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INDIVIDUALIZATION OF PROPERTY RIGHTS AND POPULATION PRESSURE, THE CASE OF THE DEMOCRATIC REPUBLIC OF CONGO

Sylvie Lambert†, Karen Macours†
and Margaux Vinez‡

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† Paris School of Economics and INRA, ‡ World Bank

Oxford Policy Management · UKaid from the British people · Université de Namur · Paris School of Economics École d'économie de Paris · ADE Analysis for economic decisions

Abstract

This paper investigates how social norms related to land conversion may evolve to accommodate greater scarcity, by taking advantage of data collected in the Equateur Province in the Democratic Republic of Congo as well as historical events that introduced exogenous changes in pressure on the land and in individualization of the rights.

Land scarcity seems to shape the local institutions for land allocation. Specifically, it increases the probability that older generations keep the control over land allocation and decreases the prevalence of situations without land chief. We investigate the within family distributional consequences of these intergenerational shifts in decision making by comparing land access and food security outcomes between households led by brothers of the same sibship. We find that keeping the land allocation institution “distant” from the current generation limits the within family inequality. Conversely, when the oldest brother controls land allocation, he uses his power to his advantage when land scarcity gives him incentives to do so, securing higher food security levels relative to their younger brother. In an environment where 60% of the households declare having missed at least one dinner in the week for lack of food, and where land scarcity is increasing with deforestation, implications of such a mechanism are important for within family inequality.

We gratefully acknowledge support from the Economic Development & Institutions programme. This research directly builds on the PARRSA impact evaluation project, and we gratefully acknowledge Tanguy Bernard (our co-PI), the enumerator team and field coordinators, the team of the PARRSA project as well as the World Bank’s Africa Gender Innovation Lab and the Paris School of Economics administrative team for support throughout. The views expressed in this paper are those of the authors and do not necessarily reflect those of the World Bank, any of its affiliated organizations. All errors and omissions are our own.

1. Introduction

Inequality in access to land is often considered symptomatic of larger inequalities of opportunities in many rural societies, and arguably lies at the basis for persistent inequalities in many countries across the world. Unequal access to land has received much attention in Latin America, (South) Asia and Southern Africa, where land frontiers are largely closed, and individual user rights - be they often very uncertain - are largely established. Much less is known about land access inequality in frontier settings where property rights have not fully transitioned from open access through communal to individual rights. Yet shedding light on the endogenous responses to increasing land scarcity in such settings, and their possible equity and efficiency implications, is important, not only because of the direct policy implications but also because it can help understand potential root causes of long-standing inequalities.

With approximately 75% of the population in sub-Saharan Africa dependent on agriculture for its livelihoods, understanding constraints and inequalities in access to land is critical to design policies for poverty reduction and food security. In response to increased land pressure, customary land tenure systems continue to evolve toward more individualization and transferability of rights in many parts of sub-Saharan Africa. Little is known about how micro-level social norms related to inheritance and access to land evolve in such settings to accommodate greater levels of land scarcity. This paper investigates how social norms related to land conversion may evolve to accommodate greater scarcity, by taking advantage of data collected in the Equateur Province in the Democratic Republic of Congo as well as historical events that introduced exogenous changes in pressure on the land and in individualization of the rights. These social norms can have important distributional and efficiency consequences since they determine access to land in contexts where land is an essential asset and agriculture is the main activity. This is relevant for the Equateur Province a remote region in the Congo Basin Forests with extensive slash and burn agriculture, high levels of food insecurity and extreme poverty, and arguably severe constraints to economic development in other sectors. Households rely mostly on subsistence smallholder agriculture through shifting cultivation of staples, as well as gathering of forest products, fishing and hunting. While agricultural potential is believed

to be large, road density is very low, and commercialization is hampered by long distances from farm to market. In this context, access to land is critical. The region exhibits large variations in relative land scarcity as well as in the level of individualization both between and within villages.

We provide empirical evidence of these mechanisms by investigating the within family distributional consequences of land scarcity, by comparing land access and food security outcomes between households led by brothers of the same sibship.

Individual households' access to family land usually depends on one male family member, in general, the eldest male of the generation in charge. This can be the grand-father, the father or the eldest uncle, the older brother, or oneself depending on one's age and the level of land division among family members. This can also depend on the seniority of the clan in the village, as clans that arrived more recently arrived clans are not only less likely to have living elders in the village to manage their land but also to have access to land in the village altogether.

We therefore investigate whether the generational distance to the land chief changes when land scarcity increases. One may expect it to become shorter if the division of land occurs at a lower level, and in which case we should observe that the land chief is more often your brother rather than your father, uncle, or grand-father. An alternative hypothesis is that distance to the land chief becomes longer if increased land scarcity induces older generations to keep control of the land for longer. We also want to investigate the distributional consequences of variation in land access institutions, focusing on unequal access among brothers. We explore this question using pairs of households whose household heads are brothers, but with varying levels of land scarcity and division of land within the family.

We use quantitative data collected for the impact evaluation of a large agriculture project, including a very detailed village questionnaire documenting the oral history of 92 villages as well as an extensive household survey. Through the village level questionnaire we gathered information regarding important historical events affecting local land scarcity, notably the establishment of plantations during colonial times, as well as the exposure to land individualization efforts attempted during the last 20 years

of colonial rule called ”Paysannat scheme” (thereafter “Paysannat”). The household survey provides information on the mechanisms through which each household obtains access to land, family relations, as well as information on food security outcomes. The sampling strategy was specifically designed to obtain information on pairs of brothers heading separate households, and always included the household of the eldest brother alive and living in the village, as well as one of the other brothers living in a separate household. Together with the survey module dedicated to individual land access, this informs us about both the level of individualization of the land within the family (characterized among other things by the distance to the land chief), as well as about the inequalities and frictions in access to land between them. The survey data was complemented with an investigation of historical records at the Ministry of Foreign Affairs in Brussels to provide support to our identification strategy.

As a proxy for exogenous variation in land scarcity, we take advantage of a colonial policy that led to the privatization of land rights in the region. The "Paysannat" scheme was a colonial intervention in the Belgian Congo that imposed the division of communal land (forests or fallows) and allocation to individual families. On the eve of Independence, the policy had only been partially rolled out due to low administrative capacity, misinformation, and local resistance. Vinez (2018) draws on historical records to shows that the spatial variation in the implementation of the intervention in Equateur can be considered as exogenous to local conditions and had long lasting effects on present day’s access to land. In particular, it led to a deterioration of the management of communal land and led to appropriation by the clans who were in the village at the time of the Paysannat implementation, leading to scarcity of the remaining (un-allocated) forest resources.

