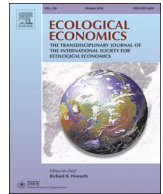




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## Analysis

## Land Property Rights, Agricultural Intensification, and Deforestation in Indonesia

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## ABSTRACT

The expansion of agricultural land remains one of the main drivers of deforestation in tropical regions. Stronger land property rights could possibly enable farmers to increase input intensity and productivity on the already cultivated land, thus reducing incentives to expand their farms by deforesting additional land. This hypothesis is tested with data from a panel survey of farm households in Sumatra. The survey data are combined with satellite imageries to account for spatial patterns, such as historical forest locations. Results show that plots for which farmers hold formal land titles are cultivated more intensively and are more productive than untitled plots. However, due to land policy restrictions, farmers located at the historic forest margins often do not hold formal titles. Without land titles, these farmers are less able to intensify and more likely to expand into the surrounding forest land to increase agricultural output. Indeed, forest closeness and past deforestation activities by households are found to be positively associated with current farm size. In addition to improving farmer's access to land titles for non-forest land, better recognition of customary land rights and more effective protection of forest land without recognized claims could be useful policy responses.

## 1. Introduction

Deforestation remains a widespread problem, especially in tropical regions. Between 2010 and 2015, about 6 million hectares of tropical forest were lost annually (FAO, 2016), entailing severe negative consequences for biodiversity, ecological systems, and climate stability (Fearnside, 2005; Butler and Laurance, 2009; Wilcove et al., 2013; Barnes et al., 2014). Agricultural area expansion is one of the main drivers of deforestation (Gibbs et al., 2010), and demand for agricultural output will further increase due to population and income growth. In addition to food, global demand for feed, fuel, and other biomass-derived renewable resources will grow substantially over the coming decades (Alexandratos and Bruinsma, 2012; Valin et al., 2014). These developments threaten the conservation of the remaining tropical forest (Laurance et al., 2014). Increasing agricultural yields on the land already cultivated, through higher input intensity and use of better technology, could be one important way to meet the rising demand and reduce further deforestation (Green et al., 2005; Ewers et al., 2009; Phalan et al., 2011a; Stevenson et al., 2013). To be sure, agricultural intensification is not a magic bullet to conserve tropical forest and

related ecosystem functions (Steffan-Dewenter et al., 2007; Perfecto and Vandermeer, 2010; Tschamtkte et al., 2012). Effects will vary with the type of intensification and also with the institutional and policy context in a particular setting. Better knowledge is required about how land-sparing agricultural intensification can be implemented locally, and why past efforts have often failed. Empirical research in this direction is scant.

Here, we propose that land property rights are fundamental for agricultural production and deforestation outcomes. Land is the main source of farmers' livelihoods and also a major means for accumulating and inheriting wealth. The institutions shaping access, use, and transfer of land are hence central for farmers' decision-making (Deininger and Feder, 2001). Ownership regulations for forest land and for agricultural land often differ. The available literature on the links between land property rights and deforestation focuses primarily on the effects of secure tenure for forest land (Araujo et al., 2009; Damnyag et al., 2012; Liscow, 2013; Robinson et al., 2014). For agricultural land, studies have analyzed effects of tenure security on input intensity and crop productivity (Deininger et al., 2011; Fenske, 2011; Bellemare, 2013), yet without linking this to potential deforestation outcomes. To address this

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gap, we use comprehensive data from Sumatra, Indonesia, one of the hotspots of recent rainforest loss due to agricultural area expansion (Margono et al., 2014; Gatto et al., 2015; Clough et al., 2016). Data from a farm household survey, a village survey, and satellite imageries are combined to examine relationships between land ownership rights, agricultural production intensity, and farm size expansion into forest areas.

In Indonesia, small farms as well as large logging and agribusiness companies contribute to deforestation (Rudel et al., 2009a; Cacho et al., 2014). Overall, the share of land deforested by companies is larger than the share of land deforested by smallholder farmers. While precise data are not available, smallholders may have contributed < 20% to overall deforestation in Indonesia in recent decades (Lee et al., 2014). However, there are at least two reasons why a focus on small farms – as taken in this study – is relevant nevertheless from a policy perspective. First, in Indonesia the role of smallholders in cultivating plantation crops, such as oil palm and rubber, continues to grow (Euler et al., 2017). Second, deforestation by smallholder farms is more difficult to monitor and control (Krishna et al., 2017b; Kubitza et al., 2018). Whereas large companies usually operate based on government concessions, smallholder decisions to clear forest land are individual responses to various incentives and constraints. Such behavioral responses need to be better understood, in order to design and implement effective policies.

For private farms, land titles can increase agricultural intensity and productivity through three effects (Feder and Feeny, 1991; Besley, 1995; Deininger et al., 2011). First, the *assurance effect*, incentivizing higher investment because farmers are more secure to also reap the benefits from long-term measures to improve land quality and yield potential. Second, the *collateralization effect*, allowing better access to investment capital because land titles can be used as collateral in formal credit markets. Third, the *realizability effect*, resulting from more efficient land allocation given that titled land facilitates land market transactions. The empirical literature largely confirms these effects (Banerjee et al., 2002; Goldstein and Udry, 2008; Holden et al., 2009; Deininger et al., 2011; Fenske, 2011; Grimm and Klasen, 2015; Lawry et al., 2016), although in some cases the influence of land titling or more secure property rights was found to be insignificant (Quisumbing and Otsuka, 2001; Brasselle et al., 2002; Jacoby and Minten, 2007; Bellemare, 2013).

