicts? ______________________

**4.2. The Land Market**

1. Since 2001, how many households have sold their land in this village?

| | Unit (specify) | In % | # HH |
|---|---|---|---|
| | | | |

Who are the buyers? YES=1; NO=2

| | |
|---|---|
| - migrants who have move into this village | |
| - other households dwelling in another village | |
| - other households dwelling in this village. | |
| - households dwelling in the city (Palu/Poso) | |
| - others (specify) | |

2. Since 2001, how many households became landless because they have sold all their agricultural land?

| | Unit (specify) | In % | # HH |
|---|---|---|---|
| | | | |

3. In 2001, the price of land per hectare was:

| | | | | | |
|---|---|---|---|---|---|
| 3. In 2001, the price of land per hectare was: | - for paddy rice | Minimum | Rp.________________ | Maximum | Rp.________________ |
| | - for other agricultural land | Minimum | Rp.________________ | Maximum | Rp.________________ |
| What is the price per hectare now? | - for paddy rice | Minimum | Rp. | Maximum | Rp. |
| | - for other agricultural land | Minimum | Rp. | Maximum | Rp. |

4. Does a system of following land rent exist in this village? The rent is paid in advance with the agreed amount of money per week, month, season or year. The tenant can have all of the harvest without paying fees, other than the money for the land rent.

Does this rent system exist in this village? YES=1; NO=2 [ ]

IF YES: Does it exist for (YES=1; NO=2) 1. Paddy rice [ ] 2. For other agricultural land [ ] 3. Cacao [ ]

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| In 2001, the rent per hectare was between: | Minimum | Rp. | Maximum | Rp. | per | Unit | Season | Year | Other |
| Now, the rent is between? | Minimum | Rp. | Maximum | Rp. | per | Unit | Season | Year | Other |

5. Does a rental agreement with sharing harvest payment exist in this village?. The tenant has to share the harvest with land owner. The quantity of harvest to be shared depends on the agreement between the two parties.

Does this rent system exist in this village? YES=1; NO=2 [ ]

IF YES: Does it exist for (YES=1; NO=2): 1. Wet land rice [ ] 2. For other agricultural land [ ] 3. Cacao [ ]

IF YES: How is the share?

| | | | | |
|---|---|---|---|---|
| The share of the harvest for ( in %) | Tenant | | Land owner | |
| The share of the inputs for ( in %) | Tenant | | Land owner | |

6. Does a system of sharing land exist in this village? The tenant works for the land owner. After some years, the land owner will give a part of the land to the tenant.

Does this system exist in this village? YES=1; NO=2 [ ]

IF YES: Does it exist for (YES=1; NO=2): 1. Paddy rice [ ] 2. For other agricultural land [ ] 3. Cacao [ ]

IF YES: What is the agreement? How many years does the tenant have to work? [ year ]

The share of the inputs for ( in %) Tenant [ ] Land owner [ ]

The share of the land for? (in %) Tenant [ ] Land owner [ ]

7. Do the people lend their land in this village? The borrower can work on the land without paying the rent or sharing the harvest to the land owner.

Do the people apply this in this village? YES=1; NO=2 [ ]

IF YES: Does it exist for (YES=1; NO=2): 1. Wet land rice [ ] 2. For other agricultural land [ ] 3. Cacao [ ]

8. Do people have mortgaged out their land (system gadai) in this village? YES=1; NO=2 [ ]

IF YES: How many households have done this?

| | | | |
|---|---|---|---|
| | Unit (specify) | In % | # HH |

9. Are there other types of land rental agreements performed in this village? YES=1; NO=2 [ ]

IF YES: Could you explain?

[ ]

## 4.3. Land Acquisition and Distribution

1. From the number of XX households in this village, how many households own the amount of land below:

| > 5 ha | 2 – 5 ha | 1 –2 ha | 0,5 – 1 ha | < 0,5 ha | No land |
|---|---|---|---|---|---|
| | | | | | |

[Check whether sums correspond to the total number of households, question no. 2, page 2]

2. If new migrants come to this village and they want to have a farm here, can they acquire the land? YES=1; NO=2 IF YES: How?

1. buying the land in the forest [ ] 2. opening new land in the forest [ ] 3. purchasing the land [ ] 4. renting the land [ ] 5. other (specify) [ ]

3. What is the common way to inherit land in this village? YES=1; NO=2

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 1. divided equally to all children | | 2. only for male children | | 3. only for the oldest son | | 4. no special rule | | 5. other (specify) | |

**4.4. Agricultural Labour**

1. Is there a system of sharing work together such as *mapalus* in this village? YES=1; NO=2 [ ]

IF YES: How many groups do this village have? [ ]

How many people does one group consist of? [ ]

For which crops do mapalus groups exist? (YES=1 NO=2)

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1. Paddy rice | | 2. Maize | | 3. Dry land rice | | 4. Cacao | | 5. Coffee | | 6. Coconut | |

2. Is it possible to hire farm labourers in this village? YES=1; NO=2 [ ]

| | | | | | |
|---|---|---|---|---|---|
| IF YES: In 2001, the wage rate was: | Rp. | per | Unit (specify) | Day | Others: |
| What is the wage rate now? | Rp. | per | Unit (specify) | Day | Others: |