A second proxy of land scarcity at the village level is the proximity of large plantations. Here again, we rely on colonial time land use decisions that have affected deforestation and land scarcity, as the establishment of large plantations during colonial times implied large shocks to the availability of open access forests for villages nearby. The location and extent of these plantations were likely driven by colonial-era considerations regarding micro-climatic suitability for targeted crops and accessibility. As we were unable to find archival data that would allow pinpointing the exact reasons for the locations of different plantation, the presence of plantation in villages proximity

arguably suffers from more endogeneity concerns than the historical incidence of Paysannat. Moreover, and in order to gain statistical power, we also include plantations of the Mobutu era, but little is known about factors driving their placement. That said, as the establishment of plantations – some of which cover very extensive areas – may have represented a much larger shock to village land resources than Paysannat, we believe it is insightful to analyze to what extent the empirical patterns founds for Paysannat villages are reflected in plantation villages. We therefore include the plantation presence as a second proxy for land scarcity, which can be further justified by our focus on within-village distributional questions.

In this paper we use these historical shocks to forest resources as proxies for land scarcity to shed light on the differences in local institutions governing land access and the resulting within-family land inequality and food security outcomes. To do so, the next section first provides more details on the context and data sources. Section 3 then presents a number of stylized facts and descriptive statistics regarding land rights and access in the region, while section 4 analyzes the relationship between land scarcity and within-family land access inequality and foo security. Section 5 concludes.

2. Context and data sources

The Equateur Province is a remote region in the Congo Basin Forests, with extensive slash and burn agriculture, high levels of food insecurity and extreme poverty, and arguably severe constraints to economic development in other sectors (Herdeschee et al., 2012). The main cash crop that was produced as part of the compulsory cultivation scheme during colonization was cotton, but rice, cocoa and palm oil were also important in parts of the region. Cotton production started to fall after Independence, and the agricultural sector was further dislocated during large-scale nationalization campaign, called the Zaïrianisation, led by Mobutu in 1974. The region includes many historic plantations of hevea, cocoa or palm trees that are still abandoned or function at very low capacity. Infrastructure was poorly maintained after Independence and conditions degraded and ultimately collapsed during the Congo Wars (1996-2003). Since then, few investments have been made in this former Mobutu stronghold. Inadequate infrastructure for the transport of agricultural products is still a key

constraint, and households rely mostly on subsistence smallholder agriculture through shifting cultivation of staples, as well as gathering of forest products, fishing and hunting. While the agricultural potential is believed to be large, road density is very low, commercialization is hampered by long distances from farm to markets, and most farmers do not have access to improved varieties or technologies. Traditional shifting methods are still widely used, and equipment often consists of simple hand tools.

There is large variation between villages in terms of access to primary and secondary forest (see figure 1). Villages are often far apart, and some rely on large stocks of forest resources to regularly open new fertile fields. Conversion of land can also involve land previously under Savannah or (to a much more limited extent) in abandoned plantations. Once fields have been opened, they are taken in cultivation for a few seasons after which they are fallowed (and eventually re-used after relatively long fallows). The institutions governing who has the right to convert land where and what are the rights associated with freshly converted land vary between villages, and sometimes even between clans or families within villages. Households often have exclusive rights of use over some land (typically the fallow plots they previously cleared) while unconverted land remains collectively owned by families, clans, or villages. Some villages still have common forests, while others don't. Finally, the generational distance to the land chief in charge of allocating clan or family land varies widely between families.[1] To study these local institutions, we take advantage of data collected as part of the impact evaluation of PARRSA.

To strengthen the agricultural sector in Equateur, the Ministry of Agriculture implemented the Agricultural Rehabilitation and Recovery Support Project (*Projet d'appui à la réhabilitation et à la relance du secteur agricole*, PARRSA) with the Support of the World Bank between 2011 and 2015. PARRSA worked in 9 territories in the 3 northern districts of the Equator Province and aimed at increasing agricultural productivity through a combination of demand-side and supply-side interventions (see appendix), and included the random distribution of vouchers for subsidized access to improved seeds in 92 villages. In the context of this evaluation, we conducted three waves of surveys, informed by extensive qualitative field work. First, a village level baseline survey was conducted in the spring of 2012. All villages targeted for the

[1] Sales and lending of land are limited, but direct inheritance between fathers and sons is relatively widespread.

PARRSA intervention (treatment or control) were surveyed providing detailed village characteristics about agricultural practices, other economic activities, access to markets, producer organization, shocks, other interventions, and access to education and health facilities. This data, together with village information discussed below, was used in part by Vinez (2018) to provide evidence of balance between Paysannat and non-Paysannat villages within the same administrative sector.

The analysis in this paper mostly draws on household and village level surveys conducted between June 2014 and March 2015 in the same 92 villages. This survey collected detailed information about two agricultural seasons, including land, seed and labor inputs, production, storage & commercialization, intra-household decision making, and collective action. We also collected detailed welfare indicators related to food security, childhood malnutrition and mortality, health and education. Crucially for the present project, detailed information was collected regarding local institutions governing land access decisions (and in particular the rights to convert forest or other common non-agricultural land into agricultural land). This includes questions regarding the existence of a land chief within the lineage (i.e. an elder who decides on the land attribution decisions), his land allocation power and the relative position of the respondent relative to this land chief were systematically asked.

We sampled 18 households in 92 villages using a stratified random sample. We then added households drawn from a list of the brothers of the household heads (a maximum of 10 such “brothers” per village) to study inequalities in access to land, inheritance rules, and diffusion of technology within family. More specifically, if the originally sampled household was that of the oldest living brother of a sibship, we randomly drew the household of another brother among those residing in the village. If the head of a sampled household was not the oldest brother of a sibship, we made sure to also sample and interview the household of the oldest brother living in the village. In total we collected data on the 624 pairs of brothers (and hence 1248 households), located in 92 villages, which together constitute the sample used in this paper.[2]

[2] Our sampling strategy excludes brothers that are not living in the same village but each household head was asked the list of all their brothers, as well as their residency and whether they were alive. Using this information we verified that any selection due to outmigration is not correlated with either paysannat nor with plantation.

In parallel with the detailed household survey, we collected oral histories through a village level survey focusing on the ethnic and clanic groups present in the village (and their migration history), available natural resources and rules of access, land allocation mechanisms, the forced cultivation of cash crops, and the history of plantations in the village proximity, and village history since the creation of the village (including colonial interventions related to resource extraction, cotton cultivation, and plantations and related land distribution policies). Answers to the village survey was obtained from a group of 3-4 key informants, selected for having leadership positions in the village, while trying to have a minimum representation of both men and women. This data was complemented and confirmed using historical record data collected from the "Archives Africaines" at the Ministry of Foreign Affairs in Belgium, as well as contemporary research on Paysannat by historians (Clement, 2015). Those records contain detailed information about the implementation of the scheme and the implementation difficulties encountered (see Vinez, 2018 for more details).

The data was further complemented by a series of qualitative interviews conducted between 2011 and 2016 in villages across the region, to deepen our understanding of several key issues such as production choices as well as land institutions and access to collective forests.

