ENDOGENOUS INSTITUTIONAL CHANGE AND ECONOMIC DEVELOPMENT: A MICRO-LEVEL ANALYSIS OF TRANSMISSION CHANNELS[1]

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Abstract—There is a well-known debate about the role of institutions in explaining the long-term development of countries. We believe there is value-added to consider the institutions hypothesis at the micro level within a country to analyze the exact transmission channels linking endogenous institutional change to development outcomes. Given the central importance of agricultural productivity improvements for initiating the process of economic development, we focus on the transmission mechanisms that lead to the emergence of institutions relevant for agricultural development, thereby incorporating insights from the literatures on demographic influences of institutional change, induced innovations, as well as the central role of land rights in our analysis. Our main argument is that in conditions of relative land abundance, geographic factors influence rural-rural migration flows to geographically well-endowed regions which in turn give rise to migration-induced land scarcity. Land scarcity in turn, provides incentives to formalize landownership. Eventually, formalized land rights increase investment in land and enhance the adoption of new and better technologies promoting agricultural growth and economic development. We provide empirical evidence for this hypothesis using longitudinal village and household survey data from Indonesia.

Key words—Geography, migration, land titles, institutions, agricultural development, Indonesia.

***JEL*-Codes:** K11, O12, Q12.

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1 Introduction

There is well-known debate about the respective roles of geography versus institutions in explaining the large differences in income per capita across countries. While some authors (e.g. Jones, 1981; Diamond, 1997; Bloom and Sachs, 1998; Gallup *et al*., 1998; Sachs and Warner, 1999; Sachs, 2003; Hibbs and Olsson, 2005) argue that geographic factors, such as location in the tropics, being land-locked and distant from markets, or being susceptible to particular diseases have a direct impact by reducing the economic potential of countries and regions, the opposing view is that institutions such as property rights, government effectiveness and the rule of law are much more important determinants of long-term economic progress (e.g. Knack and Keefer, 1995; Hall and Jones, 1999; Acemoglu *et al.*, 2001; Easterly and Levine, 2003; Rodrik *et al.*, 2004; Acemoglu *et al.*, 2005; Galor *et al.*, 2009). Those in the latter camp allow, however, for the fact that institutions have evolved endogenously responding to, among other things, geographic conditions (see e.g. Acemoglu *et al.*, 2001; Engerman and Sokoloff, 1997, 2002; Galor *et al.*, 2009).

The empirical debate between both camps has usually been based on cross-country regressions where questions about parameter heterogeneity, unobserved heterogeneity, and endogeneity cannot easily be controlled for. Moreover, these studies are relatively silent about the nature of the relevant institutions, how exactly these institutions emerged and how they shaped the pattern of economic development. Typically used proxies for institutions such as "social infrastructure"[2] (used in Hall and Jones, 1999), "the risk of expropriation of private foreign investment by government" (used in Acemoglu *et al.,* 2001) or Kaufmann's institutions index[3] (used in Easterly and Levine, 2003) are rather broad measures and say little about the precise transmission mechanisms that led to these particular institutions as well as the transmission mechanisms from these institutions to economic outcomes. Also, most of these studies lump together growth that emanated largely from agricultural productivity improvements and growth that was result of industrialization where different sets of institutions might be relevant.[4]

Given the central importance of agricultural productivity improvements for initiating the process of economic development and for poverty reduction throughout the development process,[5] our analysis will focus on the transmission mechanisms that lead to the emergence of institutions and their impact on agricultural growth and development. When focusing on these transmission mechanisms, three other strands of the literature appear to be relevant: First, the work by Boserup (1965, 1981) and Kremer (1993) (and extensions by Klasen and Nestmann (2006)), which emphasize the role of demographic factors in facilitating technological improvements; second, the works by Hayami and Ruttan (1985) on induced innovations in agriculture, and more generally North (1981) on institutional change, both of which emphasize the endogenous nature of institutional and technological change; and, third, the literature on the role of land rights as a central institution influencing technological

[2] This index combines a "government antidiversion policy index" and an index of "Openness to Trade" (Hall and Jones, 1999).
[3] Kaufmann's institutions index is the aggregation of six sub-indices: Voice and accountability, Political instability and violence, government effectiveness, regulatory burden, rule of law and graft (Kaufmann *et al.*, 1999).
[4] Galor *et al.* (2009) who carefully distinguish between agricultural modernization and industrialization as different phases in economic development are a notable exception.
[5] See World Bank (2007), for a careful assessment of the role of agricultural development for growth and poverty reduction.

improvements and investment decisions in agriculture (e.g. Binswanger *et al.*, 1995; De Soto, 2000; Deininger, 2003; Goldstein and Udry, 2008).

We believe there is value-added to examine the transmission mechanisms implied by the institutions hypothesis at the micro level in the more homogenous setting of a single country, where concerns about parameter heterogeneity and unobserved heterogeneity are arguably less serious than with cross-country regressions.[6] Moreover, by focusing on the emergence of institutions in agriculture and their impact on technological change and investments there, we are able to link our analysis to these three literatures on the determinants of institutional and technological change in agriculture. In particular, we argue that migration-induced demographic pressure, which appears to be partly linked to geographic conditions, plays an important and direct role for the emergence and organization of institutions which in turn affects investment and technological change. Our general idea is that in conditions of relative land abundance, geographic factors influence rural-rural migration flows to geographically well-endowed regions which in turn gives rise to migration-induced land scarcity. Land scarcity in turn, provides incentives to formalize landownership. Eventually, formalized land rights increase investment in land and enhance the adoption of new and better technologies promoting agricultural growth and economic development.

In this paper we present detailed micro evidence for this causal chain using original village and household level data collected on the Indonesian Island of Sulawesi. Our results suggest that rural-rural migration is partly driven by the geographic attractiveness of potential destinations. In villages that receive large inflows of migrants and thus experience rising population density, conflicts about land occur more often. Such conflicts promote the emergence of formal land titling, which in turn increase investments in irrigation systems, terrace construction and perennial crop tree planting as well as the probability of adopting fertilizer, pesticides and improved seeds. Despite the spatially confined empirical setting, which of course has the advantage of allowing us to operate with very homogenous initial conditions, there is a large heterogeneity in migration flows, the emergence of land titles, investments in land, and the adoption of new technologies; studying the determinants of this heterogeneity is the central contribution of our paper. By demonstrating the empirical relevance of our proposed transmission mechanisms, we believe that we are able provide critical details on the emergence and relevance of institutions which complements the more macroeconomic and historical studies explaining long run differences in economic development across countries.

The remainder of our paper is organized as follows. Section 2 provides a literature review, and discusses the theoretical background of our study. Section 3 gives information about the empirical context of our study and presents the different data sets used to test the hypotheses discussed in Section 2. Section 4 analyzes the link from population pressure to institutional change and investigates the role of geographic conditions in causing such population pressure. Section 5 analyzes the link between institutions and agricultural investment. Section 6 concludes.

[6] See Voors and Bulte (2008) for another study that examines the role of institutions for growth at the micro level. They use household survey data for Burundi and focus on property rights security, local political leadership and social capital. They find property rights security to be a significant driver of long-term income.

2 Literature review and theoretical background

One of the most well-known contributions in the macro literature on the emergence and role of institutions in economic development is the work by Acemoglu *et al.* (2001) where geographic conditions, particularly a high disease burden, affected European settlement patterns which in turn led to extractive institutions in non-settler economies and development-friendly institutions in settler economies. Through historical persistence, so goes the argument, these institutions still heavily influence the economic fate of nations today.[7] We will similarly argue below that geographic conditions are an important driver of institutional change which in our analysis is the emergence of land rights.

Regarding the literature on the drivers of technological and institutional change in agriculture, the roles of demographic factors, in particular population growth and population density, and institutions were so far considered largely as two distinct and not necessarily connected factors influencing agricultural development. In particular Boserup (1965, 1981), followed later by Kremer (1993) and Klasen and Nestmann (2006) have emphasized that population size and density induce technological improvements and/or the adoption of existing technologies, and thus promote development. Other authors, such as North and Thomas (1973), North (1981, 1990) and Hayami and Ruttan (1985) have emphasized the role of institutions as a critical driver for agriculture development. Hayami's and Ruttan's (1985) 'Induced Innovation Hypothesis', for instance, argues that agricultural growth needs institutional structures that enable the society to generate new technologies (to ease the constraints on production by inelastic supplies of land and labor) and the non-agricultural sector to produce and transmit these innovations. The institutional structures, in turn, are induced by the expected returns of institutional change to political entrepreneurs or leaders. Thus a critical element in this process is an effective system of market and non-market information linkages among farmers, public research institutions, private agricultural supply firms, and political entrepreneurs or leaders. Related to that literature, a third literature investigating the effects of land rights on agricultural development, has received particular emphasis (e.g. Binswanger *et al.*, 1995; De Soto, 2000; Deininger, 2003; Goldstein and Udry, 2008). We think there is a link between the literature emphasizing the role of demographic factors and the one emphasizing the role of endogenous institutional change and that land rights play a key role as a transmission mechanism.

To provide some illustrative evidence to support our motivation, Figure 1 shows the relationship between the log of population density in 1970 (people per sqkm) and the log of agricultural land productivity (value added in PPP per agricultural land in sqkm) in 2005 across 64 countries retrieved from the World Development Indicators (www.worldbank.org). Population density and land productivity are positively correlated. The corresponding linear regression coefficient is 1.18 suggesting that a one percent increase in population density is associated with a 1.18 percent increase in land productivity.[8] Figure 2 shows the relationship

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[7] Galor *et al.* (2009) is another important study with some relevance for our analysis. They argue that in economies in which land was rather equally distributed, public education was implemented earlier and hence these economies could also earlier benefit from the emergence of a skilled-intensive industrial sector than economies marked by an unequal distribution of land. In the latter landowners had still a strong political influence and favored policies that deprived the masses from education, because they needed a cheap unskilled labor force. While the focus of their analysis is more on the institutional determinants of success in industrialization, their analysis also suggests an endogenous emergence of institutions (here, public education) where rural and arguably geographic conditions (land abundance) are a key driver in shaping the endogenous emergence of institutions and their development outcomes.

[8] See also Klasen and Nestmann (2006) who provide evidence for a strong correlation between historical population densities and subsequent economic development covering the period 1 A.D. to 1990.

between a "property rights and rule-based governance rating" (1=low to 6=high), also taken from the World Development Indicators data base,[9] and the log of population density in 1970. A clear positive correlation between population density and the quality of property rights and governance arises. Finally, Figure 3 shows the association between the quality of property rights (and governance) and agricultural land productivity. Again, the correlation is clearly positive.

[Please insert Figures 1 – 3]

These statistics obviously show only correlations and say nothing about possible causalities. To examine whether causal links are behind these relationships, we focus in the remainder of this paper not on a sample of countries but rather on samples of villages and households situated in Central Sulawesi, Indonesia. Although, the villages we analyze share many common features, in particular a common historical and colonial background, and are spread over a spatially relatively limited area, we show below that they also differ significantly with respect to their level and the dynamic of living standards, geography, technology and institutions. Some of these villages stagnated, while others developed fast in the past twenty years; similar variation exists with respect to the presence of formal land titles, technologies adopted and used, investments in land, and population and migration dynamics. We can draw on two original sources of information. A longitudinal village level data set and a household level data set. The latter was collected in selected villages covered by the village survey and in which different institutional structures co-exist.

Our hypothesis is that as long as labor is scarce and land abundant, villagers have little incentive to claim formal land tenure security. However, if the potential for the conversion of uncultivated wood- and grasslands as well as of primary forests is shrinking relative to labor due to population pressure induced by natural population growth and immigration, many villages have to confront serious land shortages. This increases the potential for conflict in villages. This is particularly the case if migration is the major driving force of population growth for the following reasons: First, migration usually means an increase in the number of (agricultural) households, and not just an extension of existing households, thus usually generating more pressure on available land; second, in our study area local villagers reported to feel disadvantaged if migrants get land from village leaders, sometimes fear expropriation, and also claim additional land or believe that the land given to the migrants belonged to them (Weber and Faust, 2006). Conflicts sometimes also arise between villagers and the government when laws and regulations prevent further land conversion. Our hypothesis is that this land scarcity and the resulting conflicts lead communities to strive for greater land security and thus initiate a demand-driven implementation of formal land titles.[10] Once, formal tenure security is established, not only the conflict potential is reduced, but villagers also have a stronger incentive to undertake investments in their land, land quality and new technologies, which in turn enhance agricultural growth. The following diagram summarizes this causal chain.