## SECTION 5: LIVESTOCK

1.How many households rear the following livestock?

| Buffalo | Cattle | Horse | Sheep/ Goat | Pig | Poultry | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | Unit (specify) | In % | # HH |

2. What is the number of livestock in this village?

| Buffalo | Cattle | Horse | Sheep/ Goat | Pig |
|---|---|---|---|---|
| | | | | |

3. What is the major source of fodder? YES=1; NO=2

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Buffalo | 1. Grazing on cultivated pastures | | 2. Grazing on non-cultivated pastures | | 3. Collected fodder | | 4. Purchased feed | |
| Cattle | 1. Grazing on cultivated pastures | | 2. Grazing on non-cultivated pastures | | 3. Collected fodder | | 4. Purchased feed | |
| Horse | 1. Grazing on cultivated pastures | | 2. Grazing on non-cultivated pastures | | 3 Collected fodder | | 4. Purchased feed | |
| Sheep/Goat | 1. Grazing on cultivated pastures | | 2. Grazing on non-cultivated pastures | | 3.Collected fodder | | 4. Purchased feed | |
| Pig | | | 1. Roaming around | | 2. Collected fodder | | 3. Purchased feed | |
| Poultry | | | 1. Roaming around | | 2. Collected fodder | | 3. Purchased feed | |

4. Do the livestock mostly graze outside this village area? YES=1; NO=2 ☐

5. Are there any regulations regarding the use of fallow and pasture for animal grazing in this village? NO=1; YES=2 ☐

6. What are the functions of livestocks in this village community? YES=1; NO=2

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Buffalo | 1. Source of income | | 2. Paying customary obligations | | 3. For special occasions | | 4. Dowry | | 5. Others (specify) | |
| Cattle | 1. Source of income | | 2. Paying customary obligations | | 3. For special occasions | | 4. Dowry | | 5. Others (specify) | |
| Horse | 1. Source of income | | 2. Paying customary obligations | | 3. For special occasions | | 4. Dowry | | 5. Others (specify) | |
| Sheep/ Goat | 1. Source of income | | 2. Paying customary obligations | | 3. For special occasions | | 4. Dowry | | 5. Others (specify) | |
| Pig | 1. Source of income | | 2. Paying customary obligations | | 3. For special occasions | | 4. Dowry | | 5. Others (specify) | |
| Poultry | 1. Source of income | | 2. Paying customary obligations | | 3. For special occasions | | 4. Dowry | | 5. Others (specify) | |

## SECTION 6: THE NATIONAL PARK AND CONSERVATION ISSUES SECTION

### 6.1. Biodiversity Conservation

1. Are these following animals hunted or have their eggs collected?

| | Anoa | Pig-deer | Black monkey | Wild chicken | Maleo's eggs |
|---|---|---|---|---|---|
| In 2001, these animals have been hunted or collected for their eggs in this village YES = 1; NO = 2 | | | | | |
| Are these animals hunted or collected for their eggs in this village? YES = 1; NO = 2 | | | | | |
| At present, how many hunters hunt or collect the eggs of these animals? | | | | | |
| At present, how many days do hunters need to obtain the animals or eggs? | | | | | |
| At present, how many animals and eggs do hunters obtain per year? | | | | | |
| How far do the hunters wander to the forest to obtain the animals or eggs? (in km) | | | | | |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 2. Do the people sell Anoa? | YES=1 ; NO=2 | | IF YES | How much does it cost? | Rp. | Unit | per Kg | per animal | Others: |
| Do the people sell pig-deer? | YES=1 ; NO=2 | | IF YES | How much does it cost? | Rp. | Unit | per Kg | per animal | Others: |
| Do the people sell black monkey? | YES=1 ; NO=2 | | IF YES | How much does it cost? | Rp. | Unit | per Kg | per animal | Others |
| Do the people sell wild chicken? | YES=1 ; NO=2 | | IF YES | How much does it cost? | Rp. | Unit | per Kg | per animal | Others: |
| Do the people sell maleo's eggs? | YES=1 ; NO=2 | | IF YES | How much does it cost? | Rp. | Unit | per Kg | Per egg | Others: |

3. Do the people collect rattan? YES=1; NO=2 [ ]

| | | | | | |
|---|---|---|---|---|---|
| IF YES: | How many households collect rattan? | In 2001 | ________ | Now | |
| | How many kilograms of rattan have been collected in this village in the last 12 months? | In 2001 | ________ | Now | |
| | What type of rattan do the people collect most? | In 2001 | ________ | Now | |

1. Batang [ ] 2. Lambang [ ] 3. Pai [ ] 4. Tohiti [ ] 5. Other (specify) [ ]

| | | | | |
|---|---|---|---|---|
| How much is the price of this type of rattan per kilo? | In 2001 | Rp.__________ | Now | Rp. |
| How far do the people have to go into the forest to find rattan? (in km) | In 2001 | Rp.__________ | Now | Rp. |

**6.2. The National Park**

1. Do the people have agricultural land inside the national park in this village? YES=1; NO=2 [ ]

| | | | | |
|---|---|---|---|---|
| IF YES: How many native households have land inside the national park? | | Unit | In % | # HH |
| How many migrant households have land inside the national park? | | Unit | In % | # HH |