An increase in farm productivity induced through land titles could reduce deforestation (Angelsen and Kaimowitz, 2001). Higher output from the already cultivated land reduces the pressure to convert additional forest land. Also, a more productive agricultural sector could spur broader economic development, reducing population growth, enhancing non-agricultural income opportunities for rural households, and improving land-governance capacities and institutions. Empirical evidence for these types of effects is scarce, although a few studies show indeed that higher farm productivity can help spare natural habitat from agricultural conversion (Barbier and Burgess, 1997; Ewers et al., 2009; Phalan et al., 2011b). On the other hand, agricultural productivity growth could also be associated with higher rates of deforestation, for instance, by increasing the cost of forest conservation programs or by stimulating in-migration and road infrastructure investments in rural areas (Maertens et al., 2006; Phelps et al., 2013). Better understanding the complexities in concrete situations can help design appropriate policies aimed at promoting more sustainable development.

In Indonesia, much of the land that farmers use is not formally titled (Krishna et al., 2017b). Privately owned land can be titled, but the costs for farmers are relatively high. Additionally, farmers located close to the forest suffer from ambiguous ownership structures. Most of the forest land is formally owned by the state and not eligible for private titling (Agrawal et al., 2008). But the boundaries are not always clear-cut. Some of the land that farmers have cultivated for long officially counts as forest land. Moreover, local communities have customary

claims and deforest land even when the newly obtained plots cannot be titled (Resosudarmo et al., 2014). The motivation to deforest will likely increase when farmers have no titles for their already cultivated land and therefore limited ability and incentives to intensify production.

To answer the question whether providing secure titles for agricultural land could help to reduce deforestation, two sub-questions will have to be addressed. First, do land titles increase agricultural intensity and productivity? Second, does higher productivity on the already cultivated land reduce farmers' incentives to clear additional forest land? The first sub-question will be addressed by comparing input use and crop productivity on farms with and without land titles and controlling for other relevant factors. The second sub-question is less straightforward to answer, because this would require farm-level data on crop productivity in the past, which we do not have. However, we address this sub-question indirectly by analyzing the relationship between the possession of land titles, historical forest coverage, deforestation activities of farm households, and farm size in a spatially explicit way. In addition, we look at the association between current crop productivity and farm size, which – together with the other results – may allow some cautious conclusions on the role of land titles for deforestation and the underlying mechanisms.

## 2. Data

### 2.1. Socioeconomic Data

This research builds on data collected in Jambi Province on the island of Sumatra, Indonesia. Jambi has been one of the regions with rapid loss of tropical rainforest over the last few decades. Forest cover in Jambi declined from about 48% in 1990 to 30% in 2013 (Drescher et al., 2016). Nevertheless, 43% of Jambi's total area was officially categorized as state forest in 2000 (Komarudin et al., 2008). Agricultural production in Jambi is dominated by plantation crops, especially rubber (*Hevea brasiliensis*) and oil palm (*Elaeis guineensis*). Rubber is primarily grown by local farmers with only some involvement of large-scale companies. Companies are more involved in oil palm, but even in oil palm > 40% of the area is cultivated by smallholder farmers (Euler et al., 2017). That smallholders contribute to deforestation in Jambi in a significant way was underlined in a recent study (Krishna et al., 2017b), who showed that 18% of the rubber and oil palm plots cultivated by smallholders were acquired through direct forest appropriation.

A survey of farm households was conducted in Jambi in two rounds, 2012 and 2015, as part of a larger interdisciplinary research project (Drescher et al., 2016). A multi-stage sampling framework was used to obtain a representative sample of local farm households. At the first stage, five regencies of Jambi located in tropical lowland rainforest areas were selected. At the second stage, a total of 40 villages were randomly selected in these five regencies. In addition, five villages, where more intensive measurements by other teams of the same research project were ongoing (Drescher et al., 2016), were purposively selected, resulting in a total of 45 villages. In these villages, around 700 households were randomly selected proportional to village size. There are two types of villages in Jambi, autochthonous and transmigrant villages. Transmigrant villages were established as part of the government's transmigration program (Gatto et al., 2017). Most households in transmigrant villages were allocated titled land by the state and started producing plantation crops under contract with one of the large public or private companies. Hence, the institutional and agricultural production conditions are quite different. In this research, we only consider the 34 autochthonous villages in the sample, with 473 farm household observations in 2015 (and 471 household observations in 2012). Out of these, around 25% are migrants (Table A1 in the Online Appendix), but these migrants in autochthonous villages did not come as part of the government's transmigration program (Gatto et al., 2015). Most of the households in the two survey rounds are identical. The attrition rate

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