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[9] Collected through the World Bank's "Country Policy and Institutional Assessment" (CPIA).

[10] A different strand of the literature focuses on the evolutionary changes in *customary* land rights (in contrast to the implementation of *formal* land titles), and the effects of *customary* land tenure institutions on land use patterns (see Quisumbing and Otsuka, 2001; Otsuka, Quisumbing, Payongayong, 2003). An interesting finding of these studies with particular relevance for our analysis is that population pressure leads to an individualisation of customary land rights.

Migration induced population pressure → *Implementation of formal land titles* → *Investment in land quality and new technologies*

In Section 4 we analyze in detail the link between population pressure and tenure security. We also investigate the drivers of migration and show that geographic factors seem to play an important role. Thus similar to some of the more macroeconomic studies on the link between institutions and growth, we show that geography impacts on growth largely by affecting institutional change. In our case migration, population pressure and conflicts about land take the role of key transmission variables.[11]

To study the implications of endogenous land rights on growth, we then analyze in Section 5 the link from tenure security to investment decisions. Whereas the theoretical literature provides a number of arguments why land titling may foster agricultural development, the empirical evidence is rather mixed ranging from large positive to insignificant and even negative effects. Theoretically three arguments are particularly emphasized (see e.g. Feder and Feeny (1991), Feder and Nishio (1999) and Brasselle *et al*., 2002). First, tenure security increases the return on long-term land improvements and conservation measures and therefore farmers have a higher incentive to undertake investments (the '*assurance effect*'). Second, with land rights it is easier to sell or rent the land and thus to realize improvements made through investments enhancing such investments (the '*realizability effect*'). Third, land titles enable its holders to use land as collateral, which in turn facilitates access to credit and enables the farmer to finance investments, short-term such as fertilizer and pesticides (which often have to be financed in the pre-harvest period) and long-term such as tree planting, the construction of terraces or an irrigation system (the '*collateralisation effect*').

The empirical challenge in analyzing this relationship is to control for the possible endogeneity of land rights with respect to investment in land and the adoption of new technologies. This endogeneity can stem from different sources. Farmers may register more often parcels that benefit from relatively high levels of investment, or that more profitable farms make it easier to bear the costs of land registration. It might also be that investments such as tree planting are undertaken to enhance tenure security. However, the latter rather applies in a setting of informal land titling. Finally land rights have shown to depend on the way local authorities manage land resources, which can also entail an endogeneity problem (see Rozelle and Li, 1998).

Besley (1995) looked at two regions in Ghana and confirmed only for one of them the positive impact of land rights on investment. Braselle *et al.* (2002) analyzed a region in Burkina Faso and did also not find any systematic influence of land tenure security on investment. Jacoby and Minten (2007) analyzed the case of Madagascar and concluded similar to the former study that having a land title has no significant effect on plot-specific investment. Migot-Adholla *et al.* (1991) and Place and Hazell (1993) are other pessimistic examples for Sub-Saharan Africa. In contrast, Goldstein and Udry (2008) showed in a recent paper that in Ghana farmers who lack local political power are not confident of maintaining their land rights over a long fallow. As a consequence they fallow their land for much shorter durations than would be technically optimal, at the cost of a large proportion of their potential farm output. They suggest that in their setting the *assurance* effect of land rights is

[11] We do not exclude the possibility that there are also direct effects of geography on tenure security, i.e. individuals have a higher incentive to register land of higher quality, but hypothesize and show that the demographic channel is an important one.

particularly important and responsible for these large productivity effects of tenure security. They also argue that the importance of tenure security rises with rising land scarcity, which is particularly germane for our analysis. Other studies for Sub-Saharan Africa which show a positive impact of land titling on investment include Deininger and Jin (2006) and Deininger *et al.* (2008). Deiniger (2003, Chapter 2) provides a number of examples in particular from Asia and Latin America where land titles increased investment (see also Feder *et al.*, 1988; Jacoby *et al*., 2002; Bandiera 2007). Broeck, Newman and Tarp (2007) is another recent study which found a positive impact in Vietnam, but the authors emphasize that the positive effect only arises if land titles are exclusive and if they provide also ownership rights and not only user rights. More generally, formalization seems particularly attractive where traditional tenure systems are weak and unable to generate sufficient tenure security, where land is getting increasingly scarce, when the return on investment in land is high and where collaterized lending exists. These conditions are likely to apply in many regions in Latin America and Asia, including our study region, and some regions of Sub-Saharan Africa where land is increasingly scarce (Goldstein and Udry, 2008), but less so in many other parts of relatively land-abundant Sub-Saharan Africa which might explain the mixed evidence of the effects of land titling on investments there as suggested by many studies (see e.g. Migot-Adholla, 1991; Deininger *et al.*, 2008).

We investigate the link between land rights and investment decisions using both village level and household level data. The household level data allows us to control for plot characteristics and household fixed effects. In addition we rely on an instrumental variable strategy to account for the above mentioned endogeneity problems. We find strong evidence that land rights have a positive and significant effect on investment decisions such as land preparation expenditures, tree planting and terrace building.

Thus our study suggests and empirically confirms a link between Boserup's theory of demographically induced agricultural development and theories in the spirit of North that emphasize the role of institutional factors, in particular formal ownership rights, in affecting economic growth (North and Thomas, 1973; North, 1981, 1990; Hayami and Ruttan, 1985). In our view formal land titles, which provide the functions described above are the channel by which population pressure leads to increased investment and the adoption of new agricultural technologies.[12] Conversely, in areas with a low population density and low pressure on land, institutional change will not automatically emerge and economic development may be delayed.

3 **Data, study context and hypotheses**

3.1 Data

The longitudinal village level data set we use was collected during March to July in 2001 in the Lore Lindu region. This region includes the Lore Lindu National Park and the five surrounding sub-districts. It is situated south of Palu, the provincial capital of Central Sulawesi/Indonesia. The survey is part of an international and interdisciplinary research program known as "Stability of Rain Forest Margins" (STORMA) which studies the determinants of biodiversity and land use in this region and how such biodiversity can be protected through appropriate socioeconomic mechanisms. For the survey 80 of the 119

[12] In our study region, there are formal titles that are issued by the government and less formal ones that are based on purchase contracts or letters from the village head. The nature of these titles is less important than their ability to generate the three effects, an issue that we will discuss in detail below.

villages in the region were selected using a stratified random sampling method (Zeller, Schwarze and van Rheenen, 2002). The survey collected data on current and past demographics, land use practices and technology adoption, conflicts and the implementation of land rights, conservation issues, infrastructure and qualitative information on income and well-being. Additional information on geographic features was taken from secondary data sources and added to the data set by Maertens, Zeller and Birner (2006). It is important to note that the retrospective information on population size, migration, land rights and so on was taken from administrative records available in each village. Therefore this information is very reliable and not affected by recall bias. Interviews were held not only with the village leader but also with other persons who had good knowledge about the surveyed village. This again suggests that the quality of the data is quite high. Therefore, using this data set we can — in contrast to most of the macro-economic studies — use variations in migration flows, institutions and investment over space *and* time to test our hypotheses. Identification of our proposed causal chain is also facilitated by the fact that variations in the data over time and space are generally very large. However, a draw-back is of course the relative small sample size of only 80 villages.

Yet, to further substantiate our findings, we make also use of household survey data which was collected within the same research program mentioned above. In 13 out of the 80 villages covered by the village survey, a representative sample of 318 households were interviewed in 2001 regarding their activities, the acquisition and possession of land, land rights and land use practices. The information on agriculture is recorded on the level of plots allowing for a very detailed analysis of the relationship between household characteristics, land rights, investment and output.

Figure 4 shows a map situating the Lore Lindu region within the Island of Sulawesi and the location of the 80 villages which were covered by the village survey (empty circles). Villages marked with a filled circle are villages also covered by the household survey.

[please insert Figure 4]

3.2 Economic activity

The Lore Lindu region is rural. 87% of the 33,000 households living in the region depend economically on agriculture. 15% of the total area—excluding the National Park—is used for agricultural production. The rest of the area is mainly grasslands and forests. The principal food crop is paddy or sawah rice ('sawah' means wet rice field). Important cash crops are cocoa and coffee. Households mainly operate as smallholders (see Maertens *et al.*, 2006). Logging is either done informally, mainly for land conversion and not for selling the wood, or is done formally but then by companies from outside the Lore Lindu Region and has then only a marginal or even no impact on local incomes; compared to the rest of Indonesia (and other tropical forests), deforestation rates are, in any case, relatively low (see e.g. Erasmi and Priess, 2007).

Table 1 shows that the average population size per village was 730 in 1980 and increased to 1100 in 2001.[13] The smallest village in 2001 has 235 inhabitants the largest 4676. The average size of land used for agricultural production was 340 ha in 1980 and increased to 510 ha in 2001. The development of the land use pattern over time shows that a relatively stable

[13] We removed three villages from our sample for reasons discussed below.

share of 40 percent is used for paddy rice. The average share allocated to cash crops — cocoa, coffee and coconuts — increased from 25 percent to 46 percent over time reducing the share of land allocated to corn and other crops. As we will discuss in more detail below, the planting of cocoa and coffee trees involve heavy upfront costs, since these trees start producing beans only after three to five years. The last column of Table 1 shows also the means for the sub-sample of the 13 villages covered by the household survey. While these villages are on average a bit larger than the total sample of villages, there are quite similar in terms of their land use patterns.

[please insert Table 1]

86 percent of all villages had a primary school in 1980. In 2001 all villages except one had a primary school. Drinking water systems were in 2001 available in 90 percent of all villages, whereas only 42 percent had one in 1980. In 2001 44 percent had a doctor compared to 17 percent in 1980. Since the survey does not provide any information on village mean income, we use the percentage of all houses used for the purpose of human residence in each village built from stone, bricks or cement as a living standard indicator. Throughout the Lore Lindu region having a stone house is seen as sign of prosperity and wealth and therefore that variable should be a good measure of the villagers' living standard. As can be seen in Table 1, the share of stone houses increased from 5 percent in 1980 to 32 percent in 2001.[14] This share is slightly higher in the villages covered by the household survey. All these statistics suggest that on average the villages in the study region experienced substantial improvements in their living standards over the period 1980 to 2001 which went along with population growth and an increased cultivation of perennial crops. In the next subsection we look more closely at the heterogeneous development of migration, population growth and population density over time and space.

3.3 Migration, population growth and population density

During the past decades a significant part of the immigration into the study region has taken place from the south and middle-west of Sulawesi to the north-east of the Lore Lindu region, in particular to the districts of Palolo, Sigi Biromaru and Lore Utara.[15] Some immigration has also taken place within so called 'transmigration programs', organized by the government mainly during the 1960s and 1970s. These programs resettled people in particular from the islands Java, Bali and Lombok in Central-Sulawesi. The places were chosen according to factors such as soil fertility and land availability (Faust, Maertens, Weber *et al*., 2003). Most of these migrants have today returned and the programs are seen as having failed and were stopped with the demise of the 'New Order' regime of former president Suharto. In our sample none of the villages was affected by these programs during the 1980s, but three villages were affected during the period 1990-2001 and we decided to remove these three villages from our sample. That means we work throughout the paper with a sample of 77 villages. None of the removed villages was part of the household survey.

[14] It should be noted that stone houses are not systematically less frequent in remote villages. Stones and bricks are often made or collected in the surroundings of the villages and hence, no road is necessary to bring them. Also, heavy materials including stones are in the Lore Lindu region traditionally and still frequently transported using buffalos, donkeys, horses or motorcycles. Given that labor is very cheap, transport time plays no important role.

[15] The study region covers five districts in total. The two remaining districts are Kulawi and Lore Selatan.

Table 1 shows that annual net population growth across the villages, i.e. natural population growth plus the balance of in and out-migration, averaged around 2.1 to 2.3 percent over the period 1980 to 2001. Yet, the variance is large with a number of villages showing negative population growth and many villages having annual population growth rates as high as 10 percent. The annual net migration rate defined here as the difference of immigrating and emigrating households over a given period divided by the number of households in the village at the beginning of that period was on average 2.2 percent during the period 1980 to 1990, 1.2 percent during the period 1990 to 1995 and 1.4 percent during the period 1995 to 2001. Finally, the share of migrant households averaged between 14 and 18 percent over the period of study, but again with a large variance across villages. Given these demographic forces, population density, measured by population size per hectare of used and unused agricultural land (i.e. land that has been cleared for agricultural production), increased on average from 1.2 to 1.8. Here as well the variance is large across villages. Whereas in about 25 percent of all villages, population density increased by less than 25 percent or even declined, almost 20 percent of all villages saw an increase by more than 90 percent. 10 out of the 13 villages covered by the household survey are situated in the three above-mentioned districts that were preferred destinations by migrants. This is reflected by a higher average net immigration rate, a slightly higher share of migrants and a higher population density in these villages (column on the right of Table 1).