At present, how much land owned by the people is located inside the national park? [ ] ha

2. What is the distance of the furthest agricultural plot inside the national park and the border? [ ] km

3. At present, do the villagers have land inside the national park which does not belong to this village area? YES=1; NO=2 [ ]

IF YES: How many households? [ ] In which village? ______________________

4. Do you think the national park gives benefits or positive effects to your village? YES=1; NO=2 [ ]

Could you explain them?____________________________________________________

5. Do you think the national park gives benefits or positive effects to your children and grandchildren? YES=1; NO=2 [ ]

Could you explain them? ______________________________________________

6. Since 2001 have any programs regarding to the conservation in the national park been conducted by the government or NGOs? YES=1; NO=2 [ ]

IF YES: please describe it.

| Name of the organisation | Time | | The activities of program | What is your opinion of the implementation and results of the programs? |
|---|---|---|---|---|
| | Start | End | | Code 6a |
| | | | | |
| | | | | |
| | | | | |

7. Should the government or NGOs conduct any programs relating to conservation in the national park? YES=1; NO=2 ☐

IF YES: please describe it.

| Purpose of program | Activities |
|---|---|
| | |
| | |
| | |

**Code 6a**

*Evaluation*

1= Activity was only planned, but never implemented
2=Activity not yet finished, therefore difficult to say
3=Activity was terminated without major impact
4=The overall impact for the village was positive
5=The overall impact for the village was negative

## SECTION 7: INFRASTRUCTURE

### 7.1. Transportation & Communication

1. Can this village be accessed by car ? YES=1; NO=2 [ ]

IF YES: What is the type of the road in this village?

1. Aspalt [ ] 2. Concrete [ ] 3. Gravel [ ] 4. Ground [ ]

What is the road condition in the rainy season?

1. functioning well [ ] 2. difficult to pass by car [ ] 3. impossible to pass by car [ ]

IF NO: How long do the people need to walk to approach the road which is accessible by car? [ ] days [ ] hourrs [ ] minutes

Is this village accessible by motorcycle? YES=1; NO=2 [ ]

Is this village accessible by cart or carriage? YES=1; NO=2 [ ]

2. How many vehicles and transportation means are available in this village?

| | Car/Jeep/Truck | Motorcycle | Carriage/Cart | Horse |
|---|---|---|---|---|
| In 2001 | | | | |
| Now | | | | |

3. Does this village have public transport (car, bus and truck)? YES=1; NO=2 [ ]

IF YES: What is the frequency of public transport service to go to the city (Palu and Poso)? [ ] Times Each [ ] Unit | Day | Week | Month

What is the frequency of public transport service to go to other villages? [ ] Times Each [ ] Unit | Day | Week | Month

4. What type of facilities are available in this village? YES=1; NO=2

| Newspaper | Post office | Phone-shop | Mobile phone connection | Bank |
|---|---|---|---|---|
| | | | | |

IF YES for mobile phone: Since when? ___________________ (year)

5. How many households have a telephone line in their house?

How many households have a television in their house?

| | | | |
|---|---|---|---|
| | Unit (specify) | In % | # HH |
| | Unit (specify) | In % | # HH |

**7.2. Health Infrastructure**

1. Are these health facilities available in this village? YES=1; NO=2

| Puskesmas | Puskesmas Pembantu | Polindes | POS KB | Posyandu |
|---|---|---|---|---|
| | | | | |

**7.3. School and Education Infrastructure**

1. How many schools are in this village?

| Kindergarten | Elementary school | Junior high school | Senior high school | Vocational high school |
|---|---|---|---|---|
| | | | | |

2. From the total number of XX children of ages 7 – 12 years, how many attended school?

From the total number of YY children of ages 13 – 18 years, how many attended school?

| | | | | |
|---|---|---|---|---|
| In 2001: ________ | Now: ________ | Unit (specify) | # children | % of the children |
| In 2001: ________ | Now: ________ | Unit (specify) | # children | % of the children |

[XX = Total number of persons in the age group of 7 to 12 year (question no. 3, page 2), YY = Total number of persons in the age group of 13 to 18 year (question no. 3, page 2)]

3. From the total number of XX people of age 19 – 45 year, how many are unable to read and write?

From the total number of YY people above 45 year old, how many are unable to read and write?

| | | | | |
|---|---|---|---|---|
| In 2001: ________ | Now: ________ | Unit (specify) | # persons | In % |
| In 2001: ________ | Now: ________ | Unit (specify) | # persons | In % |

[XX = total number of people in the age of 19 to 45 year (question 3, page 2)
[ YY = total number of the people in the age of 46 to 60 year and above 60 year, question no. 3, page 2)]

4. How many people (above 15 year) are unable to speak Bahasa Indonesia?

1. none ☐ 2. 25 percent ☐ 3. 50 percent ☐ 4. 75 percent ☐

**7.4. Housing and Sanitation**

1. Is there electricity in this village? YES=1; NO=2 ☐

IF YES: How many households have electricity in their houses?

| | Unit (specify) | # HH | In % |
|---|---|---|---|
| | | | |

IF YES: How many hours a day the availability? ______ hours

2. How do the villagers obtain their drinking water? YES=1; NO=2

| | Rain | River | Spring | Well | Water chanel (pipe) public | Water chanel (pipe) private | Pump public | Pump private | |
|---|---|---|---|---|---|---|---|---|---|
| YES=1; NO=2 | | | | | | | | | |