3. Descriptive analysis

Measurement of Paysannat

Following Vinez (2018) a Paysannat village is defined as a village in which the colonial administration attempted to divide and distribute the communal land permanently (that is with the intention that this distribution would be definitive) - whether or not the scheme proved lasting. By "definitive" we mean that they were understood by villagers as being a permanent allocation of a block of land, and not simply a temporary allocation for the duration of the cultivation period. In the sample, 55% of villages report attempts by the Belgian colony to force the definitive distribution of communal land for the cultivation of cash crops (Table 1).[3] It means that we will compare villages in which

[3] In order to construct this variable, we decomposed the history of the settlement of lineage groups, cash crop

we identified an attempt by the Colony to privatize communal land permanently by force to villages where this did not occur. In those “control” villages, land may have been temporarily allocated for cash crop production, and the privatization of the land used for cotton or cash crop cultivation sometimes also occurred spontaneously at the initiative of the village in other periods. Figure 1 shows that Paysannat villages are distributed widely across the territory, with no discernible geographical patterns between the location of Paysannat and non-Paysannat villages.

Measurement of plantations

A village is defined as having had a plantation in its borders or proximity based on detailed information from the oral history of the village. In the village questionnaire, respondents were asked about the establishment of plantations during the different historical eras (pre-colonization, during colonization, post-independence, during Mobutu era pre-zairization, during Mobutu era post-zairization and after Mobutu). 48% of villages report at least one plantation, and 35% report specifically that plantations were established during colonial times (Table 1). Figure 2 shows that plantation villages are distributed widely across the territory, with no discernible geographical patterns between the location of villages with and without plantations.

Land scarcity

To analyze to what extent the historical occurrence of Paysannat and plantation affects current-day land scarcity we use information collected at the household level regarding the availability of un-claimed forest resources in the village. In many villages, land resources (even if still under forest cover) would already have been assigned to specific clans and families, and we hence also asked about the availability of land resources under these different institutional arrangements. Table 2a shows that in Paysannat villages, the probability to have non-distributed primary forest land available at the village level is 14 percentage points lower than in non-Paysannat villages (where it is 61.4%). Presence of plantations is associated with a similar difference in the probability to have land available at the village level (14 percentage points). In addition,

production, and of appropriations of communal land by periods of time (before colonization, during colonization, between Independence and Mobutu era etc). For each period, we establish whether new groups arrived in the village, whether their clan was adopted by one of the preexisting local clans or was recognized as a new clan, whether cash crops were cultivated, and whether land was distributed for cash crop production. We also investigated who benefited from those distributions, and whether the land was later redistributed, re-appropriated by the village, or simply remained the property of the beneficiaries.

villages with plantations have 7 percentage point lower probability to have land available at the clan level (from a base of 24%) and 9.5 percentage points lower probability to have land available at the family level at family level (relative to 28%). Overall both Paysannat and plantations are associated with strong differences in land scarcity between villages, with possibly even stronger differences for plantations than for Paysannat.

The clan belonging also makes a difference to perceived scarcity (Table 2b). Members of the clans who founded the village are 6.4% more likely (than the base of 54%) to claim the existence of non-distributed primary forest at the village level compared to other more recently settled clans, and also 5.8% more likely to indicate the availability of primary forest at the family level (compared to a base of 26%) .

Land chiefs

The assignment of land rights at different levels of aggregation referenced above also implies that the person deciding about the allocation of rights to individual plots to specific households is not the same type of person for all land. Indeed, there is large variation between villages (and even between families in the same village) regarding the person considered the land-chief. While traditionally land chiefs were in charge of allocating and managing the clanic or family land, about 19% of the households claim that there is no such land chief regulating their access to land (Table 3). And while 35% say that they themselves or someone from the same generation is the land chief for their family, almost 32% named someone from the previous generation (their father or uncle) and 9% named someone from the second generation (one of their grand-parents or great uncles).

Table 4 suggests that institutions governing land access respond endogenously to land scarcity. Paysannat decreases the probability that households report there is no land chief at all, and increases the probability that the land chief is of the father's generation. Plantations on the other hand double the probability that the land-chief is the grandfather (from 6.8 to 13.4%). Hence, to the extent that plantations induced more land scarcity than Paysannat, it suggests that the more land is scarce, the more the older generations keep the land allocation in their hands rather than passing it on to younger generations. This hides some heterogeneity. In particular, it is worth noting

that Paysannat increases the probability that the land chief is the village chief or the traditional chief for the *groupement* (a small set of villages) for clans that do not belong to the founders group.[4] It seems to be the case that Paysannat reinforced the control of founding clans on village forest.

In line with increased land scarcity, Table 5 shows that various measures of food insecurity suggest more precarious situations when the land chief in the father's generation (more likely to lack food in February – the height of the lean season- and more months with lack of food). Having the land chief in current generation also increases the number of months with lack of food. That said, the probability of having missed dinner for lack of food at least once in the past 7 days decreases when older generations (father or grandfather) are in charge. It might be associated with the fact it implies the presence of several generations in the village, which might create additional opportunities for food sharing in case of need. It is interesting to note that the pattern differs for older and younger siblings. In fact, the father being in charge increases more the probability of lacking food in February and decreases less the probability of missing dinner for the younger one. Note nevertheless that the results on the number of months with food shortage are not completely consistent with this pattern.

These results suggest that older generations may be reluctant to give up land rights in situations of scarcity, possibly to facilitate coordination and avoid land tensions that could arise from (too) strong sub-divisions in situations of scarcity. The fact that households report less concerns to lose fallows when land decisions are done by the grand-father's generations provides support for such an interpretation (Table 6).

Land inequality within brother-pairs

Table 5 already gave a first indication of possible differences between brothers who are the heads of separate households. There are two reasons to expect such differences. First, as older brothers, on average, started accumulating plots earlier than younger brothers, at any point in time they are more likely to have access to more land

[4] While 2.3% of the households in non-paysannat villages indicate a land chief at the village or groupement level, this is the case for 4.7% in paysannat villages for households who do not belong to founding clans, and only 0.8% for founding clans.

(even if at comparable ages brothers may have similar land endowments). Second, when decisions regarding land allocation get passed to the next generation (e.g. in case of death of the father), it is typically the oldest son who inherits the land allocation rights. Hence one could expect oldest sons to have an advantage over their younger brothers.

Figure 3 and 4 suggest, the larger stock of plots is likely to pick up the life cycle pattern, rather than an advantage per se. The figures show that young household heads in this context have much fewer plots than older ones, with the number of plots and land size increasing up to age 60. The differences are large: a household with a 19 year old household head cultivates on average 1.5 hectares (distributed across about 3 plots), while a household with a 60 year old head cultivates more than double (about 3.1 hectares distributed across 4.7 plots). Such large differences are consistent with the typical way of accumulating land in this context. Households obtain user rights to new plots of land by clearing forest (or savanna). They cultivate these plots for a few seasons, after which they leave them fallow. Households typically keep user rights to fallow lands they previously cleared, implying that they take them back into use after the fallow period (which typically lasts multiple years). In such a system, older households hence automatically have accumulated more land.

Table 6 suggests that older and younger brothers are affected differently by the identity of the land chief. Generally speaking, younger brothers appear to be in a less favorable position than their older siblings, except when their grand-father is in charge of the family land. Both siblings are at a disadvantage when the previous generation is in charge when it comes to the total number of plots accumulated, but younger ones are also worse off when their brother is the land chief or when there is no land chief as compared to the situation where they are themselves in charge. Older brothers are nevertheless more likely to have been able to cultivate on converted land when an uncle acts as land chief, while this doesn't improve access to converted land for younger siblings. On the other hand, when the older generation kept the control over family land, everyone feels more secure about keeping his fallow land and younger siblings get access to more land per capita. One interpretation of this finding is that higher age comes with an increased number of dependent, so that for a given allocation of land, younger siblings gain more land per capita.