3.4 Land tenure and land rights

The land tenure system in Central Sulawesi has experienced a substantial change in 1953 when land ownership went from the 'swaprajas' (local 'kingdoms') to the state. *De facto*, however, this new regulation had only a limited impact, and land in the Lore Lindu Region continued to be controlled by local village leaders and villagers through customary land tenure systems. Only in the 1980s and 1990s did formal land titles become more and more widespread (Nuryartono, 2005). Whereas about 10% of villages have had land titles since the early 1980s, others introduced them only recently and over a third of the villages is even today without such titles. There is also a substantial variation within villages, i.e. sometimes only a few households have such titles, whereas in other cases many households have registered their land. In the villages where land titles exist they were in most cases established in the framework of the land certification schemes PRONA (*Proyek Operasi Nasional Agraria*) and PRODA (P*rogram Proyek Agraria Daerah*), which can provide ownership rights to land holders, including the right to transfer the land through sell, rent, bequeath, pledge, mortgage and gift. These schemes were created by the Indonesian Government in 1981. However, no central or decentral government beyond the village level ever enforced land titling and land redistribution in the study area using these mechanisms. PRONA/PRODA is rather an available scheme which can be used if there is a demand and the willingness to opt for land titling by villagers (Siagian and Neldysavrino, 2007). The costs of land titling under these schemes have to be borne by the villagers (about 250,000 rupiah per plot, roughly 80 intl. $ at PPP). The process of land titling needs (collective) action by the villagers and usually starts with a proposal to the land administration office. This implies that the process of land titling is — consistent with our hypothesis — demand and not supply driven.

The local population usually acquires land through heritage, purchase from other households or by clearing forest. The latter became more and more difficult overt time due to the implementation of laws and regulations aimed at protecting the rainforest, including a prohibition of logging activities inside the National Park (see Schwarze *et al.,* 2009). Land acquisition through the clearance of forest usually implies the absence of any land title or land certificate. Migrants usually buy land from local villagers or the village leader or, in some cases, simply get land or a piece of forest to clear from the village leader by making a small gift. This is again often (in more than 80% of the cases) done without any legal land transfer and land certificate (Nuryartono, 2005). Some villagers also report that migrants come with forged land rights 'bought' from some higher 'state authority' and get possibly then some land by bribing a local village leader. If no legal land title is issued, land tenure security for migrants is usually very low and it often means that land can only be used for a limited period of time. Even a letter of temporary land-use rights issued by the village leader is not powerful enough to avoid land conflicts in the future (Nuryartono, 2005). This suggests that there is a hierarchy of tenure security which is highest for legal government titles, and lower for most other forms of titles; given the heterogeneity of non-government titles and the circumstances under which they were issued, it will be largely an empirical question to what extent they serve as a close substitute to these formal government titles. We hypothesize, however, that any form of title will enhance tenure security in this dynamic environment, compared to existing informal customary land access.

Table 1 shows that the share of villages in which legal government titles to land rights exist increased from 9 percent in 1980 to 63 percent in 2001. 85 percent of the villages covered by the household survey data have land titles. In 90 percent of all cases land titling was done under the PRONA/PRODA scheme. Our data set comprises the *shar*e of households with such formal ownership rights only for the year 2001. It is on average 26 percent, but in some villages as high as 75 percent. In the villages covered by the household survey the share is 27 percent.

This household survey data shows that out of the 1,326 plots cultivated by the 318 sampled households, 445 plots are titled (33.6 percent) (Table 2). 43 percent of these titles correspond to legal government titles — including those obtained under PRONA/PRODA. In 12 percent of the plots the title consists of a purchasing contract and in 24 percent the title is a letter from the village leader. These land rights likely provide, as hypothesized above, lower tenure security as the formal titles. In particular a letter by the village leader may only provide temporary rights and may not allow transferring the land. The remaining 18 percent of plots have other types of titles which are not further specified in the data set.

[please insert Table 2]

Most plots were acquired through heritage (35.7 percent), purchase (28.8 percent) and clearing forest (21.2 percent). The rest was obtained as a gift, through marriage or taken as a loan. It is important to note that purchasing land does not mean automatically getting a formal land title or even a contract. About 50 percent of all purchased plots are without such titles. This share of plots lacking titles does not differ between migrants and locals. However, this issue will be further analyzed in Section 4.

The village survey asked village leaders also regarding the occurrence of conflicts about land rights in the village. As Table 1 shows such conflicts seem to occur quite frequently. Out of the 77 villages, 55 villages reported conflicts among native households in the village, 18 reported conflicts between native households and migrants, 35 reported conflicts with households residing in other villages and 21 reported conflicts with governmental or other institutions. Conflicts between native households and migrants occurred particularly often in the villages covered by the household survey.

Regarding access and use of technologies and investments in land, the data in Table 1 and 2 show a great deal of heterogeneity between and within these villages, and across time. In particular, the use of modern seeds, fertilizer, and pesticides rose across all villages, but at different speeds and with great heterogeneity. Also within villages, there are great differences in the use of perennial crops as well as investments in land preparation.

4 Geography, demography and the emergence of tenure security

4.1 Migration, population pressure and the demand for land rights

4.1.1 Evidence from the village level data

Based on the theoretical considerations and the discussion of the context, we proceed now to testing the hypotheses formulated in Section 2. We start by analyzing whether migration and associated pressure on land enhance land titling. For this purpose, we rely first on the village level data, but use in a second step also the household survey data to further substantiate our findings. As we explained in the data section, the village level data consists of information about the year 2001 and retrospective information back to 1980. Some of our variables of interest are available quasi continuously. For instance, we know in which year formal land titles emerged and hence can code for each year and each village whether formal land titles existed or not in any year during this period. For other variables we only have information for the years 1980, 1990, 1995 and 2001. This is for example the case for the demographic information. A few variables are only available for the year 2001, such as *the share* of households having formal land titles in a village. Hence, wherever possible we rely on a panel estimator covering the years 1980, 1990, 1995 and 2001. If panel estimation is not possible, we rely on an analysis of the 2001 cross-section.

In order to analyze whether migration enhances land titling at the village level, we specify the following equation:

$$R_{it} = \alpha_R M_{it-1} + X_{it}^{'}\gamma_R + T_t^{'}\tau_R + \lambda_{Ri} + \upsilon_{Rit}, \qquad (1)$$

where R_{it} is a dichotomous variable which takes the value one if legal government titles (formal ownership rights) for land exist in village i at time t. M_{it-1} stands for the average annual net migration rate, measured, as mentioned above, by the difference of immigrating and emigrating households over a given period divided by the number of households in the village at the beginning of that period.[16] The time-lagged index indicates that we take migration prior to land rights, i.e. for instance whether migration between 1980 and 1990 has had an effect on the existence of land rights in 1990.

The vector X_{it} stands for a set of time-varying village control variables. In X_{it} we include for instance the share of land allocated to paddy rice and cash crops (coffee, cocoa, coconuts). This is important because it might be that migrants differ in their crop choices from locals, and that crop choices differ in turn in their required investments in land. As mentioned above, coffee and cocoa trees need three to five years until they produce beans. This may provide a

[16] It should be noted that we take here the household as the observation unit and not the individual, since rural-rural migration is in this context usually household migration. We also ran the models using the stock of migrants that is argued to be more appropriate for the specifications below and found that the results are very similar.

higher incentive to title land than the cultivation of corn or paddy rice. In X_{it} we also include population density, since we think migration bears a higher potential for land conflicts than natural population growth alone, thus it should be significant despite the control of population density. We also control for village infrastructure as this may have an impact on the marginal productivity of land, and thus determine migration and land titling simultaneously.

The panel structure also allows including village-fixed (λ_{Ri}) effects and year dummies (T_t). That means we can control for all unobserved factors which are constant within villages across time, such as land form, soil quality and historical background characteristics, which might be correlated with migration flows and institutional change.[17] The period-specific effects allow us to control for temporal shocks which are constant across villages, such as country-wide or province-specific policy reforms and macro-economic shocks. The error term in Equation (1) is denoted υ_{Rit}.

Given the binary nature of R_{it}, Equation (1) should be estimated with a binary choice model, and conditional fixed-effects. However, it is well known that in this case the model encounters an incidental parameters problem that renders the maximum likelihood estimator inconsistent (Greene, 2003). Hence, we use a simple linear probability fixed-effects model using the within regression estimator. However, the results below also hold if a probit model with random effects is used.[18]

Column (1) in Table 3 shows that the net migration rate has a substantial and significant impact on the existence of land rights. The estimated coefficient suggests that an increase in the net migration rate to a village by 10 percentage points (which is within the range of observed differentials in migration rates) increases the probability of the existence of formal land titles in the village by about 4.3 percent. Whereas the 1995 year effect is insignificant, the 2001 dummy clearly indicates that formal land rights were more widespread at the end of our observation period. Column (2) includes infrastructure as control variables, but these are insignificant and do not substantially change the effect of migration on land rights. The effect of migration on the probability of land rights also holds if we control for population density (column (3)). Moreover, column (4) shows that *natural* population growth does not have any impact on the existence of land rights, suggesting that it is migration-induced population pressure and not population pressure *per se* that brings about the institutional change. Again, we think, as we explained in Section 2, migration usually means new agricultural households (and not just the extension of existing households) and bears a higher conflict potential than just natural population growth. Finally, the effect of migration is also robust against the inclusion of land use patterns as controls.[19]

[please insert Table 3]

We also tested whether being at the border of the rainforest in interaction with time had any effect on land titling (not reported in Table 3). Given that, as mentioned above, during the period of study more and more rainforest protection rules and laws emerged, it could be that land conversion became particularly difficult in villages at the rainforest margin and that

[17] We believe that for our purposes, the fixed effect specification is best as discussed above. We also perform the usual statistical tests (esp. the Hausman test) to test whether random effects might be preferred as it is the more efficient estimator. The choice of fixed versus random effects has no significant effects on the results.
[18] Results are available on request.
[19] As we argue below, land use patterns, including the decision to cultivate cash crops may respond to formal land titles, and thus have to be considered as endogenous. Thus the coefficients should be treated with caution; we include them here to ensure that this (possibly bi-directional) correlation is not affecting our results.

therefore in these villages land scarcity became a more important problem and land titling more likely.[20] However, border-time interactions were not significant and thus were dropped from the list of included control variables.

As we have explained above the data set includes some other variables which are potentially interesting for our analysis, but which are not available for different years and can thus only be analyzed using the cross-sectional dimension of the data. This set includes the prevalence of conflicts about land, the availability of unused agricultural land for paddy rice and inequality in the distribution of land. They can all be seen as proxy variables for the pressure on land. These factors are analyzed now using a probit model. We also consider estimations where we use the *share* of households in a village having formal land titles as the dependent variable (instead of the binary land title variable). Given that this variable is left-censored, since many villages do not have land titles at all, we use a tobit model in this case. Note that we use now the share of migrants in the village as dependant variable. This makes more sense than the net migration rate, because we now look at the existence of land rights in the year 2001 (not at the change in land titles status over time), which should be related to cumulative migration in the past.

The results are reported in Table A1 in the appendix. Column (1) shows that the results obtained with the panel estimator also hold in the cross-section. The coefficient of the share-of-migrants-variable suggests that an increase of this share by 10 percent holding all other variables at the sample means increases the probability of land titles in a village by 8.8 percent. The average share of migrants is about 14.6 percent (see Table 1). The occurrence of conflicts about land is significantly and positively associated with a higher probability of having formal land titles (column (2)). The availability of unused agricultural land for paddy rice decreases the prevalence of formal land rights (column (3)) and higher inequality in the distribution of land as measured by the Gini coefficient increases this prevalence (column (4)), though the effect of inequality becomes insignificant when we include other control variables (column (5)). All these effects are in line with our expectations. Finally, the results also hold if we use the tobit specification and the *share* of households with land titles in village *i* as dependant variable (column (6)). The share of migrants in the village is significantly and positively associated with the share of households having land titles in a village.