How many households have private and pumped water?

| Unit (specify) | # HH | In % | Water chanel (pipe) public | Water chanel (pipe) private | Pump public | Pump private |
|---|---|---|---|---|---|---|
| | | | (shaded) | | (shaded) | |

3. How many houses are built from stone, brick and cement? ( %)

| In 2001 | Now |
|---|---|
| ________ | ________ |

## 7.5. Market Facilities

1. Are there small shops in this village? YES=1; NO=2 [ ] IF YES: When were these small shops established? year [ ]

2. How many small shops are there in this village?

| Now |
|---|
| |

3. Is there a market day in this village? YES=1; NO=2 [ ] IF NO: What is the nearest village which has a market ? [ ]

## 7.6. Social Organisations

How many social organisations move actively in this village? YES=1; NO=2

| Type of the organisations | Number of organisations | First established? (year) | # member (Avr) | # of meeting per month (Avr) | | | Attendance of the group membership (Avr) | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | (1 time) | (2-3 times) | (4 times) | ≤25 % | 26-50% | 51-75% | > 75% |
| Religious groups | | | | | | | | | | |
| Business associations | | | | | | | | | | |
| Sport clubs | | | | | | | | | | |
| Neighbouring group | | | | | | | | | | |
| Womens' associations | | | | | | | | | | |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Farmers' groups | | | | | | | | | | |
| Youth groups | | | | | | | | | | |
| Cultural groups | | | | | | | | | | |
| Others (specify) | | | | | | | | | | |

2. Are there events together with members of other villages? YES=1; NO=2

| | | | |
|---|---|---|---|
| Sport events | | Religious events | |
| Art and culture events | | Other (specify) | |

3. At what age do the girls usually get married in this village? minimum [ ] year maximum [ ] year

4. If one of the village members wants to build a new house, how would this work be done? YES=1; NO=2

1. work individually [ ] 2. helped by neighbour and familly only [ ] 3. helped by other villagers [ ] 4. Other (specify) [ ]

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | Constructing Road | Building a church or mosque | Making a new paddy field | Cleaning the village | Other (specify) |
| 5. Do the villagers work together to complete these works? YES=1; NO=2 | | | | | | | | | |
| IF YES: How many households participate in this work? | Unit | ≤25% | 26-50% | 51-75% | > 75% | | | | |

**7.7. Access to Credit**

1. Since 2001, has there been any credit program run by government or NGOs in the village ? YES=1; NO=2 [ ]

| | Government | | | | | | | | NGOs |
|---|---|---|---|---|---|---|---|---|---|
| | KUD | KUT | SAADP | CSIAD | IDT | UPPKS | JPS | Others | |
| IF YES: What type of credit programs? YES=1; NO=2 | | | | | | | | | |
| When did the credit programs start ? (year) | | | | | | | | | |
| Is the credit program still going on? YES=1; NO=2 | | | | | | | | | |
| IF NO: When was the credit program stopped? (year) | | | | | | | | | |
| How much is the annual interest rate of each credit? | | | | | | | | | |

2. Is there a credit association in this village? YES=1; NO=2 [ ]

IF YES: How many households are members of this credit association? [ ]

3. Are there villagers such as traders, machinery owners, landlords who give credit to other village members? YES=1; NO=2 [ ]

IF YES: How much is the average interest rate of the credit? [ ] per

| Unit (specify) | day | month | year | Other (specify) |
|---|---|---|---|---|

Are there people from other villages offering credit to people in this village? YES=1; NO=2 [ ]

IF YES: How much is the average interest rate of the credit? [ ] per

| Unit (specify) | day | month | year | Other (specify) |
|---|---|---|---|---|

Are there people who come from the city (Palu and Poso) who offer credit to the villagers in this village? YES=1; NO=2 [ ]

IF YES: How much is the average interest rate of the credit? [ ] per

| Unit (specify) | day | month | year | Other (specify) |
|---|---|---|---|---|

## SECTION 8: INCOME AND WELL-BEING

| | | |
|---|---|---|
| 1. From the number of XX households in this village, how many households depend on agriculture as their main occupation? | | 1 |
| From those who are farmers: | How many households have their own land? | 11 |
| | How many households borrow or rent the land for agricultural production? | 12 |
| | How many households work as farm laborers only? | 13 |
| | How many households work in livestock-rearing? | 14 |
| From the number of XX households in this village, how many are non-farmers? | | 2 |
| From those who are non-farmers: | How many households work as hunters? | 21 |
| | How many households work as lumberers or rattan collectors? | 22 |
| | How many collect orchids in the forest? | 23 |
| | How many households are traders? | 24 |
| | How many are entrepreneurs (eg. run a small shop, run a beauty salon...) | 25 |
| | How many are civil servants? | 26 |
| | Others wage laborers in private households/businesses | 27 |

