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Land Tenure Security and Deforestation: A case Study of Forest land conversion to Perennial crops in Côte d'Ivoire.

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Abstract

Understanding the causes of agricultural expansion in Côte d'Ivoire may then prove useful to understand deforestation process in the context of a coexistence of two systems of land tenure (customary and statutory). This paper investigated the relationship between land tenure security and forest outcomes. A modified version of Heckman selection model controlling for the endogeneity of tenure security is used to predict the probability and intensity of cropping perennials. We alternately used two tenure security measures related to substance and assurance of property rights. The results indicated that the decision to adopt and expand perennial crop increases (among other factors) with tenure insecurity, household size, the interference of the administration in land distribution, and the proximity of the village to the forest area. Furthermore, findings revealed that land tenure security, agricultural yield improvement, farmer's experience and higher educational attainment are the key factors of forest preservation in Côte d'Ivoire.

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1. Introduction

Although it currently occupies second place in terms of its contribution to total GDP after the tertiary sector, the agricultural sector continues to drive the Ivorian economy. Agriculture employs more than 2/3 of the active population, contributes one third of GDP and 66% of export revenues in 2008. The agricultural and agro-industrial exports accounted for 53% of total exports of the country in 2012.

Unfortunately, the agricultural expansion has been sharply detrimental to the country's natural capital including forests, agricultural land and microclimate. In 2002, the area under cultivation was approximately 6.9 million hectares representing 33% of the arable land (PND 2012). More than 72% of the farmland is dominated by perennial crops namely cocoa and coffee (75% of the cash crop surfaces) which grow only in forest area. Thus, this extensive farming system has resulted in, with the logging, an annual rate of deforestation of about 300,000 hectares. Indeed, as shown by FAO, the agricultural growth was not realized through productivity gain but was rather closely related to the increase in the agricultural land surface and the number of workers (FOSA 2001). Such agricultural development process has been possible thanks to a policy of the first president Felix Houphouet-Boigny (FHB), who stated in 1963 that "the land belongs to those who value it". This policy has encouraged internal and external migration to forest areas for cocoa and coffee production. But, the "back to the land" policy promoted by the national authorities due to the economic crisis of the 1980s revealed the tensions between the different communities (indigenous, allochthonous, migrants) over the land since customary rules of land transfer exist. The coexistence of two systems of land tenure (customary and statutory) led to a confusing situation in which actors perceive differently the security of land tenure. For some, the land belongs to those who cultivate it, for others, it is the inheritance that confers ownership of the land. This situation influences the behavior of stakeholders vis à vis the forest which constitute the main support of agriculture. This raises questions about the relationship between land tenure security and forest land conversion to agriculture (deforestation). Indeed, according to the literature, while secure tenure may induce investment because of a low risk of dispossession, insecure tenure may also induce investment if investment in the land secures land tenure. In terms of deforestation, some authors showed that tenure insecurity protects forest (Angelsen 2007) while others consider it as a destruction factor (Reed 1984, Bohn and Deacon 2000, Zhang 2001). Other authors found an ambiguous link (Mendelsohn 1994, Burgess 2001, Amacher *et al.* 2009). From all this literature, it comes out that the relationship between tenure security and forest preservation is not yet established and may depend both on the measure of tenure security and the local context. In this paper, we consider land tenure security as a process that allows rights holders to gain a social and legal recognition of their rights and to reaffirm it against challenging claims (Lavigne 1998).

This paper intends to contribute to this literature with a case study of Côte d'Ivoire[1] using alternatively two tenure security measures. One is related to the substance of property rights while the other is related to the assurance of property rights (mode of governance or institutional arrangement) which is considered here as endogenous. We performed a modified version of the Heckman selection model proposed by Schwiebert (2014) to account for endogeneity bias. To the best of the author's knowledge, this paper is the first attempt in exploring the link between these variables using the above definition of tenure security and dealing with endogeneity problem.

[1] In Côte d'Ivoire, there is a coexistence of two systems of land tenure especially customary and statutory. But the customary system is the dominant one as less than 2% of rural land is registered since the adoption of the new law of land in 1998 (Initiatives Côte d'Ivoire 2014).

Our objective is to better understand the relationship between land tenure security and forest outcomes. In doing so, we hope to highlight policy makers' interventions in land tenure that can help slow deforestation in the context of green economy i.e increasing agricultural production while preserving forest.
The rest of the paper is arranged as follows. Section 2 analyses briefly the land tenure process in Côte d'Ivoire. Section 3 presents an econometric model used to test the hypotheses and then a brief description of data collection methods. Section 4 describes and discusses the results of our analysis first at a descriptive level and then based on our econometric analyses. Section 5 concludes the paper by drawing some policy implications.