Although we have relied above on an appropriate lag-structure and used a fixed-effects estimator and thus controlled for unobserved heterogeneity that is constant over time, we cannot, based on the above estimations, fully rule out that reverse causality is not an issue, i.e. that prospective migrants chose destinations according to the possibility to register newly acquired land. To investigate this possibility, we also estimated the reverse relationship for different periods, i.e. the impact of land rights on migration. In this case we use the availability of land rights at the beginning of the period over which migration is observed. Although this is obviously only a very rudimentary exercise, all regressions show, whether we take the absolute or the net immigration rate, whether we look at the eighties or the nineties or whether we add further controls, land rights have never had a significant impact on migration in the subsequent period. Hence, we are quite confident that migration and the induced population pressure on land resources enhance land rights and not the other way around.[21]

Another issue which may bias our results is that migrants frequently acquire land by purchasing it and this may make it more likely that land is formally registered. As discussed

[20] See Schwarze *et al.* (2009) on the effects of National Park regulations on deforestation rates.
[21] Results are available on request.

above, the descriptive evidence already suggested that 50% of purchased plots lacked official titles and that this share did not differ between migrants and locals so that there is little *prima faciae* evidence for such a bias (see Table 2). But to complement this descriptive evidence, we now use the household survey data to investigate this issue further.

4.1.2 Evidence from the household survey data

Using the household survey data we now test whether the share of migrants in a village makes it more likely that a plot is titled controlling for migrant status of the household head. We also estimate this relationship on a sub-sample of non-migrants. If the share of migrants in the village is positive and significant, we can take this as evidence that migration-induced population pressure makes land titling more likely. We specify the following probit model:

$$\Pr(R_{ijp} = 1) = \phi(\beta_R M_i + MS_{ij}^{'}\chi_R + X_{ij}^{'}\delta_R + P_{ijp}^{'}\eta_R + \varepsilon_{Rijp}), \qquad (2)$$

where R_{ijp} is a binary variable taking the value 1 if plot p of household j in village i is titled. We distinguish two types of land titles: formal government land titles ('government land titles' hereafter), these correspond to those we consider on the village level and a broader set of land titles which includes also purchasing contracts, letters by the village chief and other certificates ('land titles' hereafter). As discussed above, these titles are rather heterogeneous; some may grant similar security and functions as government title, while others might be less valuable.

M_i stands for the share of migrants in village i, which should measure the migration-induced pressure on land. MS_{ij} stands for the migration status of the household head. We distinguish four categories: household head is a migrant, the household head's parents were migrants, the household head's grandparents were migrants and none of these, i.e. neither the household head, nor his or her parents or grandparents were migrants. X_{ij} is a vector of household and household head characteristics, e.g. gender of the household head. P_{ijp} is a vector of plot characteristics including a self-assessment of the soil quality by the household head, and the log size of the plot. The error term is denoted ε_{Rijp}. Given that we have multiple plots at the household level, we compute robust standard errors to account for the correlation of observations within households. We do not include household fixed-effects as this would then not allow analyzing the impact of the household head's migration status. For a similar reason we do not include village fixed-effects, since it would prevent us to see the isolated impact of the share of migrants in the village on the probability of plot titling. Descriptive statistics for the variables we use here are presented in Table 2.

[please insert Table 4]

The results in Table 4 (columns (1) and (2)) show that the prevalence of both general land titles and government land titles is increasing in age of the owner but at a decreasing rate. There is no significant difference in land titling between plots owned by men and plots owned by women. Plots owned by households where the head has at least some secondary education are much more likely to have general and government land titles. Computing the marginal effects at the sample means suggests that owners having at least some secondary schooling are 20 percent more likely to have some type of formal land title and 12 percent more likely to have an official formal government title for their plot. First generation migrants are also more likely to have some type of land rights, often a purchase contract, but they are *not* more likely than locals to have a formal government title. Households in which the parents of the household head came as migrants to the village, have even a clearly lower probability of having land titles.[22]

In line with our hypothesis, the share of migrants in the village has a clearly positive effect on the probability that a plot is titled. The marginal effect evaluated at the sample means indicates that an increase of the share of migrants in a village by 10 percentage points (again, well within the range of actual observations) increases the probability that a plot has some form of a land title by 4.3 percent and the probability that a plot has an official government title by 2.6 percent. These effects are significant at the 5 percent level and they also hold and show a similar order of magnitude if we restrict the estimation to the sub-sample of non-migrant households (columns (3) and (4)). The share-of-migrants-effect also remains significant if further plot characteristics are introduced as control variables such as soil quality and the log of plot size (columns (5) and (6)). All these characteristics seem to have no substantial impact on land titling.

4.2 Geographic origins of migration and land rights

In this section we analyze whether geography is a driving force of land titling. There are potentially two important channels, one more directly and another more indirectly. First, plots in geographically more favorable areas are more valuable and thus might be more likely to be titled. Second, and as we argued in Section 2, it might be that the intense immigration flows we observe in some of the villages in our study region are driven by the geographic attractiveness of these villages, i.e. prospective migrants choose destinations that offer geographic conditions, that are favorable for agricultural production. It is this latter channel which is of particular interest to us. If it exists it would indicate that institutional change has, among others, geographic origins, as it is hypothesized by some of the more macro literature discussed in Section 2.

To measure the geographic features (G) of villages, we use the share of agricultural land that is on steep slopes (in 2001),[23] the year of the last drought (as a proxy for the frequency of droughts), and the logarithm of the village altitude above sea level (in meters). One may question the exogeneity of our "share of agricultural land on steep slopes" variable, because it is observed in 2001 and not in the historical past. Hence, one may argue that immigration and economic expansion lead to the conversion of land which is more difficult to cultivate than existing land. We checked this hypothesis by comparing villages where expansion of land was possible in 1990 and 2001 with villages where expansion was possible in 1990 but *not* anymore in 2001. Obviously, in the latter villages conversion has taken place. However, in these villages the share of agricultural land on steep slopes was not significantly different from the share observed in other villages. However, since we cannot fully exclude that this measure is endogenous, we also use alternative measures.

Table 5 provides the sample means and standard deviations of these three variables. On average 16 percent of the fields are on steep slopes (>30°). In 31 villages there are no fields that are on steep slopes. In three villages more than 90 percent of the fields are on steep

[22] Surprisingly, third generation migrants, i.e. households, in which the grand-parents came as migrants to the village have again a higher probability of having land titles. However, only 1.8 percent of all plots (24 cases) fall into this category and hence one should be cautious in interpreting this effect, but it might suggest that on the one hand these households still face a higher potential risk of expropriation and on the other hand thanks to their long stay in the village have more possibilities than more recent migrants to obtain formal land titles.

[23] In the village survey a slope of more than 30° is defined as 'steep'.

slopes. The standard deviation is 0.26. On average droughts occurred the last time nine years ago. The median and mode is four, the minimum is one and the maximum 41. The mean altitude is 647m above see. The median is 696m, the minimum 51m and the maximum 1,225m. It should be noted that this variable stems from Geographical Information System Data (GIS) data and thus is an exact measure; it is not an estimate by the village leader or any other person.

[please insert Table 5]

We start by showing some descriptive evidence that suggests that migration indeed responds to geographic conditions (Table 6). Villages that did not experience a drought during the past three years have a significantly higher share of migrants than villages that did experience a drought recently. The same is true for villages that have less than 50 percent of their fields on steep slopes and that are situated at an altitude below 750m. The next row in Table 6 shows that the geographic differences seem also lead to differences in the quality of institutions. In villages with favorable geographic conditions formal land titles are more prevalent than in other villages.

[please insert Table 6]

To further substantiate the finding that geographically-induced migration leads to institutional change, we first show, in a simple OLS framework, that geography affects land rights and that a considerable share of the effect is transmitted via migration. Second, we also estimate a simultaneous-equations system that is consistent with our hypothesis that geography affects land rights via its effect on migration patterns. The system consists of the following two equations:

$$R_{it} = \alpha_R M_{it} + X_{it}^{'}\gamma_R + T_t^{'}\tau_R + \upsilon_{Rit}, \tag{3a}$$
$$M_{it} = G_i^{'}\alpha_M + T_t^{'}\tau_M + \upsilon_{Mit}, \tag{3b}$$

i.e., we treat migration as endogenous in the land rights equation and model it as a function of geographic factors, G_i, that make a destination more or less attractive for prospective migrants. Given that geography does not vary over time, we just use the pooled sample, control for time effects and adjust standard errors for clustering. Note that migration is measured here again by the share of migrants in village *i.* It is thus a stock and cumulative measure of past migration, which seems to be the appropriate measure to study the lasting effect of geographic conditions on migration. In X_{it} we include population density and land use patterns.

To identify the system described in (3), we assume that geography affects land rights via its effects on migration, i.e. it can be omitted from Equation (3a), once we control for migration and the variables included in X_{it}. We make this assumption to test whether geography-induced migration has a significant impact on land rights, i.e. to provide further support that migration is a channel from geography to land rights.[24] Moreover, identification requires at least one significant coefficient in X_{it} and one in G_i, i.e. we use geography as an instrument for migration, which is endogenous in Equation (3a). For estimation we use three-stage least

[24] We are therefore not arguing that geography might not have a direct impact on land rights, over and above the impact it has on migration. But to show the relevance of our proposed channel, this specification is a useful way to proceed.

squares (3SLS). Joint estimation has the advantage of accounting for the cross-equation error correlations.

Table 7 below shows the results. In column (1) we start by presenting the simple OLS estimate of Equation (3a). This specification differs slightly from the one in Table 3, since we use the share of migrants as explanatory variable and, again, do not introduce village fixed-effects here.[25] Consistent with the evidence presented in Table 3, the results suggest that the share of migrants has a significant and positive effect on the probability of having land titles in a village. The point estimate implies that an increase of this share by 10 percentage points increases the probability of finding land titles in the village by 3.1 percent. Population density has an insignificant effect. The estimated coefficients for the land use variables indicate that a higher share of land allocated to paddy rice and cash crops is associated with a higher probability of observing formal land titles in a village. These variables had the same sign but were not significant in the fixed-effects specification shown in Table 3. Table 7 also shows significant time effects, suggesting, *ceteris paribus*, a higher share of villages in which land titles exist in 1990, 1995 and 2001 relative to 1980. Columns (2), (4) and (6) show specifications of the reduced form relationship between land titles and geography. All coefficients have the expected sign and they are all significant at the 5% or even 1% level. If we add to these regressions migration (see Columns (3), (5) and (6)), we see that in each case the share of migrants is highly significant and the effects of the geographic variables are reduced and show a lower level of significance, suggesting that migration is indeed a relevant channel between geographic endowments and the process of land titling. This is also the case if we include all three geographic variables simultaneously.[26]

[please insert Table 7]

Column (7) shows the results obtained through simultaneous estimation as described in Equations (3). The joint estimation yields results which are fully consistent with our hypothesis. The significant coefficient of migration instrumented by geography shows the relevance of the channel from geography to migration to land titling.[27] We take the results from the OLS as well as the simultaneous-equations system as evidence that land rights have geographic origins and that one important channel of transmission is migration.

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[25] Please note also that the sample is larger as we are able to use four periods rather than three in Table 3; we redid the analysis with just three periods and the results are largely unchanged. As stated above, we also redid the analysis in Table 3 with the share of migrants variable and the results are basically the same as when we use the migration flows.

[26] However, the fact that the geographic variables do not completely lose their significance, suggests that other channels might also be at work.

[27] There is a substantial increase in the point estimate associated with the share of migrants, when the system is estimated simultaneously and migration is instrumented by geography. This finding is common to studies of this nature. It suggests that the share of migrants in a village is either reported with some error or that the existence of land titles lowers migration. The latter may occur if villages with established land markets are also villages – consistent with our theory – where land is becoming scarce. A final possibility is obviously omitted variable bias, i.e. omitted factors which are positively correlated with migration *and* with the existence of formal land titles. The unobserved quality of governance in villages would be a candidate for such a variable. It is likely that all three factors play a role, i.e. measurement error, reverse causality and omitted variable bias. Would the instrumented point estimate be correct, it would mean that an increase in the share of migrants by 10 percentage points makes formal land titles more likely by 10 to 15 percent. However, standard errors are large and one should not base inference on the point estimates. Obviously, the high standard errors partly also result from a relatively small sample size, which typically makes the robust estimation of systems such as described in Equation (3) difficult.

Finally, another natural way to explore the geographic-demographic origins of formal land titles is to choose a dynamic perspective. Assuming that sooner or later formal land titles will exist in most if not all villages in our study region, a meaningful question is what are the determinants of the duration until the event of land titling occurs, i.e. we analyze the determinants of the hazard rate of land titling. To do this, we define the 'duration' by the time that elapsed between 1980 and the year in which the event of land titling occurred. For villages that in 2001 still had no formal land titles the duration is right-censored.