Table 5 suggests that this difference between siblings does have a direct correspondence in terms of food security indicators. For example, older siblings seem to benefit more than their younger ones from having a grand-father in charge, despite the fact that grand-fathers seem to allocate more land per capita to younger ones. This points to the potential complex relationship between land access rights decisions in the presence of scarcity and welfare outcomes, motivating the analysis in the next section.

4. The relationship between land scarcity, within-family land access inequality and food security

To analyze the relationship between land scarcity and within-family land access inequality we focus on differences between brothers, using a brother-pair fixed effect estimation. This fixed effect cancels out all factors that affect both brothers in similar ways, allowing zooming in on factors that affect unequal access between the oldest brother in a sibship and one of his younger brothers. As we are interested in analyzing whether land access differences between brothers depend on the scarcity of land in the village, we interact an “oldest brother dummy” (refered to as “elder” in the tables) with the village level variable capturing the historical presence of Paysannat. To account for the possible endogenous higher intensity of Paysannat in some administrative sectors compared to others, and following Vinez (2018) we only use the within sector variation in Paysannat presence, by also interacting the oldest brother dummy with sector fixed effects.

Being the oldest brother may have different effects depending on the age difference between the brothers. This is so because of the strong life cycle patterns documented in the previous section (with larger age differences leading to larger differences in the stock of available land due to past accumulation) and possibly also because large age difference may make it easier to establish ones authority over younger siblings. Either of these mechanisms may work differently in contexts with more land scarcity. We therefore include in all specification an interaction between the oldest brother dummy and the age difference between brothers, as well as the triple interaction effects (including the Paysannat variable).

Finally, we expect differences between siblings to be particularly relevant when the land chief is from the same generation, i.e. when the oldest brother himself is likely to be the land chief. However, as documented earlier, land scarcity is likely to affect which generation has the rights to decide on land allocation. We therefore show regressions pooling all brother pairs, and also separately show results for brother pairs whose generation is in charge of land rights and those for whom land allocation is in the hands of an older generation. The first column always has the full sample (which also includes pairs claiming that there is not land chief or that it is someone more remotely related), and hence does not need to account for the endogeneity of the decision-making generation, but has the drawback of pooling in many brother pairs for whom no difference may be expected.

We first consider access to land in terms of the flow, i.e. access to newly converted land in 2014. Column 1 in Table 7 shows that being the oldest brother in a sibship does not necessarily lead to a higher probability of having access to freshly converted land in places with higher land scarcity (as proxied by Paysannat). Column 2 and 3 moreover show that this result doesn't depend on whether the land chief is in the current generation (i.e. likely to be the oldest brother himself). PaysannatConsidering then the stock of land, differences appear between those for whom the land chief is in the same generation (column 8), versus those for whom the land chief is in previous generations (column 9). In fact, for those whose land chief is from the previous generation, older sibling have a net advantage when land is scarce. When considering the number of plots, such pattern doesn't exist. When age difference between brothers is large, the (not statistically significant) advantage of being the older one is dampened, in particular when he's not the land chief. Age difference contributes to making older brothers more secure about keeping their fallow land, whether land is scarce or notPaysannat (Table 8, column 1).

Considering instead the presence of plantation as a proxy for land scarcity, the pattern is fairly similar. The noteworthy divergence is that being the elder reduces total area cultivated when plantations are present (compared to when they are not) when the land chief belongs to previous generations (column 9). This is not the case for the subset of brother-pairs that have the land allocation decision maker in their own

generation (column 8) suggesting that older brothers are better able to protect their prioritized access in such conditions of extreme scarcity. No differences between siblings emerge on the fear of losing fallows when there are plantations (Table 10).

Do these (sometimes subtle) differences in land access between brothers translate in differences in food insecurity? Using two independent indicators of food insecurity covering two different reference periods (the number of months in the last 12 months that household suffered lack of food, and the number of days in the last 7 days that the respondent went to bed without a meal) we note that older brothers generally have somewhat lower food insecurity when their own generation (and hence possibly themselves) is in charge and in particular when considering the short term indicator of food insecurity (Tables 11 and 12). This is true whether we proxy land scarcity with Paysannat or with plantations. There is also some evidence land scarcity reduces the advantage given by a large age difference. When another generation is in charge of land allocation decision the advantage of being the eldest when land is scarce disappears.

5. Conclusions

This paper uses historical shocks to forest resources of 92 villages in the equatorial forest in DRC as proxies for land scarcity to shed light on the differences in local institutions governing land access and the resulting within-family land inequality and food security outcomes. Land scarcity seems to indeed shape the local institutions for land allocation. Specifically, it increases the probability that older generations keep the control over land allocation and decreases the prevalence of situations without land chief. In contrast to what is often hypothesized in the literature, land scarcity in this context therefore did not lead to higher individualization of rights within families, suggesting on the contrary that lower margin of rights adjustments at the village level due to the decrease in available collective primary forest lead family to keep a tighter control on the allocation of their land. These results suggest that older generations may be reluctant to give up land rights in situations of scarcity, possibly to facilitate coordination and avoid land tensions that could arise from (too) strong sub-divisions in situations of scarcity.

The implications of these intergenerational shifts in decision making for within-family inequalities of brothers from the same generation are nuanced. The oldest brother within a sibship doesn't in general benefit from any advantage of seniority in terms of land access, beyond the nearly mechanical life-cycle effects expected when one has to clear land to assert rights on it. Nevertheless, when land is scarce, and where it is the current generation who is in charge of land allocation, outcomes are more beneficial - or less detrimental - to the oldest brother, in particular it allows them to gain in food security relative to their brothers. Younger siblings are faring a bit better when the grand-father's generation is in charge, suggesting fairness concerns might be more present in those cases, consistent with the idea that elder might be trying to reduce intra-family tensions that can be induced by land scarcity.

Hence keeping the land allocation institution "distant" from the current generation limits the within family inequality, while oldest brother use their power to their advantage when it is in their hands and land scarcity gives them incentives to do so. In an environment where 60% of the households declare having missed at least one dinner in the week for lack of food, and where land scarcity is increasing with deforestation, implications of such a mechanism are important for within family inequality.

