

**Josef G. Knoll-Wissenschaftspreisträger 2004**

**Josef G. Knoll-Science Award Winner 2004**

**Miet Maertens “Economic Modeling of Agricultural Land-Use Patterns in Forest Frontier Areas”, University of Goettingen, 2003**

#### Summary

The objective of this study was to identify the economic factors influencing land use and to explain and quantify the effects for the Lore Lindu region in Central Sulawesi. We aimed at understanding the underlying microeconomic decision-making process that leads to certain land-use patterns and causes land-use changes such as deforestation and agricultural expansion. We developed and elaborated different analytical models and estimated three econometric models using socioeconomic survey data and geographic data from the Lore Lindu region. The combination of analytically founded empirical models at the aggregate village level and the spatially disaggregated pixel level resulted in a profound understanding of the economic processes associated with land use in the Lore Lindu region.

The application of a Chayanov-type agricultural household model with varying assumptions about the functioning of labor markets and with a distinction between lowland and upland agriculture has provided useful insights into the factors influencing households' land allocation decisions. Three main conclusions resulted from the analytical considerations. First, the way in which the factors hypothesized to influence land use (e.g. population, technical change, prices, etc.) affect land allocation decisions depends to a large extent on how well households are integrated in product and factor markets. Second, the impact of technical change on land allocation critically depends on the factor intensity of the technology. Third, changes that are specific to the lowland or upland sector (e.g. prices, technology, etc.) might have a large impact on land allocation in the other sector if households can shift resources between the sectors. Because they provide a more comprehensive approach than subsistence or open-economy models that have been used more often in economic land-use studies, we conclude that Chayanov-type models are better suited to model land allocation decisions, especially in the context of rural areas in developing countries.

We elaborated on the von Thunen - Ricardo land rent model developed and applied in spatially explicit economic land-use studies, which has contributed to an improved description of spatial land-use patterns in forest frontier areas. By considering village-level relative prices instead of plot specific absolute prices, we could take into account differences in the location where labor, agriculture outputs, and inputs are traded. In addition, Chayanov-type features were included by assuming local relative wages to depend on household- and village-specific characteristics. Next to the role of transport costs and access to markets, the specification of the model allowed us to emphasize more precisely the impact of population and differences in labor and capital intensity between land-use systems. The refinement of the von Thunen - Ricardo land rent model presented in this work might be a first step in the direction of incorporating a more realistic description of economic behavior into spatial land-use models.

We estimated village-level empirical models based on the analytical Chayanov-type models and a spatially explicit statistical model based on the refined von Thunen - Ricardo model. The empirical results from the different models and a comparison of these results has led to important findings concerning the economic factors associated with land use in the Lore Lindu region. First, expansion of the agricultural area is to a large extent driven by population growth. Second, irrigation development substantially reduces agricultural expansion and pressure on forests. Third, mechanization and other labor-saving technologies increase agricultural expansion in forest margins. Fourth, plots with a higher natural productivity are taken into cultivation sooner but a larger amount of more productive land reduces the expansion of the agricultural area. Fifth, agricultural expansion is highest in villages partially integrated in markets. Sixth, better market access and higher natural productivity are associated with reduced agricultural expansion in the short run but might have a land expansionary effect in the long run due to increased migration and population growth. Seventh, the agricultural frontier is driven further into forests if agricultural land-use systems are less labor intensive. In line with these findings, some policy recommendations were made. Trade-offs between environmental goals and socioeconomic goals can be minimized by focusing rural development policies on road intensification and promoting labor-intensive farming systems and technical progress. Road expansion and labor-saving technical change could be detrimental from an environmental point of view. In addition, rural development policies should be complemented with the direct protection of the environmentally most valuable forests and ecosystems.

The combination of analytical and empirical models in this study has provided a good basis for a profound understanding of how certain key economic factors influence land use. The application of a Chayanov-type model and the refinement of the von Thunen - Ricardo land rent model contributed to the comprehension of farmers' land allocation decisions. In addition, analyses at an aggregate level and a spatially disaggregated level were proven to be highly complementary, leading to additional insight. However, the study also has some limitations. The land-use analyses in this work concentrated completely on agriculture to examine the driving forces of agricultural land-use trends and the interactions between forest and agriculture. An economic assessment of land use in forest frontier areas could be improved by taking into account the benefits farmers derive from forests, mainly by extraction of wood and non-timber forest products. Moreover, most of the analyses were static and considered only one point in time. Therefore certain economic processes that are occurring simultaneously with land-use change processes could not be considered. The process of institutional change was mentioned only briefly in the descriptive analysis but not considered in further econometric analysis. Also, we only looked at migration originating outside the research region and contributing to population growth in the region. Internal migration was not considered. In this study we focused more on processes of technical progress, market development and population growth. Issues such as institutional change, migration, etc. could be dealt with more thoroughly if changes over time are considered or by using dynamic models.

The data set including village-level socioeconomic data and GIS data, which was compiled for this study has provided a rich body of information for modeling land use. With the village as focus for the empirical analysis we have taken into account that decisions taken by single households might have consequences for land use that are apparent only at a broader level. In addition, the combination of spatial data and village-level data has proven to be an adequate method for an economic approach to spatial land-use modeling. The availability of GIS and satellite imagery data has created new opportunities and challenges for spatially explicit

econometric analysis within agricultural economics research. As shown in this study, some caution is required with the use of such data. Land-use data derived from satellite image interpretation can be imprecise for a variety of reasons. These issues have often been ignored in spatial economic studies and should receive more attention. Unfortunately, the estimation of a spatial model of land-use changes was not possible due to the lack of historical land use data. In addition, the spatial land-use model would have been better defined if climate data, better soil data, etc. had been available. Also, the use of village-level data brings on certain limitations. For example, the effect of poverty on land use and deforestation was not considered in this study although this is an important and controversial issue. Poverty and other household-specific aspects (e.g. use of fertilizers, access to capital, etc.) are difficult to measure at the village level. Therefore a combination of household- and village-level data could improve economic land-use studies. Data collected at the household level could also greatly improve spatially explicit land-use analysis. This does not necessarily include that household data should be attached to single plots or pixels. Household data could be aggregated to the village level and capture certain distributional aspects in spatial land-use models that combine spatial data with village-level data.

In conclusion, the models presented together with the descriptive analysis have resulted in a good comprehension of the economic factors associated with land-use trends. The study is particularly strong in explaining how population growth, market development and technical progress influence land use. The future direction for this research should aim to include the analysis of land-use changes over time and incorporate household-level data in aggregated as well as spatially disaggregated land-use models.

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