The econometric literature offers a large variety of duration models. Given the discrete nature of our duration data, we start by estimating a discrete time duration model, where the hazard rate is conditional on covariates, x_i, as well as survival, t_i:

$$h(t,x) = \Pr(T = t_i \mid T \geq t_i, x). \tag{4}$$

We first regress the hazard rate of establishing land rights on migration and show that this yields results which are consistent with the results in the previous sub-section. Then we analyze differences in the hazard rate across different geographic conditions. Hence, we write the probability that a village introduces land rights as $\Pr(R_{it}=1) = \psi_i$ and the probability of non-occurrence as $\Pr(R_{it}=0) = 1 - \psi_i$. Modelling ψ_i as a probit model, we get:

$$\psi_i = \phi(\alpha_\psi M_i + X_i^{'}\gamma_\psi). \tag{5}$$

Migration and the control variables (population density and land use patterns) are treated as time-varying variables. Since these variables are only observed for specific years (1980, 1990, 1995 and 2001), we code them for all other years using the information of the closest observation. For instance, we impute the observation of 1980 to the years 1981 to 1985 and the one of 1990 to the years 1986 to 1989, and so on. Hence, we produce a data set which has yearly observations over the period 1980 to 2001. To account for the fact that a probit model produces estimates that are consistent but inefficient if there is time dependence and that in this case also standard errors are wrong (Poirier and Ruud, 1988), we introduce a set of period dummies or, alternatively, simply the duration, either linearly or non-linearly and use robust standard errors clustered on villages.

Table 8 shows the results of the discrete time duration model. Column (1) just includes the share of migrants as a regressor. There is a clear positive association between the share of migrants in a village and the hazard rate of introducing formal land titles in a village. Villages with a higher share of migrants have, on average, land titles earlier. This relationship also holds if we control for population density and for land use patters, i.e. for the shares of agricultural land allocated to paddy rice and perennial crops (column (2)). The latter two yield positive and significant coefficients. The effect of migration also remains significant if we introduce period dummies and thus control for time effects (column (3)). The period dummies are jointly significant (χ^2=28.4, p-value<0.040). Including period dummies implies that some spells have to be dropped from the sample due to collinearity. Our results do qualitatively not change if we use various versions of continuous time duration models instead of the discrete-time duration model.

[please insert Table 8]

Next, we show simple smoothed estimated Kaplan-Meier hazard functions stratified by geographic characteristics. These functions show (see Figures 5a-c) that in villages with favourable geographic characteristics, the likelihood of land titling is higher throughout the period. In these villages, land titling occurs quite frequently in the early eighties and then again in the mid-nineties.

[please insert Figures 5a-c]

Based on the evidence presented in this section, we conclude that migration and the resulting pressure on land and associated conflicts lead villages to opt for formal land titles and to regulate their land market. This has been shown using the village level data, where villages with higher immigration are more likely to have formal land titles controlling for population density and land use patterns. This link could also be shown using the household survey data. Plots in villages with a higher share of migrants are more likely to be titled, controlling for migrant status of the household head, crop choices and plot quality. We have also shown that the prevalence of formal land titles is higher in villages where land is scarce, conflicts about land arose frequently in the past and where land inequality is high. We have then provided evidence that migration can be traced back to geography, i.e. villages that offer geographic conditions favourable for agricultural production experience higher inflows of migrants. Hence, we have found evidence that there is a link of geography via demography to the quality of institutions, i.e. migration is an important channel in the causal chain from geography to institutional change. In the next section, we analyze whether, as theory predicts, 'better' institutions also lead to more investment, new technologies and thus economic development. Thus this part of our analysis contributes to the debate on whether tenure security in the form of land rights indeed influences investments in land and technological change in agriculture.

5 Tenure security and investments in land and agricultural technologies

As we have discussed in Section 2, the empirical analysis of the effects of land rights on investment gives rise to a number of serious challenges. In particular, there might be a problem of reverse causality from investment to land rights. Moreover, there is a potential omitted variable bias, for instance if plots of higher productivity are more likely to benefit from investments such as tree planting, and are also more likely to be titled. We will explain below how we deal with these problems. In this part of the paper, we rely primarily on our household survey data, since investment decisions and to some extent also the adoption of new technologies as well are rather individual decisions. Hence, the problem is better treated by analyzing the behavior of households at the plot level and not at the village level. This can also deal with the fact that in a village in which land rights exist not necessarily all households have such land titles, and even within households there are often titled and non-titled plots. But below, we will also show that our findings hold when using the village-level data.

When examining the plot-level, we look at two types of investments. First investment in land quality and land fertility which we measure by expenditures made for land preparation, seeds and planting, fertilizer, pesticides and irrigation. These are generally more short-term investments which pay out within a year or two, or sometimes even within a single planting season. Second, the planting of cocoa and coffee trees, since both, as explained earlier in this paper, entail a significant amount of investment costs in form of labor and expenses for land preparation but start to produce beans only after a period of three to five years. For both types of investment land rights may matter through all three channels discussed in Section 2, i.e. the 'assurance effect', the 'realizability effect' and the 'collateralization effect'. It should be emphasized that formal credit is available in 71 out of the 77 villages we look at. The remaining villages offer at least possibilities to take an informal credit. In all 13 villages covered by the household survey data, credit programs are available now and were available during the past 20 years. Nuryartono, Schwarze and Zeller (2004) report that titled land is frequently used as collateral in this region. Credits are in principle not only important for longer term investments but also for short term investments, such as expenditures for seeds, fertilizer and pesticides, which usually have to be paid before the harvest. We would expect, however, that these effects of titling on investment are larger and more important for the choice of planting perennial crops than for land preparation expenditures, as particularly the assurance and realizability effect also depend on whether investments yield a return in the long term or not.

As before, we distinguish between formal government land titles and a broader set of land titles including purchase contracts and letters by village leaders and other 'officials'. We speculate that there is unlikely to be much difference between them when it comes to short-term investments (such as land preparation expenditures) but the government titles might have a larger effect on longer-term investments such as planting of perennial crops. We exclude from the analysis plots which are leased, because depending on the contractual arrangements, the costs for inputs may be shared and the incentive structure is probably different from own plots.

To analyze investment in land quality and land fertility (in millions of Rupiah), *EXP*, by household *j* on plot *p*, we specify a tobit model since for part of the plots no expenditures at all have been undertaken (in what follows we omit the village index *i*). The model is as follows:

$$
\begin{aligned}
EXP^*_{jp} &= \beta_E R_{jp} + C'_{jp}\zeta_E + P'_{jp}\eta_E + \omega_{Ej} + \varepsilon_{Ejp}, \qquad (6)\\
EXP_{jp} &= 0 \qquad \text{if } EXP^*_{jp} \le 0,\\
EXP_{jp} &= EXP^*_{jp} \quad \text{if } EXP^*_{jp} > 0,
\end{aligned}
$$

where as before R_{jp}, is a binary variable taking the value one if plot *p* of household *j* is titled. The vector C_{jp} stands for different types of crops and plants, such as maize, coffee, cocoa, and others or whether a plot is left fallow. P_{jp} is again a vector of plot characteristics such as self-assessed soil quality, slope of the plot,[28] log distance of the plot from the house of its owner and of course log plot size. Given that households own usually several plots, we can also control for household random effects, ω_{Ej}. The error term is denoted ε_{Ejp}. We exclude from this analysis paddy rice fields since these fields require very different land investments, compared to fields with other crops. The literature on intra-household decision making suggests that it might make a difference who in the household owns and manages a plot as this affects the allocation of agricultural input across plots and output (see e.g. Udry, 1996). In our case, 93 percent of all plots are owned by the household head. We have no information on who actually manages the plot. Hence, a bias in the land rights coefficient could arise if in our context gender mattered for agricultural productivity *and* land titling. However, Table 4 shows that gender of the household head had no impact on whether a plot is titled or not, suggesting that the bias is probably low.

[28] The slope of a plot is a self-assessment by its owner. Interviewers showed owners a sheet with lines of different slopes (such as 0°, 15°, 30° etc.) and asked which of the slopes would correspond to the slope of the plot.

To analyze coffee and cocoa tree planting, we estimate the following linear probability fixed-effects model:

$$CO_{jp} = \beta_{CO} R_{jp} + C'_{jp} \zeta_{CO} + P'_{jp} \eta_{CO} + \nu_{COj} + \varepsilon_{COjp}, \qquad (7)$$

where the variable CO_{jp} is a binary variable which takes the value one if a plot has coffee and cocoa trees as a primary or secondary crop. Often plots are used to cultivate different crops and households were asked which crop the main or primary crop on each plot is. We exclude from this sample again all paddy rice plots, since no trees are planted on wet rice fields. The other variables are defined as before, except that in Equation (7) we can include household specific fixed-effects, ν_{COj}, not just random effects. Identification is thus over households which have at least two plots that have a different land title status. In our sample 72.4 percent of all plots (excl. paddy rice plots) belong to households which have more than one plot. 37.6 percent of these plots (432 plots) have a counterpart with a different land title status if the broader set of land titles is used. If we stick to official government titles only, this percentage declines to 31.3 percent (360 plots). To test the robustness of our results, we also estimate a probit model with random effects.

As mentioned above, there are at least three good reasons why the identification of the effect of land rights on investment might pose a problem. We think that our estimation strategy deals with these problems quite satisfactory. First, a bias may arise because farmers may register more often plots that have a higher productivity and these get also higher investments. Given that we control for a large number of plot characteristics, we think that this source of bias is not a serious problem in our case. We cannot think of a plausible reason why two plots of the same quality get different investments for another reason other than a difference in the land tenure status. Second, a bias may arise because more profitable farms, and thus farms with higher investments, make it easier to bear the costs of land registration. Again, we think we can deal with this problem, since our estimations include household fixed effects, so we control for the overall-profitability of the farm. Third, a bias may arise because investments such as tree planting are undertaken to enhance tenure security. Here again, we think that the inclusion of household fixed-effects and controls for plot characteristics can solve this problem by a large extent. It is not obvious why a farmer would invest in only one out of two plots of the same quality to enhance tenure security. But more importantly, investment to enforce property rights may be more relevant for customary land rights, but less for formal land titles that we analyze. If indeed our household-fixed-effects estimator can deal with the above-mentioned endogeneity problems, which would all lead, if not dealt with, to an overestimation of the effect of land rights, then the only remaining source of bias is measurement error in land titling. Measurement error may occur if our two binary land title variables do not capture the full heterogeneity in rights which may exist. Measurement error would downwardly bias our estimate; hence our result would constitute a lower benchmark.

Although we are quite comfortable with our identification strategy, we present in addition an instrumental variable approach in the crop choice estimation. Partly following Besley (1995), we use the following two instruments: (1) the number of years since the plot was taken into cultivation the first time and (2) whether the owner is the first owner of this plot. For both variables one can argue that they have an influence on whether a plot is titled but that they have not a direct impact on investment decisions, or influence investment decisions only through their impact on land rights.[29]

[29] These instruments are not totally beyond reproach. If, for example farmers decided to first accumulate experience with a particular plot to get precise knowledge about the soil quality and soil characteristics before

Table 9 shows the results for the regressions looking at land preparation expenditures. Land preparation expenditures increase with the size of the plot and with the distance between the plot and the house. Expenditures are particularly high for maize and cocoa and, as one can expect, and very low for land left fallow. Plots at a moderate slope is, compared to flat land, also associated with higher expenditures, but on plots with steep slopes such expenditures are lower again. In line with our hypothesis, we find that in both specifications and for both types of land titles, tenure security significantly increases land preparation expenditures on plots. We do not find a significant difference between the effects of the broader definition of land titles and government titles. This is as we might expect since it is likely that in the short term, the value of these titles for the three effects is quite similar.

[please insert Table 9]

Table 10 shows the results for the analysis of cocoa and coffee tree planting. Again, we find a substantial positive and significant effect of both types of land titles. As expected, the point estimate is always larger for government titles (rather than all land titles), suggesting that for longer-term investments, government titles are more important.[30] This also holds if we use instead of a linear probability model a probit model (columns (3) and (4)). The specification with the full set of explanatory variables suggests that land titles increase the probability of tree planting by 12 to 15 percent (columns (5) and (6)). If we instrument land titles, as described above, we still find a significant effect, but the estimation coefficients become very large (columns (7) and (8)), which can either be a sign of strong measurement error in the land rights variable or indicate a weak instrument problem. Indeed the *F*-statistics are with 6 and 6.7 below the critical value of about 10. However, an over-identification test does not reject the exogeneity of our instruments. Overall we conclude from this analysis that formal land titles have a (substantial) positive impact on land preparation expenditures and on tree planting. Although we cannot be sure that we deal with all the potential biases in a fully satisfactory way and hence, we have to be careful in drawing conclusions from the estimated magnitude of our coefficients.