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Appendix: details on the PARRSA program and evaluation

To strengthen the agricultural sector in Equateur, the Ministry of Agriculture implemented the Agricultural Rehabilitation and Recovery Support Project (*Projet d'appui à la réhabilitation et à la relance du secteur agricole*, PARRSA) with the Support of the World Bank between 2011 and 2013. PARRSA operated in 9 territories in the 3 northern districts of the Equator Province and consisted of three components: (i) dissemination of improved seeds, techniques and technologies to improve agricultural and animal production through agricultural extension services; (ii) marketing - rehabilitating feeder roads and local markets (iii) capacity building support to the Ministry of Agriculture and Rural Development. In cooperation with the Ministry of Agriculture, the World Bank, and the Gender Innovation Lab, the Paris School of Economics designed and conducted a randomized impact evaluation in the region. This evaluation aimed at providing experimental evidence on the impact of several interventions targeting demand constraints to the adoption of improved seed varieties and subsequent welfare gains among poor smallholders. We measured the impact of extension through demonstration plots, different levels and modalities of seed price subsidies, and improved road access. We also introduced experimental variations that allowed targeting extension and subsidies specifically to women and hypothesized that such gender targeting could increase both the sustainability of adoption and the translation of the adoption of improved seeds in better nutrition, health and education outcomes. The evaluation specifically focused on such welfare outcomes given the high levels of poverty, malnutrition, food insecurity and child mortality in the region studied, and the importance of crop income in households' income portfolio. We further studied diffusion patterns of the improved technologies by exploiting experimental variation in the density of the interventions and in whether potential opinion leaders or close family members (brothers) received high subsidies, and by separately analyzing men and women's social networks.

Figures and Tables

Figure 1: Map: Paysannat and forest cover

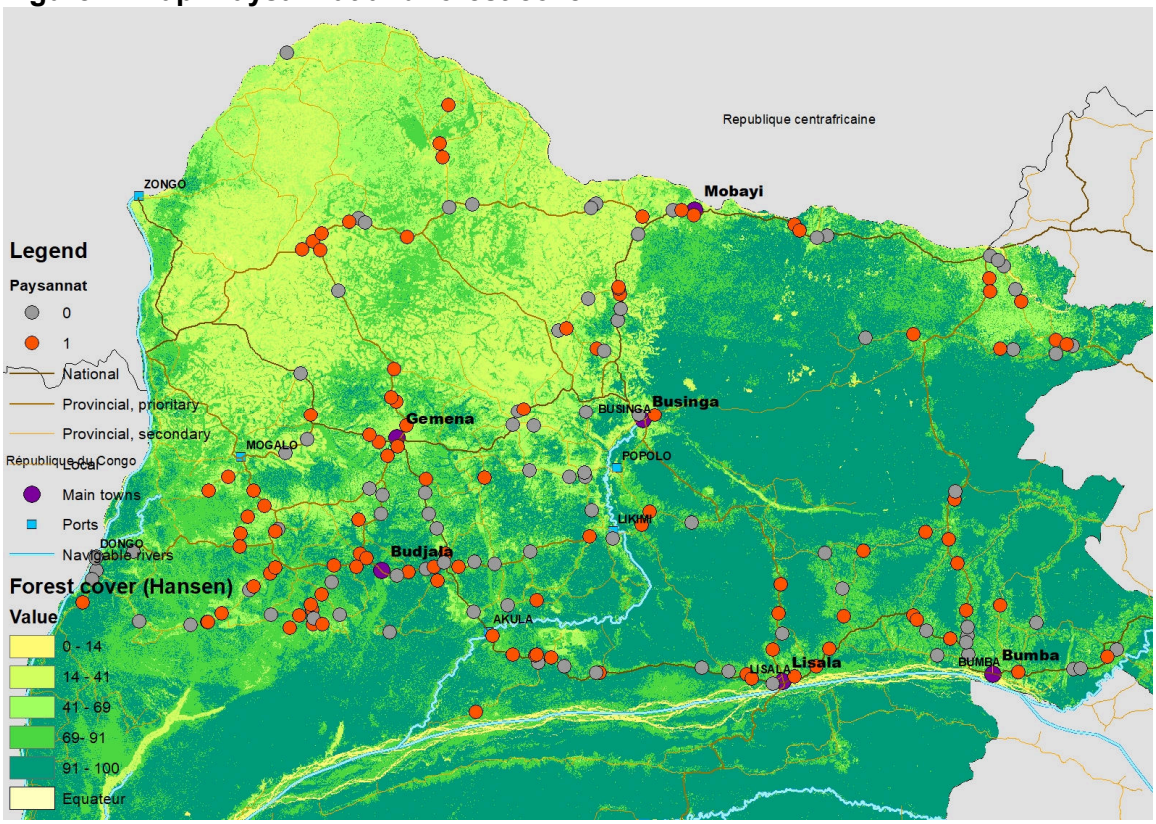

Figure 2: Map: plantation and forest cover

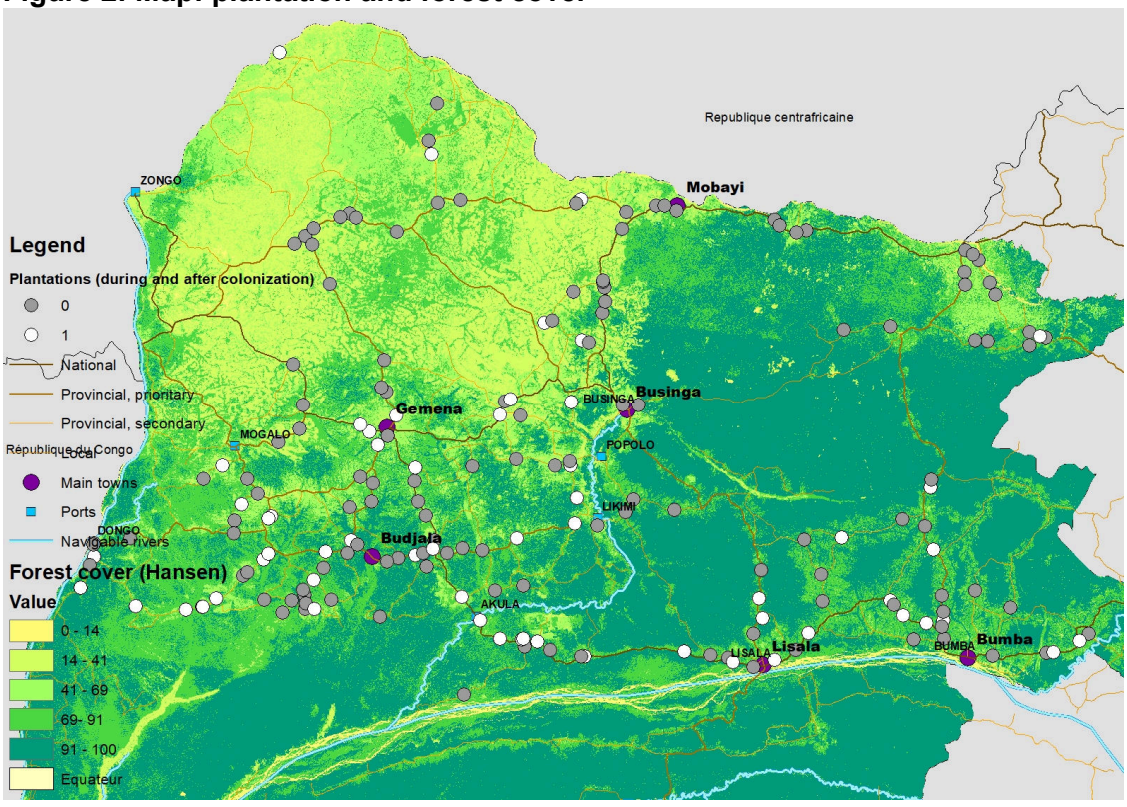

Figure 3: non-parametric relationship between number of plots and household head's age