[XX = the total number of households (question 2, page 2)
*CHECK WHETHER 1 + 2 = XX     11 + 12 + 13 + 14 = 1     21 + 22 +23 + 24 + 25+26+27 = 2 ]*

| | | |
|---|---|---|
| 2. How is the availability of food in this village? | Plenty = 1; Enough = 2; Inadequate = 3 | |
| How was the availability of food in this village in 2001? | Plenty = 1; Enough = 2; Inadequate = 3 | |
| How was the availability of food in this village in 1996? | Plenty = 1; Enough = 2; Inadequate = 3 | |
| How was the availability of food in this village in 1991? | Plenty = 1; Enough = 2; Inadequate = 3 | |
| How was the availability of food in this village in 1981? | Plenty = 1; Enough = 2; Inadequate = 3 | |

3. Have households suffered from food shortages since 2001? Never = 1; Sometimes = 2; Often = 3 [ ]

4.Have the villagers received any direct food aid from the government since 2001? YES=1; NO=2 [ ]

IF YES: When did the villagers receive the food aid? From [ ] Until [ ]

How many households have received this food aid?

1. (1- 25%) [ ] 2. (26 - 50%) [ ] 3. (51 - 75%) [ ] 4. (> 75%) [ ]

5. How many households can be characterised by at least 2 out of the following 3 categories?

| | Unit (specify) | # HH | In % |
|---|---|---|---|

1. The main house has a wall made out of stone with plaster.
2. At least one adult household member has finished secondary school.
3. The household has its own pit toilet.

6. How many households can be characterised by at least 2 out of the following 3 categories?

| | Unit (specify) | # HH | In % |
|---|---|---|---|

1. The main house has a wall made out of bamboo.
2. None of the adult household members has attended (or completed) primary education.
3. The household has no toilet facilities available (goes to the river or field).

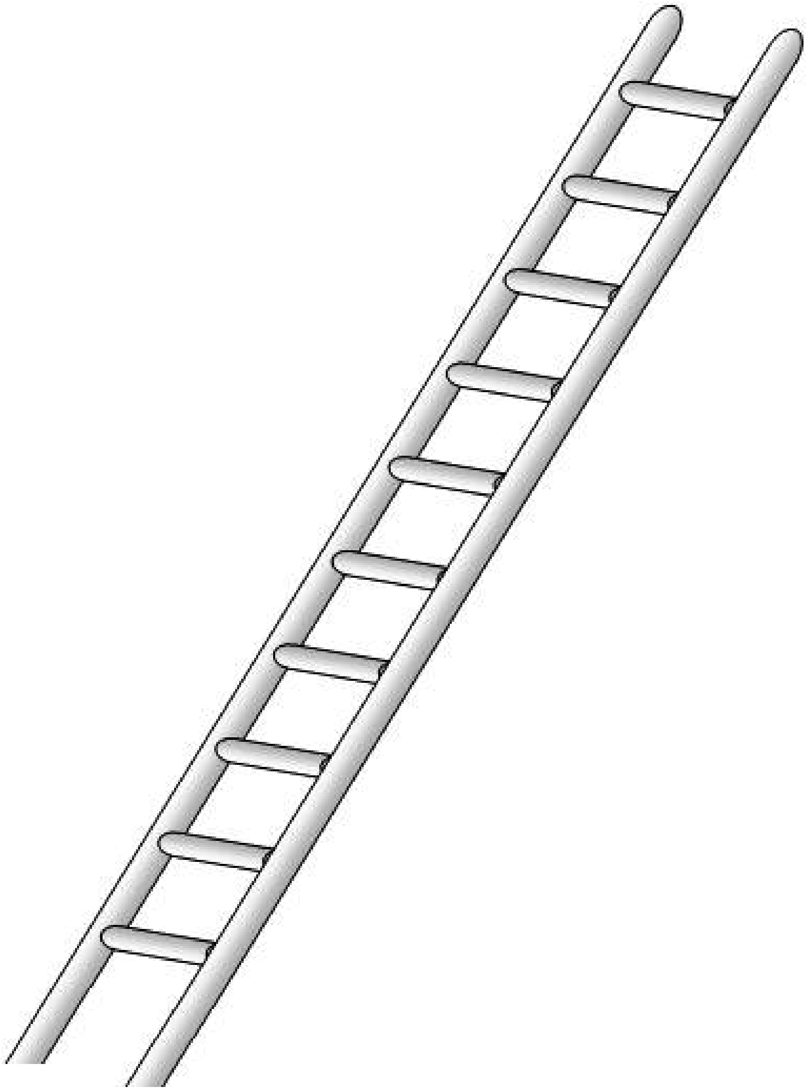
7. Here is a picture of a 10-step ladder. Imagine that at the bottom, on the first step, stand the poorest villages, and on the highest step, the tenth, stand the richest village of the Lore-Lindu area. On which step of this ladder is your village located today?