[please insert Table 10]

Yet, to give further substance to our findings, we estimated similar relationships with our village level data. We defined three types of investments: first, the building of terraces for paddy rice in villages which have steep slopes; second, the investment in a technical or semi-technical irrigation system; and, third, the use of improved seeds, fertilizer and pesticides. Due to lack of space we do not show the details of the results here, but it turns out that the existence of land rights in a village make all three investments more likely. The effects are in each case substantial and significantly positive at the one percent level. The existence of formal land titles increases the probability of having an irrigation system by roughly 25 percent, the use of improved seeds, fertilizer and pesticides by about 20 percent and the construction of rice terraces in villages with steep slopes by almost 90 percent. All estimations control for village fixed effects. These effects also hold if we instrument land

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they make specific investments, then (1) would not necessarily satisfy the exclusion restriction. A similar argument may apply to (2). If a farmer is not the first owner, he or she may copy investment decisions by previous owners which may make such investments more likely, since there is less uncertainty involved. However, with the data set at hand we found it difficult to come up with any better instrument.

[30] Moreover, if we define a variable 'non-governmental titles' and exclude from the regression all plots with government titles, although the coefficient has the right sign, we do not obtain a significant effect for the 'non-government titles variable', which also suggests that for longer-term investments government titles are more important.

rights by migration levels, in line with the discussion above on the role of migration on land rights. Finally, the results hold, if we restrict the sample to those villages that have land titles established under the PRONA/PRODA framework (which was described in Section 3).[31]

To conclude this section, we have demonstrated that the existence of land rights promotes greater investment in land. This we showed by examining the impact of land rights on land preparation expenditures, a rather short-term investment, where the type of land title seems to matter little. We also show that both forms of titles promote the planting of perennial crops. In this model we are also able to control for household fixed effects and use instrumental variables so that we are quite confident that we have addressed the most important econometric problems of such an estimation. In line with our expectations, now the more secure government titles are more important drivers of crop choice. Using our village level data, we also find full confirmation of our results as land rights promote the use of modern technologies, whether or not we we use migration as an instrument for the existence of formal land titles.

6 Conclusion

A critical question in the more macro-oriented literature on the endogenous institutional drivers of economic development has been the precise nature of the relevant institutions in question as well as the transmission mechanisms that drive institutional change and in turn promote economic development. These questions are taken up in a more micro-economic literature on endogenous institutional and technological change, where demographic pressure and land rights play an important role. In this paper we have empirically explored linkages between these literatures and tested these linkages using village and household level data from Indonesia. We find considerable empirical support for our causal chain running from favourable geographic conditions via migration, demographic pressure and conflict over land to the emergence of formal land titles. These land titles in turn promote short-term and long-term investments in land improvement and cash crops as well as technological change.

[31] All results are available upon request from the authors. In this context, one might argue that migration has a direct impact on technology adoption (and not an indirect impact through its effect on institutions). Such a link could exist if migrants bring new technologies to the villages. For example, there is evidence that Bugis (or Buginese, an ethnically Malay, nomadic tribe from the south-western 'leg' of Sulawesi) are well experienced in growing coffee. While we do not deny this link — in fact it is complementary to our approach — we claim that this is not the dominating force. We tested this link also empirically by estimating a regression of technology use on past migration. It turned out that the migration was never significant in these regressions. Another issue which may have an impact on investment decisions and which we have not addressed so far is the provision of extension services by the government. In principle many villages in our study region have today some support by governmental or non-governmental extension workers which might also play a role in promoting technological progress and investment in new crops such as cocoa and coffee. Our data do not contain any information when these workers came for the first time to the village or whether specific households benefited from such services. But anecdotal evidence suggests that extension work is rather a demand and not a supply driven process. Villagers report that these workers, although they are quite well trained, are only rarely able to transmit their knowledge. Usually these workers do not have a car or motorbike to reach the villages and dispose of almost no technical equipment and training material. Hence, the real impact of these workers in the Lore Lindu region is in most cases, according to the villagers, very limited, or needs at least explicit action to bring these workers to the village. If we regress again using the village level data terrace building, having a irrigation system or the use of improved seeds, fertilizer and pesticides on land rights and add as an additional regressor the presence of an extension worker in 2001, the effects of land rights on technology adoption hold and the coefficient of the extension worker variable is insignificant except for fertilizer use, without however in this case changing very much the coefficient of the land rights variable.

These findings lend themselves to a range of extensions and further research. First, the microeconomic mechanism we have identified might also be an important part of the link between institutions and development identified by the cross-country literature. Acemoglu *et al.* (2001) use the 'Average protection against expropriation risk index' and expects that a high value of this index is associated with "the tradition of rule of law and well-enforced property rights" (p. 1378). In this sense we use in our study a notion of institutions which is very close to the one in mind by Acemoglu *et al.* (2001). In fact, one natural extension of our work would be to look at land rights as a critical institution that affected economic performance in settler versus non-settler colonies and under different colonial regimes.

Second, our results might also be relevant for further explorations of the role of land titling in Sub Saharan Africa. While in many parts of Africa, land has been abundant, it is getting increasingly scarce as demographic pressure is building up in many countries. In those contexts, land rights might become more important than elsewhere, a finding also consistent with Goldstein and Udry (2008). Exploring this link more carefully across African countries might be a fruitful area of further research.

Lastly, the question arises to what extent policy can intervene to promote agricultural productivity and rural development in such a setting. One way of reading our results is to say that there is little role for policy as land rights emerge endogenously, given the right conditions. But this is not our interpretation as the 'right conditions' are also shaped by policy in several ways. First, the availability of a demand-driven land titling system is critical for the emergence of land rights and the associated investment and technological change. In fact, such a demand-driven approach might be better suited to promote agricultural development than the often heavy-handed supply-driven approaches that have tended to fail in the past (e.g. Deininger, 2003). Second, Indonesian policy has been to accommodate and sometimes encourage migration which then helped along the process of endogenous titling and technological change; allowing such migration can thus be critical to set a virtuous chain of events in motion Finally, policy might help along the process in other ways. Apart from the more obvious policies of supporting technological change and investments by lowering their costs (through subsidies or extension services), placing further restrictions on rainforest conversion (and enforcing them) might actually help the process of establishing land rights and then promoting land use intensification outside the rainforest. There might be a win-win opportunity here, which should be investigated more carefully in future research.

Appendix

[please insert Table A1]

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Tables

Table 1 Summary statistics of village-level variables of interest (village survey)

Variable	1980	1990	1995	2001	2001 (sub-sample)
Basic characteristics					
Population size	733	912	987	1102	1549
	(693)	(826)	(857)	(876)	(996)
Size agricultural land (ha)	338	374	436	514	572
	(270)	(310)	(358)	(398)	(424)
Share of land allocated to	0.417	0.443	0.431	0.410	0.362
paddy rice	(0.317)	(0.311)	(0.312)	(0.302)	(0.290)
Share of land allocated to coconuts,	0.252	0.305	0.389	0.459	0.472
cocoa and coffee	(0.199)	(0.204)	(0.229)	(0.248)	(0.234)
Share of land allocated to	0.176	0.129	0.082	0.052	0.050
other crops	(0.242)	(0.202)	(0.155)	(0.110)	(0.103)
Primary school in village	0.857	0.961	n.a.	0.987	0.923
	(0.352)	(0.195)		(0.114)	(0.277)
Drinking water system in	0.416	0.455	n.a.	0.896	1.000
village	(0.496)	(0.501)		(0.307)	(0.000)
Health facility in village	0.169	0.338	n.a.	0.442	0.385
	(0.377)	(0.476)		(0.500)	(0.506)
Percentage of stone	0.054	0.125	0.214	0.317	0.371
houses in village	(0.107)	(0.180)	(0.235)	(0.303)	(0.320)
Demographic dynamics					
Annual population growth (relative to		0.023	0.021	0.021	0.030
previous period)		(0.024)	(0.018)	(0.037)	(0.049)
Annual net immigration rate (relative		0.022	0.012	0.014	0.072
to previous period)		(0.130)	(0.071)	(0.100)	(0.190)
Share of migrants	0.151	0.150	0.176	0.146	0.161
	(0.283)	(0.254)	(0.271)	(0.215)	(0.120)
Population density (population	1.237	1.488	1.652	1.829	2.067
per used and unused agric. land))	(0.909)	(1.047)	(1.173)	(1.187)	(1.291)
Land distribution and land titles					
Formal land titles in	0.091	0.351	0.403	0.636	0.846
village	(0.289)	(0.480)	(0.494)	(0.484)	(0.376)
Percentage of households				0.260	0.270
with formal land titles				(0.220)	(0.168)
Percent. of land titles issued				0.896	1.000
under PRONA/PRODA				(0.309)	(0.000)
Conflicts about land					
- among native households				0.714	0.769
				(0.455)	(0.439)
- between native people				0.234	0.462
and migrants				(0.426)	(0.519)
- with people residing in				0.455	0.538
other villages				(0.501)	(0.519)
- with the government or				0.273	0.385
other institutions				(0.448)	(0.506)
Further expansion of				0.416	0.462
paddy rice fields possible				(0.496)	(0.519)
Gini coefficient of land				0.349	0.336
distribution				(0.175)	(0.178)

Table notes, see next page.

Table 1 (*continued*)

Variable	1980	1990	1995	2001	2001 (sub-sample)
Technology use					
Irrigation system	0.200	0.329	0.371	0.514	0.667
(villages with paddy rice fields only)	(0.403)	(0.473)	(0.487)	(0.503)	(0.492)
Use of fertilizer	0.403	0.584	0.649	0.727	0.846
	(0.494)	(0.496)	(0.480)	(0.448)	(0.376)
Use of pesticides	0.455	0.636	0.753	0.948	1.000
	(0.501)	(0.484)	(0.434)	(0.223)	(0.0)
Use of improved seeds	0.286	0.416	0.545	0.870	0.923
	(0.455)	(0.496)	(0.501)	(0.338)	(0.277)
Building of terraces	0.065	0.217	0.283	0.522	0.571
(villages with fields on slopes only)	(0.250)	(0.417)	(0.455)	(0.505)	(0.535)
Number of villages	77	77	77	77	13

Standard deviations in parentheses. The sub-sample (last column) refers to the sample of 13 villages, which were covered by the household survey.

Table 2 Summary statistics of household-level variables of interest (household survey)

Variable	Mean	Standard Dev.
Household level information (n=318)		
Age household (HH) head	44.155	(12.531)
HH head male (=1)	0.761	(0.427)
HH head primary educ. completed	0.635	(0.482)
HH head migrant	0.390	(0.489)
HH head's parents migrants	0.063	(0.243)
HH head's grand parents migrants	0.016	(0.125)
Plot level information (n=1326)		
Average number of plots per household	4.170	(2.243)
Crop choices		
Paddy rice	0.134	(0.341)
Maize	0.090	(0.286)
Coffee (as primary or secondary crop)	0.162	(0.369)
Cocoa (as primary or secondary crop)	0.352	(0.478)
Fallow	0.075	(0.264)
Land acquisition		
Heritage	0.289	(0.453)
Purchase	0.233	(0.423)
Clearing forest	0.170	(0.375)
Gift	0.053	(0.224)
Other (e.g. marriage)	0.063	(0.244)
Plots with land titles	0.336	(0.472)
Of which		
Government titles	0.434	(0.496)
Purchasing contract	0.112	(0.316)
Letter from the village chief	0.227	(0.419)
Other letter	0.121	(0.327)
Other type of title	0.106	(0.308)
First plot owner	0.750	(0.433)
Years since plot is in cultivation	20.741	(17.215)
Soil quality (self-assessed)		
Less fertile soils	0.025	(0.156)
Medium fertile soils	0.321	(0.467)
Fertile soils	0.494	(0.500)
Missing	0.160	(0.367)
Plot size in ares	65.8	(222.3)
Distance plot–house walk. min.	25.2	(52.7)
Slope of plots		
Plot not on slope	0.688	(0.464)
Plot on slope of 0-15°	0.115	(0.319)
Plot on slope of 15-25°	0.064	(0.245)
Plot on slope of 25-35°	0.063	(0.244)
Plot on slope of 35-45°	0.070	(0.255)
Land preparation expend. (in 1000 Rupiah)	963	(3667)