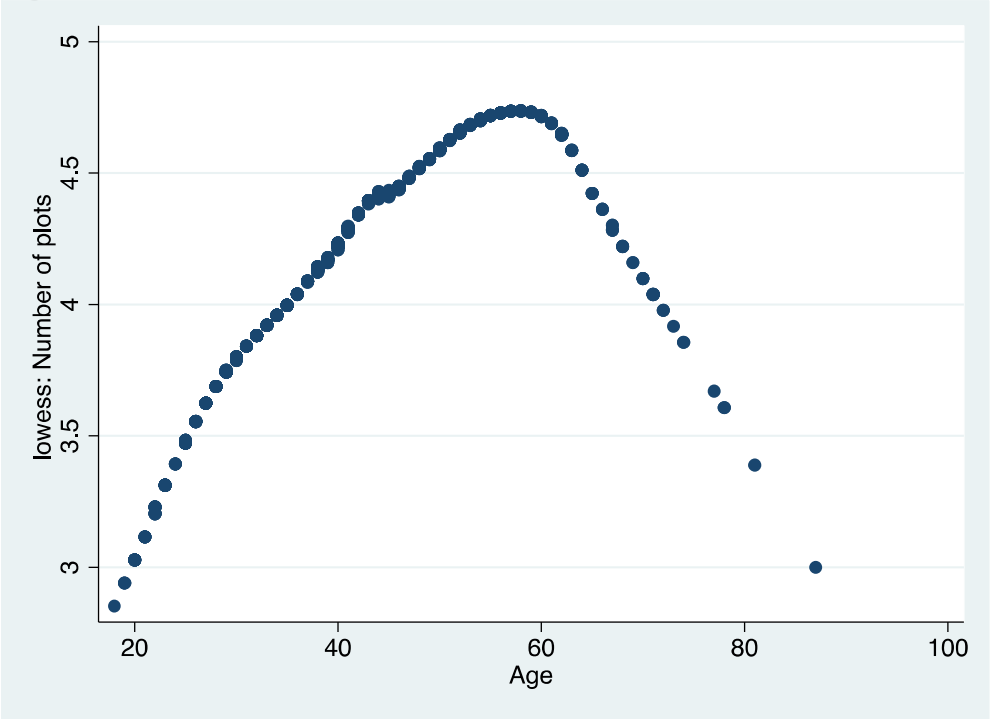

Figure 4: non-parametric relationship between area cultivated and household head's age

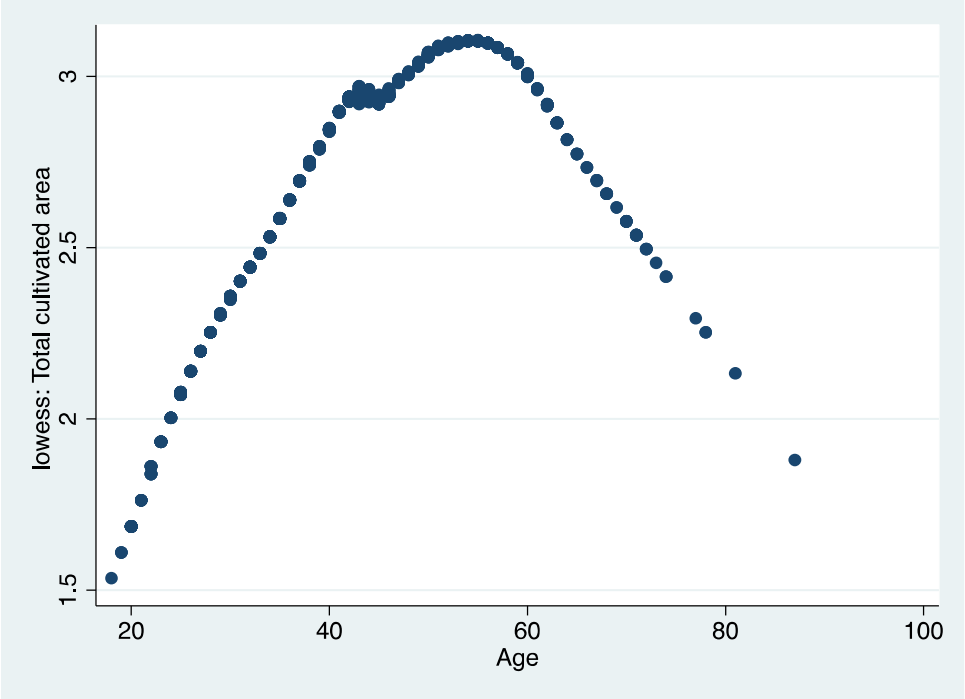

Table 1: Paysannat and plantation at the village level – variation in land scarcity

	N	%
Paysannat	91	54,9
Plantations	92	47,8
Neither Paysannat nor plantation	92	25
Plantations at colonial time	92	34,5
Plantations after independence	92	20,7

Table 2a: Paysannat and plantation at the village level and the availability of unclaimed forest land

Level at which there is non distributed available primary forest:	(1) village	(2) village	(3) clan	(4) clan	(5) family	(6) family
Paysannat	-0.142***		-0.00669		7.65e-05	
	(0.0288)		(0.0258)		(0.0269)	
Plantation		-0.140***		-0.0720**		-0.0951***
		(0.0318)		(0.0285)		(0.0297)
Observations	1,202	1,222	1,202	1,222	1,203	1,223
R-squared	0.201	0.194	0.094	0.106	0.103	0.119

Standard errors in parentheses, ***p<0.01, ** p<0.05, * p<0.1
Controls for administrative division (sector) not shown.

Table 2b: Clan membership and the availability of unclaimed forest land

Level at which there is non distributed available primary forest:	Village	Clan	Family
Founding clan	0.0636**	0.0106	0.0578**
	(0.0275)	(0.0246)	(0.0256)
Observations	1,220	1,220	1,221
R-squared	0.184	0.101	0.115

Standard errors in parentheses, ***p<0.01, ** p<0.05, * p<0.1
Controls for administrative division (sector) not shown.

Table 3: Relationship with the person deciding on land allocation (land chief)

Land chief	No land chief	Current generation		Previous (father's) generation		Grand-father's generation	Other
	242 (19.4%)	462 (34.5%)		398 (31.9%)		113 (9.1%)	64 (5.1%)
Among them :		ego	Brother	father	uncle		
		237	194	204	194		

Note : N=1248. In the category "other" , the land chief is either a cousin whose generation is unknown, a nephew, or someone in the wife's family.