8. Where on the ladder would you locate your village 6 years ago (2001)?

9. Where on the ladder would you locate your village 11 years ago (1996)?

10. Where on the ladder would you locate your village 26 years ago (1981)?

***Self-assessment with ladder of life* -> Interviewer, Show the respondents a picture of a ladder with 10 steps:**



## SECTION 9: ENSO

1. Have you ever experienced drought periods which were longer and/or more severe than the usual dry season? YES=1; NO=2
   IF NO: *skip to section 10*

2. IF YES: Time and severity of the drought period(s) experienced.
   Please score the severity on a scale from 0 (= no negative impact on the village) to 5 (= very serious negative impact on the village).
   *(Ask about the most recent drought period first, then go to the previous one etc.)*

| | Year the drought occurred | Duration of the drought (months) | Severity score (0-5) |
|---|---|---|---|
| Last drought period | | | |
| Drought period before | | | |
| Drought period before | | | |
| Drought period before | | | |

*If any abnormal dry periods were experienced*:

3. Did you know in advance when a period of drought would come? YES=1; NO=2, IF NO: *skip to question number 4*

   How long in advance did you know? ______ weeks______ months

   Where did you get this information from? [ ]

   1=Television; 2=Radio; 3=Agricultural extension service (PPL); 4=Stars (specify):; 5=Animals (specify); 6=Others (specify):

4. Do you think that droughts will get more severe in the future as compared to the last 20 years? YES=1; NO=2 [ ]
   IF YES: Could you explain why?

**Direct effects of abnormal weather conditions**

For this section, refer to the most severe drought experienced. Refer to the most recent event if there are several of equal severities. If this leads you to an event experienced in 1999 or earlier, and there is a more recent event (2000 or later) with a severity score $\geq 3$, select the most severe recentevent.

5. Was there any negative effect on agricultural production in your village caused by the severe drought? YES=1; NO=2
   IF NO: Skip to question 9.

6. Did the severe drought cause any yield decline? YES=1; NO=2 ☐

IF YES: To which extent was the yield of the major crops affected by the drought?

Note: - Share of 'normal' yield is 100% if there was no yield decline at all; it is 0% if the crop failed completely.

| Major seasonal crops | Crop grown during the drought? YES=1; NO=2 | Share of a 'normal' yield? (%) | Major perennial crops | Crop grown during the drought? YES=1; NO=2 | Share of a 'normal' yield? (%) |
|---|---|---|---|---|---|
| Paddy rice | | | Coconuts | | |
| Dry-land rice | | | Coffee | | |
| Maize | | | Cacao | | |

7. Was the area of any of the following annual crops reduced or increased? Reduced=1; Increased=2; No change in area=3

1. Paddy rice ☐ 2. Dry-land rice ☐ 3. Maize ☐

8. Because of the drought, did farmers in your village grow any crop(s) that they you usually do not grow at all? YES=1; NO=2 ☐

IF NO: Skip to question 19.

9. Which crops have been grown instead? YES=1; NO=2

1. Maize ☐ 2. Peanut ☐ 3. Others (specify) ☐

10. Because of the drought did farmers: (YES=1; NO=2)

a. Change the amount of fertiliser normally applied? ☐

IF YES: Did the majority of the farmers changing the amount of fertiliser used increase (1) or decrease (2) fertiliser use?

b. Change the amount of pesticides/herbicides normally applied? ☐

c. Change the amount of labour normally applied? ☐

11. Because of the drought did households: (YES=1; NO=2)

a. Reduce the number of meals normally eaten? [ ]
b. Eat less expensive food? [ ]
c. Take children out of school? [ ]
d. Reduce clothing expenditures? [ ]
e. Reduce health expenditures? [ ]
f. Reduce expenditures for maintaining the house? [ ]
g. Reduce expenditures for social/family events? [ ]
h. Reduce other expenditures (specify)? [ ]

12. Because of the drought, did households utilise any sources of food which are usually not utilised at all? YES=1; NO=2 [ ]

13. Which additional sources of food have been utilised? YES=1; NO=2

1. Sago [ ] 2. Wild pig [ ] 3. Wild chicken [ ] 4. Bird's eggs [ ] 5. Bats [ ] 6. Others (specify) [ ]

14. Please score the availability of drinking water in your village on a scale from 1 (= totally insufficient) to 5 (= abundant).

'Normal' dry season before the drought: [ ]

During the drought in … (mentioned year): [ ]

15. Because of the drought, did households in your village raise income through sources which are usually not utilised, or which are usually utilised to a much lesser extent (excluding the sale of assets)? YES=1; NO=2 [ ]

16. Which additional sources of income did they utilise? YES=1; NO=2

a. Selling rattan: [ ]

b. Selling wood from the forest:

c. Remittances:

d. Temporary agricultural employment within the village:

e. Temporary agricultural employment outside the village:

f. Temporary non-agricultural employment within the village:

g. Temporary non-agricultural employment outside the village:

h. Others (specify):_________________________________

17. Because of the drought, did children (age < 18 years) who are usually not involved in income generation, get involved in income generating activities? YES=1; NO=2

18. Because of the drought did households: YES=1; NO=2…

a. Take a loan (in cash or in kind):

b. Sell any assets:

19. Do households in the village take any of the following **precautionary** measures to mitigate the effects of a **possible** severe drought event: YES=1; NO=2

a. Plant drought tolerant crops/varieties:

b. Have non-agricultural income source(s):

c. Keep food stocks:

d. Keep livestock for selling in case of drought

e. Keep cash savings

f. Be a share tenant

g. Others (specify):_____________________________________

## SECTION 10: FUTURE CHALLENGES

Imagine in ten years time, when children in your village who are currently 10 years old will then be 20 years old and responsible for their own families.