Table 3 The effect of immigration on the existence of formal land titles (village level)
linear probability fixed-effects model, dependant variable: in village exist formal land titles (= 1)

	(1)		(2)		(3)		(4)		(5)	
Net immigration rate	0.435	(1.84*)	0.636	(1.95*)	0.437	(1.84*)			0.411	(1.70*)
Population growth rate							-0.180	(–0.17)		
Population density					0.027	(0.29)	0.033	(0.29)	0.027	(0.28)
Health facility in village			–0.164	(–0.91)						
Primary school in village			0.285	(0.88)						
Drinking water system in village			0.040	(0.38)						
Share cash crop fields									0.201	(0.68)
Share paddy rice fields									0.154	(0.40)
Year 1990	Ref.		Ref.		Ref.		Ref.		Ref.	
Year 1995	0.053	(1.20)			0.048	(1.03)	0.042	(0.86)	0.033	(0.63)
Year 2001	0.289	(6.57***)	0.275	(3.86***)	0.279	(5.08***)	0.273	(4.53***)	0.253	(3.73***)
Constant	0.350	(11.09***)	0.113	(0.35)	0.309	(2.14**)	0.314	(1.95*)	0.182	(0.66)
Fixed effects	yes		yes		yes		yes		yes	
Observations	231		154		231		231		231	
Number of villages	77		77		77		77		77	
R^2 (within)	0.260		0.329		0.260		0.243		0.262	

The net immigration rate and population growth rate refer to the periods 1980-1990, 1990-1995 and 1995-2001. The regressions including infrastructure variables as regressors cover only the periods 1980-1990 and 1995-2001, therefore column (2) does only include 154 village-year observations.
Cash crops include coconuts, coffee and cocoa (this definition refers to the primary crop on a field).
Robust *t*-statistics in parentheses; * significant at 10%; ** significant at 5%; *** significant at 1%.

Table 4 The effect of migration and migrant status on the prevalence of formal land titles (household-plot level) probit model, dependant variable: plot is titled (= 1)

	All households				Non-migrant households			
	Land titles (1)		Government land titles (2)		Land titles (3)		Government land titles (4)	
Age household (HH) head	0.088	(2.65***)	0.058	(2.14**)	0.071	(1.61)	0.053	(1.14)
Age HH head squared/ / 100	-0.075	(-2.21**)	-0.055	(-2.12**)	-0.063	(-1.35)	-0.042	(-0.89)
HH head male (=1)	-0.502	(-1.40)	-0.039	(-0.12)	-0.284	(-0.68)	0.427	(1.19)
HH head primary educ. completed	0.591	(3.18***)	0.717	(4.10***)	0.626	(2.62***)	0.697	(2.97***)
HH head migrant	0.451	(3.10***)	0.135	(0.89)				
HH head's parents migrants	-0.334	(-1.31)	-0.163	(-0.68)				
HH head's grand parents migrants	0.645	(1.72*)	1.179	(2.88***)				
Share of migrants in village	1.210	(2.14**)	1.266	(2.21**)	1.180	(1.74*)	1.132	(1.71*)
Constant	-3.164	(-3.63***)	-3.446	(-4.20***)	-2.918	(-2.54**)	-3.870	(-3.09***)
Number of plots	1326		1326		808		808	
Number of households	318		318		194		194	
Pseudo R^2	0.073		0.077		0.057		0.072	

Table notes, see next page.

Table 4 *(continued)*

	All households			
	Land titles		Government land titles	
	(5)		(6)	
Age household (HH) head	0.089	(2.77***)	0.056	(2.03**)
Age HH head squared/ / 100	-0.077	(-2.33**)	-0.053	(-2.00**)
HH head male (=1)	-0.476	(-1.26)	0.014	(0.04)
HH head some second. schooling	0.617	(3.21***)	0.777	(4.40***)
HH head migrant	0.517	(3.53***)	0.192	(1.21)
HH head's parents migrants	-0.291	(-1.16)	-0.138	(-0.56)
HH head's grand parents migrants	0.815	(2.02***)	1.452	(3.18***)
Share of migrants in village	0.983	(1.70*)	1.205	(2.02**)
Less fertile soils	Ref.		Ref	
Medium fertile soils	-0.298	(-1.17)	0.088	(0.28)
Fertile soils	0.050	(0.21)	0.304	(1.02)
Log plot size in ares	-0.035	(-1.20)	-0.105	(-2.74***)
Constant	-2.977	(-3.34***)	-3.311	(-3.66***)
Number of plots	1326		1326	
Number of households	318		318	
Pseudo R^2	0.098		0.108	

Robust *t*-statistics in parentheses, standard errors adjusted for clustering of plots within households; * significant at 10%; ** significant at 5%; *** significant at 1%. We included a dummy variable taking the value 1 if the self-assessed soil quality variable was missing.

Table 5 Geographic conditions in villages (n = 77)

Variable	Mean	Std. Dev.	Median	Min	Max
Share of fields on steep slope (>30°)	0.156	0.259	0.012	0	0.992
Number of years since last drought	9.3	10.7	4.000	1	41
Altitude above sea level in meter	647.3	339.9	669.0	50.9	1,225.2

Altitude is missing for three villages.

Table 6 Correlations between geographic conditions of villages, immigration and the prevalence of formal land titles

	Share of fields on steep slope		Number of years since last drought		Altitude above sea level in meter	
	≤ 50%	> 50%	> 3	≤ 3	≤ 750	> 750
Share of migrants in village (in 2001)	0.158	0.061	0.168	0.042	0.181	0.092
p-value (diff > 0)	0.008***		< 0.001***		0.020**	
Formal land titles exist in village (in 2001)	0.662	0.444	0.688	0.385	0.745	0.467
p-value (diff > 0)	0.134		0.032**		0.008***	

* significant at 10%; ** significant at 5%; *** significant at 1%. Altitude is missing for three villages.

Table 7 The effect of geography induced migration on land titles
OLS estimates and simultaneous equations system (village survey, pooled sample), dependant variable: in village exist formal land titles (= 1)

	OLS (1)		OLS (2)		OLS (3)		OLS (4)		OLS (5)	
Share of migrants	0.314	(3.42***)			0.344	(3.79***)			0.339	(3.79***)
Population density	0.040	(1.60)								
Share cash crop fields	0.384	(2.52**)								
Share paddy rice fields	0.483	(4.57***)								
Year 1980	Ref.									
Year 1990	0.219	(3.41***)								
Year 1995	0.230	(3.30***)								
Year 2001	0.444	(5.77***)								
Constant	-0.301	(-4.16***)								
Share of fields on steep slope (>30°)			-0.223	(-2.12**)	-0.185	(-1.76*)				
Number of years since last drought							0.006	(2.40**)	0.005	(1.96*)
Ln altitude above sea level in meter										
Year 1980			Ref.		Ref.		Ref.		Ref.	
Year 1990			0.261	(4.02***)	0.262	(4.06***)	0.262	(4.06***)	0.263	(4.09***)
Year 1995			0.314	(4.75***)	0.306	(4.65***)	0.315	(4.80***)	0.306	(4.70***)
Year 2001			0.542	(8.40***)	0.544	(8.44***)	0.544	(8.38***)	0.545	(8.43***)
Constant			0.129	(3.46***)	0.071	(1.73*)	0.038	(0.92)	-0.003	(-0.08)
Number of observations	303		303		303		303		303	
Number of villages	77		77		77		77		77	

Table notes, see next page.

Table 7 *(continued)*

	OLS (6)		OLS (7)		OLS (8)	
					Land rights equ. (3a)	
Share of migrants			0.339	(3.75***)	1.266	(1.88*)
Population density					0.027	(0.90)
Share cash crop fields					0.380	(2.46**)
Share paddy rice fields					0.447	(3.85***)
Year 1980					Ref.	
Year 1990					0.210	(2.53**)
Year 1995					0.198	(2.31**)
Year 2001					0.451	(4.99***)
Constant					-0.414	(-3.36***)
					Migration equation (3b)	
Share of fields on steep slope (>30°)					-0.090	(-1.65*)
Number of years since last drought					0.004	(2.75***)
Ln altitude above sea level in meter	-0.128	(-4.42***)	-0.119	(-4.07***)	-0.034	(-2.22**)
Year 1980	Ref.		Ref.		Ref.	
Year 1990	0.246	(3.83***)	0.247	(3.86***)	-0.004	(-0.09)
Year 1995	0.301	(4.61***)	0.293	(4.51***)	0.023	(0.55)
Year 2001	0.539	(8.18***)	0.541	(8.20***)	-0.007	(-0.16)
Constant	0.894	(4.71***)	0.785	(4.03***)	0.349	(3.48***)
Number of observations	292		292		292	
Number of villages	74		74		74	
p-value that geographic effects = 0					0.002	

Cash crops include coconuts, coffee and cocoa (this definition refers to the primary crop on a field). Altitude is missing for three villages. Robust *t*-statistics in parentheses; * significant at 10%; ** significant at 5%; *** significant at 1%.

Table 8 The effect of migration on the hazard of land titling
probit discrete time duration model: duration starts in 1980 and is censored if land titling did not occur in 2001

	(1)		(2)		(3)	
Share of migrants	0.512	(2.47**)	0.545	(2.01**)	0.642	(2.33***)
Population density			0.075	(1.10)	0.082	(1.10)
Share cash crop fields			1.615	(3.63***)	1.485	(3.08***)
Share paddy rice fields			1.189	(3.12***)	1.191	(3.06***)
Time-effects	no		no		yes	
Constant	-1.750	(24.16***)	-2.920	(-9.28***)	-2.416	(-7.42***)
Number of spells	1105		1105		918	
Number of villages	77		77		77	
Pseudo-R^2	0.009		0.059		0.134	
p-value that time effects = 0					0.040**	

Cash crops include coconuts, coffee and cocoa (this definition refers to the primary crop on a field).
Robust *t*-statistics in parentheses; * significant at 10%; ** significant at 5%; *** significant at 1%.

Table 9 The effect of land titling on investment in plots, excluding rice plots (household-plot level)
tobit household random-effects model, dependant variable: land preparation expenditures (in millions of Rupiah)

	(1)		(2)		(3)		(4)	
Land titles	1.706	(2.94***)			1.823	(2.99***)		
Government land titles			1.400	(1.83*)			1.582	(1.97**)
Log plot size in ares	2.393	(9.22***)	2.416	(9.31***)	2.062	(6.93***)	2.080	(7.00***)
Other crops	Ref.		Ref.		Ref.		Ref.	
Maize	4.852	(5.96***)	4.852	(5.97***)	4.370	(5.35***)	4.372	(5.36***)
Coffee	-0.023	(-0.03)	0.111	(0.17)	-0.127	(-0.19)	0.046	(0.07)
Cocoa	4.690	(7.61***)	4.690	(7.57***)	4.727	(7.55***)	4.716	(7.50***)
Plot is fallow	-2.497	(-2.02**)	-2.470	(-2.00**)	-2.603	(-2.08**)	-2.550	(-2.04**)
Less fertile soils								
Medium fertile soils					3.096	(1.35)	3.055	(1.32)
Fertile soils					2.958	(1.30)	2.994	(1.31)
Log distance plot–house walk. min.					0.575	(2.35**)	0.612	(2.48**)
Plot not on slope					Ref.		Ref.	
Plot on slope of 0-15°					1.888	(2.42**)	1.637	(2.12**)
Plot on slope of 15-25°					-0.766	(-0.76)	-0.964	(-0.96)
Plot on slope of 25-35°					-2.213	(-1.79*)	-2.612	(-2.13**)
Plot on slope of 35-45°					-1.494	(-1.35)	-1.750	(-1.60)
Constant	-16.954	(-13.57***)	-16.664	(-13.47)	-20.229	(-7.90***)	-19.866	(-7.75***)
Random effects	yes		yes		yes		yes	
Number of plots	1148		1148		1148		1148	
Number of households	317		317		317		317	

Robust *t*-statistics in parentheses, standard errors adjusted for clustering of plots within households; * significant at 10%; ** significant at 5%; *** significant at 1%. We included a dummy variable taking the value 1 if the self-assessed soil quality variable was missing.

Table 10 The effect of land titling on investment in plots, excluding rice plots (household-plot level)
linear probability household fixed-effects model and probit random-effects model, dependant variable: planted cocoa or coffee trees

	LP model (1)		LP model (2)		Probit model (3)		Probit model (4)	
Land titles	0.181	(3.25***)			0.282	(2.67***)		
Government land titles			0.224	(3.88***)			0.613	(4.46***)
Fixed effects	yes		yes					
Random effects					yes		yes	
Constant	0.509	(21.02***)	0.535	(30.74***)	0.124	(1.88*)	0.130	(2.19**)
Number of plots	957		957		957		957	
Number of households	302		302		302		302	

Table notes, see next page.