Table 4. Relationship between institutions governing land access and land scarcity

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Land chief	Self	Brother	Father	Uncle	Gd-father	other	Not family	no land chief
Paysannat	0.0354	-0.000515	0.0428**	0.0210	-0.0129	-0.0119	-0.00175	-0.0596***
	(0.0227)	(0.0212)	(0.0211)	(0.0207)	(0.0166)	(0.0129)	(0.00896)	(0.0215)
plantation	-0.0203	-0.0218	-0.0237	0.0105	0.0658***	0.00824	-0.0129	-0.00230
	(0.0226)	(0.0210)	(0.0210)	(0.0206)	(0.0165)	(0.0128)	(0.00890)	(0.0214)
Constant	0.179***	0.168***	0.145***	0.133***	0.0678***	0.0550***	0.0315***	0.200***
	(0.0192)	(0.0179)	(0.0179)	(0.0175)	(0.0141)	(0.0109)	(0.00758)	(0.0182)
Observations	1,228	1,228	1,228	1,228	1,228	1,228	1,228	1,228
R-squared	0.002	0.001	0.004	0.001	0.013	0.001	0.002	0.006

Standard errors in parentheses, *** p<0.01, ** p<0.05, *p<0.1

Table 5. Relationship between institutions governing land access and food security

Generation of the land chief	lacked food in February			nb of months with lack of food			missed dinner for lack of food at least once in the past 7 days		
	all	older	younger	all	older	younger	all	older	younger
current	0.0290	0.0222	0.0355	0.271**	0.406**	0.134	-0.0481	-0.0756	-0.0190
	(0.0537)	(0.0749)	(0.0772)	(0.129)	(0.185)	(0.181)	(0.0581)	(0.0817)	(0.0826)
father's	0.105*	0.0697	0.146*	0.292**	0.346*	0.240	-0.0936	-0.163**	-0.0171
	(0.0540)	(0.0745)	(0.0786)	(0.130)	(0.184)	(0.185)	(0.0585)	(0.0812)	(0.0841)
gd-father's	0.00615	0.00556	0.00719	0.169	0.311	0.0267	-0.154**	-0.260**	-0.0538
	(0.0661)	(0.0933)	(0.0940)	(0.159)	(0.230)	(0.221)	(0.0713)	(0.101)	(0.100)
no land chief	0.0113	0.0160	0.00659	0.172	0.277	0.0622	-0.0497	-0.0394	-0.0595
	(0.0585)	(0.0812)	(0.0844)	(0.141)	(0.200)	(0.198)	(0.0633)	(0.0885)	(0.0904)
Constant	0.241***	0.244***	0.238***	1.125***	1.022***	1.233***	0.659***	0.689***	0.628***
	(0.0484)	(0.0670)	(0.0702)	(0.117)	(0.165)	(0.165)	(0.0524)	(0.0731)	(0.0750)
N	1,114	560	554	1,126	565	561	1,125	564	561
R-squared	0.008	0.003	0.016	0.006	0.009	0.006	0.006	0.021	0.001

Standard errors in parentheses, ***p<0.01, ** p<0.05, * p<0.1

For each outcome, the column "Older" presents results for the set of households whose head is the older sibling of the pair, and the column "younger" presents results for the younger one.

Table 6. Relationship between institutions governing land access and households' reported land

VARIABLES	at least one plot on converted land			total number of plots			area cultivated per capita			fear of losing fallow		
	all	older	younger	all	older	Younger	all	older	younger	all	older	younger
Older	0.0444			0.105			-0.0423			-0.0139		
	(0.0295)			(0.125)			(0.0589)			(0.0152)		
No land chief	0.106**	0.0728	0.137*	-0.169	0.0812	-0.507*	0.0572	0.194	-0.0756	0.00802	0.0171	-0.0159
	(0.0453)	(0.0594)	(0.0720)	(0.192)	(0.260)	(0.294)	(0.0889)	(0.136)	(0.118)	(0.0233)	(0.0297)	(0.0379)
Land chief is (omitted category: oneself):												
brother	0.157***	0.202**	0.146**	-0.333	-0.263	-0.495*	-0.0108	-0.0951	-0.0218	-0.0187	-0.0529	-0.0380
	(0.0487)	(0.100)	(0.0655)	(0.206)	(0.437)	(0.269)	(0.0951)	(0.281)	(0.107)	(0.0249)	(0.0493)	(0.0344)
Father	0.0487	0.0340	0.0625	-0.542***	-0.598**	-0.565*	0.0772	0.0921	0.0537	0.0107	0.0371	-0.0314
	(0.0456)	(0.0594)	(0.0730)	(0.194)	(0.260)	(0.300)	(0.0876)	(0.133)	(0.118)	(0.0235)	(0.0297)	(0.0384)
Uncle	0.131***	0.166***	0.0854	-0.640***	-0.474*	-0.921***	-0.00572	-0.0110	-0.0113	-0.000846	0.0336	-0.0565
	(0.0464)	(0.0590)	(0.0759)	(0.197)	(0.258)	(0.312)	(0.0913)	(0.141)	(0.120)	(0.0237)	(0.0293)	(0.0399)
Gd-father	0.0535	0.0430	0.0614	-0.294	-0.196	-0.479	0.276**	0.0938	0.426***	-0.0538*	-0.0529	-0.0708
	(0.0550)	(0.0744)	(0.0840)	(0.233)	(0.325)	(0.345)	(0.119)	(0.189)	(0.152)	(0.0284)	(0.0378)	(0.0439)
Other	0.106	0.158*	0.0484	-0.269	-0.257	-0.367	-0.0878	-0.110	-0.0816	-0.0234	0.00959	-0.0725
	(0.0679)	(0.0917)	(0.103)	(0.288)	(0.401)	(0.424)	(0.157)	(0.262)	(0.191)	(0.0350)	(0.0458)	(0.0545)
Constant	0.496***	0.539***	0.500***	4.528***	4.560***	4.690***	0.446***	0.393***	0.465***	0.0789***	0.0529***	0.106***
	(0.0357)	(0.0350)	(0.0530)	(0.151)	(0.153)	(0.217)	(0.0703)	(0.0828)	(0.0875)	(0.0183)	(0.0174)	(0.0278)
Observations	1,237	619	618	1,240	619	621	452	201	251	1,212	603	609
R-squared	0.012	0.019	0.011	0.013	0.014	0.015	0.018	0.017	0.052	0.006	0.013	0.007

Standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1

Variables refer to the situation of the past agricultural season (A2014)

For each outcome, the column "Older" presents results for the set of households whose head is the older sibling of the pair, and the column "younger" presents results for the younger one.

Table 7: The relationship between Paysannat and within-family land access inequality

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
VARIABLES	at least one plot on converted land			nb of plots cultivated			total area cultivated		
Sample	All	land chief in current generation	land chief NOT in current generation	all	land chief in current generation	land chief NOT in current generation	all	land chief in current generation	land chief NOT in current generation
Elder*Paysannat	-0.0286	-0.242	0.0225	0.194	1.211	0.620	-0.145	-0.387	1.132**
	(0.0725)	(0.170)	(0.160)	(0.302)	(0.832)	(0.586)	(0.375)	(0.811)	(0.553)
Elder*age difference btw brothers	-0.00215	-0.00610	-0.00532	0.0274	0.0577	0.0496	0.0334	0.0112	0.0588
	(0.00427)	(0.0102)	(0.0105)	(0.0178)	(0.0499)	(0.0386)	(0.0221)	(0.0486)	(0.0364)
Elder*age difference*Paysannat	0.00585	0.0204	0.00400	-0.0216	-0.0739	-0.0797*	-0.00467	-0.0143	-0.0627
	(0.00601)	(0.0136)	(0.0130)	(0.0250)	(0.0666)	(0.0475)	(0.0311)	(0.0649)	(0.0448)
Observations	1,217	423	527	1,220	423	528	1,220	423	528
R-squared	0.621	0.833	0.764	0.637	0.822	0.789	0.662	0.884	0.862

Standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1. Pair of brothers fixed-effect.