What do you think are the **three** major challenges for them when living in this village?
*Don't read the mentioned answers to them, but tick the appropriate box if mentioned*

Conflicts: Ethnic ☐ ☐ ☐ Religious ☐ Migrants-locals Population growth

Limited access to land for agriculture ☐ ☐ Tenure security

Droughts ☐ ☐ Lack of water for household use Lack of water ☐ agriculture/floods/erosion

Lack of rattan availability ☐

Lack of jobs outside agriculture ☐

Lack of adequate education/ health services ☐

Low prices for agricultural products ☐

Others, please write:________________________________________ ☐

## SECTION 11: KKM/CCA (COMMUNITY CONSERVATION AGREEMENTS)

**ALL QUESTIONS ARE APPLICABLE FOR ALL VILLAGES IN SAMPLE:**

1. Since when, has the village resided in its current location? (year)

Before this time was the village located inside the boundaries of LLNP? Yes/no

| | | | | | | |
|---|---|---|---|---|---|---|
| Why did it move at this time? | To find new land for agriculture | | Establishment of LL National Park | | Other – please describe | |
| Did the village receive anything when it moved? | Cash – how much? | | Social developments – please describe | | Agricultural assistance | |
| | Other – please describe | | | | | |
| If YES, who gave this? | Central government | | Local government | | NGO | |
| | Other – please describe | | | | | |
| Why was this given? | To compensate village for moving out of LLNP | | Other (please describe) | | | |
| Would you like to move back? | Yes/no | | | | | |

(NOTE on following questions: a 'KKM' refers to any kind of agreement made with an NGO (TNC, CARE, JAMBATA, YTM etc) over community forest use and not just agreements made with TNC): (KKMA/KKM)

2. Does the community have knowledge of KKMs in other communities? Yes/no

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| If YES, when did you know? | Before 1999? | Yes/no | | | Between 1999 and 2001? | Yes/no | | | After 2001? | Yes/no | | |
| Did you gain positive, negative or both positive and negative knowledge? | Before 1999? | + | - | Both | Between 1999 and 2001? | + | - | Both | After 2001? | + | - | Both |

If this community had a KKM, did it already have knowledge of KKMs in other communities:

| | | | | | |
|---|---|---|---|---|---|
| Before negotiations began for the KKM? | Yes/no | If YES, what kind of knowledge (describe) | | | |
| | | Would you describe this as positive, negative or both? | + | - | Both |
| During KKM negotiations? | Yes/no | If YES, what kind of knowledge (describe) | | | |
| | | Would you describe this as positive, negative or both? | + | - | Both |
| After KKM negotiations completed? | Yes/no | If YES, what kind of knowledge (describe) | | | |
| | | Would you describe this as positive, negative or both? | + | - | Both |

3. Why did KKMs in Lore Lindu begin?

| | | | |
|---|---|---|---|
| Don't know | Yes/no | To allow communities to use forest inside LLNP | Yes/no |
| To give forest rights to communities | Yes/no | To stop forest degradation in LLNP | Yes/no |
| Other (please describe) | | | |

4. Does the community have knowledge of other communities moving out of LLNP? Yes/no

| | | | | | | |
|---|---|---|---|---|---|---|
| If YES, when did you know?? | Before 1999? | Yes/no | Between 1999 and 2001? | Yes/no | After 2001? | Yes/no |

| | | | | |
|---|---|---|---|---|
| When did other communities stop moving out of LLNP? | They did not stop moving | | Before 1999 | |
| | Between 1999 and 2001 | | After 2001 | |

If this community had a KKM, did it already have knowledge of other communities moving out of LLNP:

| | | | | | |
|---|---|---|---|---|---|
| before KKM negotiations begun? | Yes/no | during KKM negotiations? | Yes/no | after KKM negotiations completed? | Yes/no |

5. Were there any conflicts over forest use or forest conversion in LLNP between this community and other villages? Yes/no

If YES, please describe:

| | | | | | | |
|---|---|---|---|---|---|---|
| When did this conflict first occur? | Before 1999? | Yes/no | Between 1999 and 2001? | Yes/no | After 2001? | Yes/no |

If this community had a KKM, did conflict occur:

| | | | |
|---|---|---|---|
| Before negotiations began for the KKM? | Yes/no | If YES, what kind of conflict (describe) | |
| During KKM negotiations? | Yes/no | If YES, what kind of conflict (describe) | |
| After KKM negotiations completed? | Yes/no | If YES, what kind of conflict (describe) | |

6. Were there any conflicts over forest use or forest conversion in LLNP between this community and the NP authorities? Yes/no

If YES, please describe:

| | | | | | | |
|---|---|---|---|---|---|---|
| When did this conflict first occur? | Before 1999? | Yes/no | Between 1999 and 2001? | Yes/no | After 2001? | Yes/no |

If this community had a KKM, did conflict occur:

| | | | |
|---|---|---|---|
| Before negotiations began for the KKM? | Yes/no | If YES, what kind of conflict (describe) | |
| During KKM negotiations? | Yes/no | If YES, what kind of conflict (describe) | |
| After KKM negotiations completed? | Yes/no | If YES, what kind of conflict (describe) | |