Table 10 (*continued*)

	LP model (5)		LP model (6)		IV-LP model (7)		IV-LP model (8)	
Land titles	0.124	(2.19**)						
Government land titles			0.147	(2.39**)				
Land titles IV					1.555	(2.67***)		
Government land titles IV							1.860	(2.82***)
Log plot size in ares	-0.073	(-3.52***)	-0.073	(-3.54***)	-0.052	(-1.62)	-0.057	(-1.66*)
Less fertile soils	Ref.		Ref.		Ref.		Ref.	
Medium fertile soils	0.145	(1.20)	0.140	(1.16)	0.138	(0.95)	0.071	(0.41)
Fertile soils	0.029	(0.24)	0.023	(0.19)	0.144	(0.91)	0.068	(0.39)
Log distance plot–house walk. min.	0.004	(0.24)	0.010	(0.56)	0.057	(1.65**)	0.132	(2.44**)
Plot not on slope	Ref.		Ref.		Ref.		Ref.	
Plot on slope of 0-15°	0.181	(2.84***)	0.169	(2.66***)	0.327	(3.13***)	0.173	(1.90*)
Plot on slope of 15-25°	0.154	(1.93**)	0.152	(1.91**)	0.225	(1.67**)	0.197	(1.47)
Plot on slope of 25-35°	0.018	(0.20)	0.010	(0.12)	0.040	(0.31)	-0.058	(-0.42)
Plot on slope of 35-45°	-0.010	(-0.12)	-0.015	(-0.18)	0.019	(0.17)	-0.041	(-0.33)
Fixed effects	yes		yes		yes		yes	
Constant	0.666	(5.09***)	0.681	(5.29***)				
Number of plots	957		957		902		902	
Number of households	302		302		247		247	
First-Stage *F*-statistic					6.03		6.69	
Hansen *J*-statistic					0.327		0.109	
p-value					0.568		0.741	

Robust *t*-statistics in parentheses, standard errors adjusted for clustering of plots within households; * significant at 10%; ** significant at 5%; *** significant at 1%. We included a dummy variable taking the value 1 if the self-assessed soil quality variable was missing.

Table A1 The effect of immigration on the existence of formal land titles (village level)
probit model, dependant variable: in village exist formal land titles in 2001 (= 1)
tobit model, dependant variable: share of household n village having formal land titles in 2001

	Probit model (1)		Probit model (2)		Probit model (3)		Probit model (4)		Probit model (5)		Tobit model (6)	
Share of migrants in 2001	2.426	(1.91*)									0.326	(1.97*)
Conflicts about land in the past (=1)			0.725	(1.79*)								
Further expansion of paddy rice fields possible in 2001					–0.700	(–2.18**)						
Gini coefficient of land distribution in 2001							1.766	(1.93*)	1.305	(1.35)		
Population density in 2001	0.060	(0.39)	0.174	(1.20)	0.042	(0.29)			0.071	(0.49)	0.004	(0.11)
Share other fields in 2001	Ref.		Ref.		Ref.				Ref.		Ref.	
Share cash crop fields in 2001	1.459	(1.20)	1.412	(1.18)	1.830	(1.62)			1.590	(1.38)	0.248	(0.89)
Share paddy rice fields in 2001	1.891	(1.79*)	1.541	(1.49)	2.234	(2.29**)			1.755	(1.76*)	0.369	(1.59)
Constant	–1.467	(–1.50)	–1.801	(–1.71*)	–1.150	(–1.22)	–0.250	(–0.74)	–1.661	(–1.69*)	–0.241	(–1.03)
Number of villages	77		77		77		77		77		77	
Pseudo-R^2	0.107		0.095		0.107		0.039		0.078		0.121	

Cash crops include coconuts, coffee and cocoa (this definition refers to the primary crop on a field).
Robust *t*-statistics in parentheses; * significant at 10%; ** significant at 5%; significant at 1%.

Figures

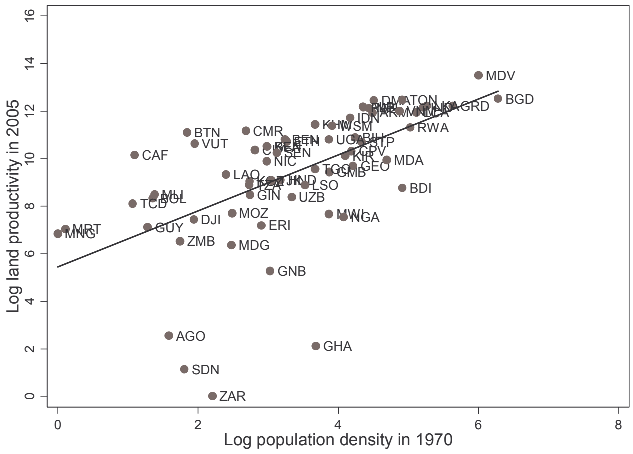


Fig. 1 Log land productivity in 2005 and log population density in 1970 ($\beta = 1.177$, $p<0.001$)

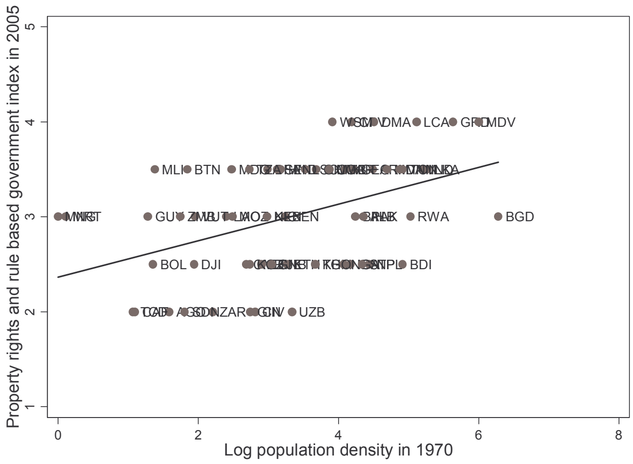


Fig. 2 Property rights and governance index in 2005 and log population density in 1970 ($\beta = 0.192$, $p<0.001$)

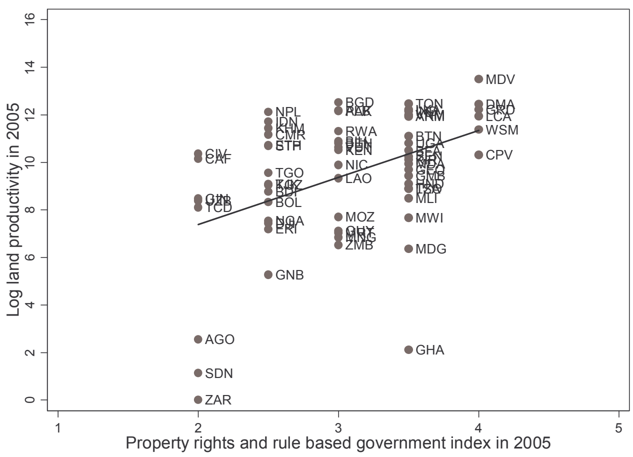


Fig. 3 Log land productivity in 2005 and property rights and governance index in 2005 ($\beta = 1.977$, $p=0.002$)

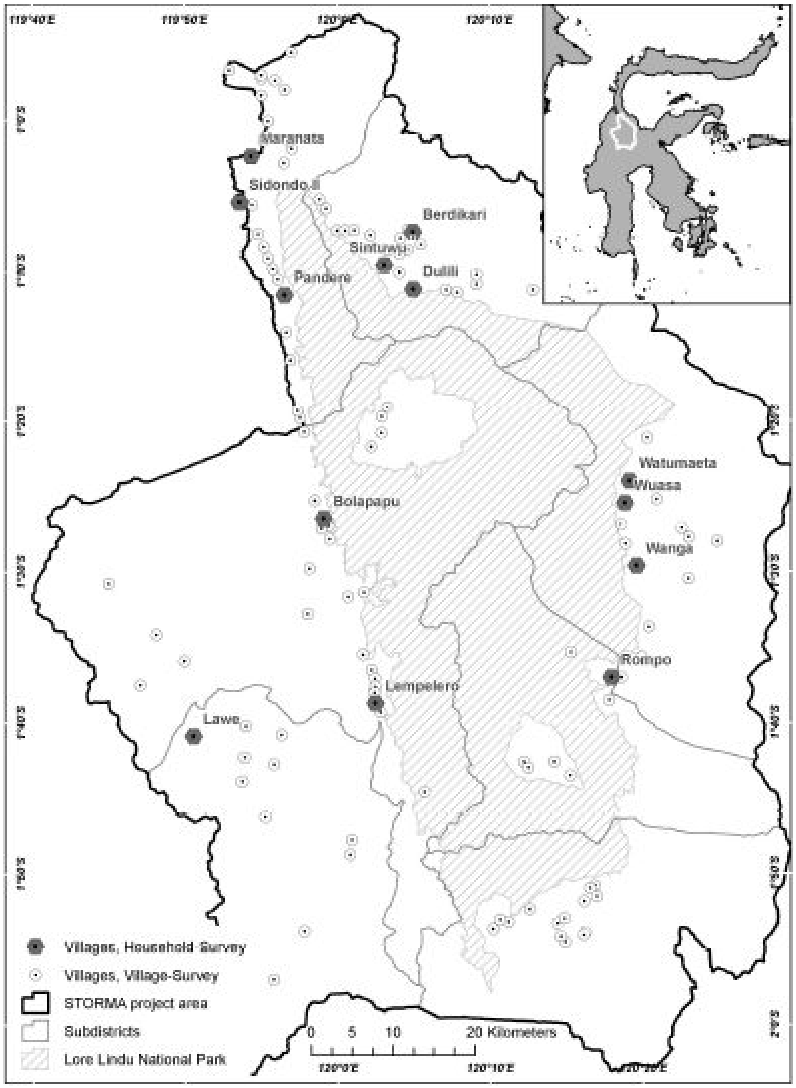
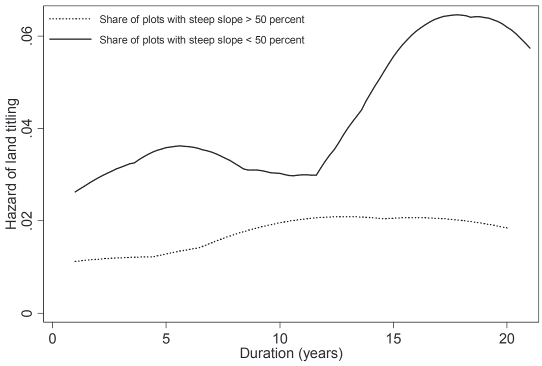
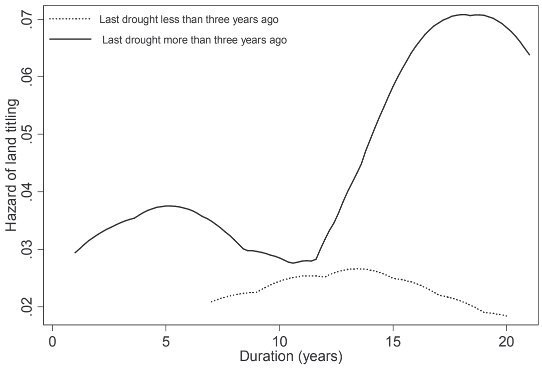


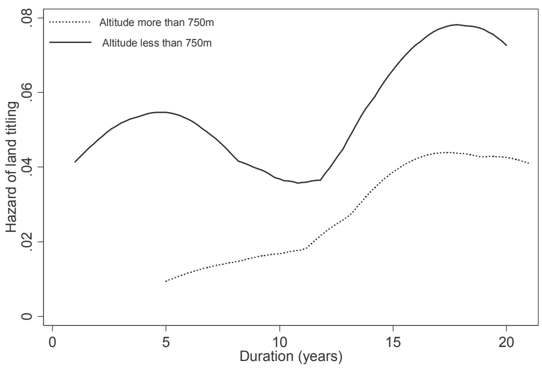
Fig. 4 The study area



(a) by share of plots with steep slope



(b) by number of years since last drought



(c) by altitude above sea level in m

Fig. 5 Kernel smoothed hazard rate of land titling by geographic conditions. Kaplan-Meier estimates.