Pairs for whom there is no land chief in the family or a land chief whose generation cannot be identified (cousins for example), are excluded from the set of pairs with land chief NOT in the current generation.

Converted land= cultivation on a plot converted from forest or savannah.

controls for sectors interacted with elder.

Table 8: The relationship between historical Paysannat and within-family differences in perceived land rights

VARIABLES	Fear of losing fallow		
Sample	all	land chief in current generation	land chief NOT in current generation
Elder*Paysannat	-0.0149	-0.0244	-0.0131
	(0.0400)	(0.0995)	(0.0961)
Elder*age difference btw brothers	-0.00436*	-0.00678	-0.00421
	(0.00241)	(0.00596)	(0.00618)
Elder*age difference*Paysannat	0.00325	0.00407	2.42e-05
	(0.00335)	(0.00796)	(0.00780)
Observations	1,192	417	515
R-squared	0.574	0.754	0.664

Standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1. Pair of brothers fixed-effect.
Pairs for whom there is no land chief in the family or a land chief whose generation cannot be identified (cousins for example), are excluded from the set of pairs with land chief NOT in the current generation.
controls for sectors interacted with elder.

Table 9: The relationship between plantations and within-family land access inequality

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
VARIABLES	at least one plot on converted land			nb of plots cultivated			total area cultivated		
SAMPLE	all	land chief in current generation	land chief NOT in current generation	all	land chief in current generation	land chief NOT in current generation	all	land chief in current generation	land chief NOT in current generation
Elder*plantation	-0.0338	0.136	0.0869	-0.255	-0.515	-0.259	-0.573	-0.300	-0.895*
	(0.0765)	(0.187)	(0.154)	(0.314)	(0.927)	(0.567)	(0.389)	(0.897)	(0.538)
Elder*age difference btw brothers	-0.00304	-0.00160	0.00129	0.0101	0.000341	-0.00561	0.00936	-0.00692	0.00859
	(0.00377)	(0.0102)	(0.00854)	(0.0155)	(0.0506)	(0.0314)	(0.0192)	(0.0490)	(0.0298)
Elder*age difference*plantation	0.00640	0.0127	-0.00838	0.0115	0.0274	0.00195	0.0480	0.0203	0.0139
	(0.00597)	(0.0136)	(0.0121)	(0.0245)	(0.0671)	(0.0446)	(0.0304)	(0.0649)	(0.0423)
Observations	1,219	439	539	1,221	439	540	1,221	439	540
R-squared	0.625	0.829	0.767	0.648	0.842	0.787	0.669	0.880	0.859

Standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1. Pair of brothers fixed effects.

Pairs for whom there is no land chief in the family or a land chief whose generation cannot be identified (cousins for example), are excluded from the set of pairs with land chief NOT in the current generation.

Converted land= cultivation on a plot converted from forest or savannah.

Controls for sectors interacted with elder.

Table 10: The relationship between plantations and within-family differences in perceived land rights

	(1)	(2)	(3)
VARIABLES		Fear of losing fallow	
sample	All	land chief in current generation	land chief NOT in current generation
Elder*plantation	0.0226	-0.127	-0.158
	(0.0433)	(0.107)	(0.0991)
Elder*age difference btw brothers	0.00152	-0.000711	-0.00698
	(0.00215)	(0.00585)	(0.00521)
Elder*age difference*plantation	-0.00530	-0.00721	0.00613
	(0.00338)	(0.00775)	(0.00768)
Constant	0.0531	0.814***	0.164
	(0.0665)	(0.257)	(0.140)
Observations	1,212	421	527
R-squared	0.566	0.790	0.657

Standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1. Pair of brothers fixed-effect.
Pairs for whom there is no land chief in the family or a land chief whose generation cannot be identified (cousins for example), are excluded from the set of pairs with land chief NOT in the current generation.
Controls for sectors interacted with elder.

Table 11: The relationship between historical Paysannat and within-family differences in food security

	(1)	(2)	(3)	(4)	(5)	(6)
VARIABLES	Number of months with lack of food			missed dinner for lack of food at least once in the past 7 days		
sample	all	land chief in current generation	land chief NOT in current generation	all	land chief in current generation	land chief NOT in current generation
Elder*Paysannat	-0.196	0.138	-0.259	-0.0354	-0.571**	0.0858
	(0.183)	(0.427)	(0.364)	(0.0892)	(0.240)	(0.172)
Elder*age difference btw brothers	-0.0149	-0.00343	-0.00113	-0.0124**	-0.0379**	-0.00500
	(0.0116)	(0.0273)	(0.0233)	(0.00562)	(0.0153)	(0.0110)
Elder*age difference*Paysannat	0.00659	-0.0561	-0.00432	0.0181**	0.0407**	0.0138
	(0.0155)	(0.0347)	(0.0292)	(0.00752)	(0.0194)	(0.0138)
Observations	1,106	380	480	1,105	379	480
R-squared	0.644	0.865	0.810	0.587	0.776	0.790

Standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1. Pair of brothers fixed-effect.

Pairs for whom there is no land chief in the family or a land chief whose generation cannot be identified (cousins for example), are excluded from the set of pairs with land chief NOT in the current generation.

Controls for sectors interacted with elder.

Table 12 : The relationship between plantations and within-family differences in food security

	(1)	(2)	(3)	(4)	(5)	(6)
VARIABLES	Number of months with lack of food			missed dinner for lack of food at least once in the past 7 days		
sample	All	land chief in current generation	land chief NOT in current generation	all	land chief in current generation	land chief NOT in current generation
Elder*plantation	-0.264	0.145	-0.528	-0.139	-0.665**	-0.264
	(0.186)	(0.491)	(0.356)	(0.0908)	(0.265)	(0.168)
Elder*age difference btw brothers	-0.0174*	-0.0292	-0.0212	-0.00957**	-0.0400***	0.00183
	(0.00950)	(0.0259)	(0.0190)	(0.00464)	(0.0139)	(0.00894)
Elder*age difference*plantation	0.0177	-0.0126	0.0358	0.0136*	0.0530***	0.00198
	(0.0148)	(0.0352)	(0.0272)	(0.00723)	(0.0190)	(0.0128)
Observations	1,126	384	492	1,125	383	492
R-squared	0.647	0.860	0.813	0.585	0.787	0.794

Standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1. Pair of brothers fixed-effect.
Pairs for whom there is no land chief in the family or a land chief whose generation cannot be identified (cousins for example), are excluded from the set of pairs with land chief NOT in the current generation.
Controls for sectors interacted with elder.