7. Was the community aware of any conflicts over forest-use or forest conversion in LLNP among other communities? Yes/no

If YES, please describe:

| | | | | | | |
|---|---|---|---|---|---|---|
| When did this conflict first occur? | Before 1999? | Yes/no | Between 1999 and 2001? | Yes/no | After 2001? | Yes/no |

If this community had a KKM, did conflict occur:

| | | | |
|---|---|---|---|
| Before negotiations began for the KKM | Yes/no | If YES, what kind of conflict (describe) | |
| During KKM negotiations | Yes/no | If YES, what kind of conflict (describe) | |
| After KKM negotiations completed | Yes/no | If YES, what kind of conflict (describe) | |

8. What forest rules did the community have?

| | Before 1999 | Between 1999 and 2001 | After 2001 | Today |
|---|---|---|---|---|
| 1. Rules about the allowed number of woodcuts | | | | |
| 2. Rules about the agricultural land expansion | | | | |
| 3. Rules about crop expansion | | | | |
| 4. Rules about using and selling timbers | | | | |
| 5. Rules about collecting, using and selling rattans | | | | |
| 6. Rules about selling the non-timber products | | | | |
| 7. Rules about hunting | | | | |
| 8. Others (Please explain) | | | | |

<u>If the community has a KKM:</u>

| | Which of these forest rules did it have <u>before</u> negotiations for the KKM? | Did any of these forest rules change <u>during</u> negotiations for the KKM? |
|---|---|---|
| 1. Rules about the allowed number of woodcuts | | |
| 2. Rules about the agricultural land expansion | | |
| 3. Rules about crop expansion | | |
| 4. Rules about using and selling timbers | | |
| 5. Rules about collecting, using and selling rattans | | |
| 6. Rules about selling the non-timber products | | |
| 7. Rules about hunting | | |
| 8. Others (Please explain) | | |

# CURICULUM VITAE

**First and Last Name:** Sunny Winujiwati Hotmarisi Reetz
**Date of Birth:** November 10, 1974
**Nationality:** Indonesian
**Gender:** Female

| | | |
|---|---|---|
| **Education:** | At present | Ph.D. candidate at the Department of Agricultural Economics and Rural Development, Faculty of Agriculture, Georg-August-Universitaet Goettingen, Germany<br><br>Dissertation topic: "Effects of Land use, Agricultural Market, and Poverty on Tropical Deforestation: Evidence from the Protected Forest Margins Areas in Central Sulawesi Indonesia" |
| | April 2006 | Master's Degree in Tropical and International Agriculture, Institute of Rural Development, Faculty of Agriculture, Georg-August-Universitaet Goettingen, Germany.<br><br>Thesis title: "Market Integration and Trade Liberalisation Policy Analysis of Sugar in Indonesia and the World Market". |
| | April 1998 | Bachelor's Degree in Agricultural and Resource Economics, Social Economic Department, Faculty of Agriculture, Bogor Agricultural University (IPB), Bogor, Indonesia.<br><br>Thesis title: "Farm and Marketing Analysis of Fresh Bananas, Case Study in Sadeng Village, Bogor Sub-District". |
| **Work Experience:** | 2006–now | Research Associate at the Department of Agricultural Economics and Rural Development, Faculty of Agriculture, Georg-August-Universitaet Goettingen, Germany |
| | 2001–2002 | Project Development Officer<br>PT. Agronetcom Indonesia-Agribusiness Consultant, Jakarta, Indonesia. |
| | 1999–2001 | Project Coordinator<br>World Vision International (NGO), Jakarta, Indonesia. |

**Publications and Presentations:**

Reetz, S. 2008. Socioeconomic Dynamics and Land Use Change of Rural Communities in the Vicinity of the Lore Lindu National Park. STORMA (Stability of Rainforest Margins) project. Discussion Paper series no. 28.

Reetz, S. The Dynamics of Cacao Agro-forestry in the Margins of Protected Forest Areas. Paper presented at the Tropentag Conference, Hamburg, Germany, 2009.

Reetz, S. The Dynamics of Cacao Agro-forestry in the Margins of Protected Forest Areas. Paper presented at the 2nd World Agro-forestry Conference, Nairobi, Kenya, 2009.

Reetz, S. and Bruemmer, B. Determinants of Forest Cover Dynamics in the Margins of Protected Forest Areas. Poster presentation at the Tropentag Conference, Zurich, Switzerland, 2010.

Reetz. S. and Brüemmer, B. Determinants of Land Use Change Dynamics in the Margins of Protected Forest Areas. Paper presented at the European Association of Agricultural Economists (EAAE) Congress, Zurich, Switzerland, August to September 2011.

Reetz. S., Brüemmer, B., and Schwarze, S. 2011. Poverty and Tropical Deforestation in Forest Margin Areas: Evidence from Central Sulawesi, Indonesia. Paper presented at the Tropentag Conference, Bonn, Germany, October 2011.

**Research Interests:**

REDD (Reducing Emissions from Deforestation and Forest Degradation) in developing countries, payments for environmental services, agricultural land use change, agricultural prices and policy, sustainable agroforestry systems. General interest in project planning and management, including monitoring and evaluation

**Language Skills:**

Bahasa Indonesian (native), English (fluent spoken and written), German *(upper-intermediate knowledge), Spanish (lower-intermediate knowledge),* French (lower-intermediate knowledge).