2. Evolution of Land tenure and land policy in Côte d'Ivoire

Since the 1990s, land conflicts have been multiplied and aggravated (with a number of deaths) in Côte d'Ivoire in general and in forest areas in particular. These conflicts opposed different communities namely the indigenous and non-indigenous (allochtonous and non-ivorians). The reasons for this situation must be sought within the land tenure systems and land policies implemented by the authorities of the country since the colonial and post-colonial period.
In 1920, the colonial administration promoted massive immigration from neighboring countries for the exploitation of cash crops to supply France's industry. To this end, this administration took some laws on land that affirm the state ownership of all vacant lands and strengthen the land rights of cocoa and coffee producers regardless of their origin. Thus, the decree of 25/05/09 recommends the issuance of a permit of occupation to people who are producing cocoa or coffee crops. This permit can be permanent in case of an effective development of cash crop plantations regardless of the origin of the beneficiary. Such institutional arrangement deprived customary owners with their rights as the customary law only provides the transfer of the usage right to the foreigner who in turn must recognize the preeminence of customary owner generally in the form of a symbolic gift.
This land policy continued after 1960 independence from France since the land tenure code of 20 March 1963 stipulates in its first article that "all lands and forests that are not registered are the property of the State." Indeed, the economic development option based on agriculture did not change and land tenure policies continued to support the process. The legal framework encouraged a massive migration of foreign populations (immigrant and non-indigenous) to forested areas especially in the former cocoa belt. In 1975, the foreign population was estimated at 32% of the population of the department of Abengourou and 25% of the one of the department of Aboisso. Competition for land clearing led to the destruction and degradation of forests in the Eastern area that resulted in the displacement of the pioneer front towards the west and south-west areas. But, Côte d'Ivoire became the most prosperous country in the region with an average GDP growth rate of 7% over the decade 1960-1970 and the largest producer of cocoa in the world, as well as an important producer of the robusta variety of coffee.
However, when unemployed urban youth returned to their home villages, thanks to "the back to land policy" promoted by the authorities in 1985 due to the economic crisis of the 1980s, land transactions established earlier with the foreigners have been challenged because of the scarcity of land. Indeed, in response to the limited recognition of customary rights, indigenous peoples have proceeded to land transactions with foreigners to prevent the state from taking hold of vacant land. However, those people of foreign origin affirmed their legitimacy based on the slogan launched in 1963 by President FHB that the land belongs to those who value it. In this context, serious conflicts have emerged in forest areas and even fishing areas with the expulsion of foreign populations.

To address this situation of uncertainty and tenure insecurity, the state opted for a formalization of customary rights by adopting the 1998 Rural Land Law n◦98-750 of 23 December 1998 along with three decrees and 15 implementation orders. This law recognizes customary rights and plans to eventually transform them into private property rights regulated by the state.

Unfortunately, this law aggravated tensions and deteriorating relations between Ivorians and foreigners. The non-indigenous people feel dispossessed of their property that they have acquired for many decades although the law proposes them an emphyteutic lease (up to 99 years of duration). Thus, from Tabou in south-west to Bonoua in the East via the west and center, many conflicts erupted and resulted in the socio-political crisis of 2002 which lasted for nearly ten years.

The limited implementation[2] of this law has created a superposition (coexistence) of two systems of land tenure (customary and statutory). This situation leads to tenure insecurity[3] as there is confusion in land ownership status. Indeed, in Côte d'Ivoire, actors perceive differently the security of land tenure. For some, the land belongs to those who cultivate it; for others, it is the inheritance that confers ownership of the land. In this context, changes in rules encompass tenure security (Arnot *et al.* 2011). Following Lavigne (1998), in this paper, we consider land tenure security as a process that allows rights holders to gain a social and legal recognition of their rights and to reaffirm it against challenging claims. More specifically, Lavigne (2010) claims that tenure security is a matter of institution that lies partly in the legitimacy of local traditional authorities so that the actors involved do not use the public system to claim illegitimate rights. Indeed, most of the conflicts that occur today about land are the results of land agreements between the previous generations that are diversely interpreted by the present protagonists. This includes land donation that is discussed in contradictory ways by the opposing parties. In such cases, a strategy used by each of the protagonists is the mobilization of strategic groups to show arbitration authorities that he enjoys social recognition. It consists on mobilizing the people who belong to a social group or the same social organization (family, ethnic group, political party) to prove that he enjoys legitimacy as measured by its social recognition in the village arena.

This complex and elusive situation related to land access regulation, ownership conflicts resolution and property rights definition has implications beyond agricultural production especially on forest preservation. According to the literature on property rights (neoclassical view), land security is a necessary condition to encourage farmers to invest in farming. Therefore, it becomes necessary in such context, in a country with agricultural economy such as Côte d'Ivoire, to undertake a study on the impact of land tenure on the preservation of forest areas.

3. Methodology and Data.

3.1 Econometric model specification

According to Delacote (2008), Grau *et al.* (2008) and FAO (2007), agricultural expansion is the main cause of tropical deforestation. Thus, understanding the causes of agricultural expansion may then prove useful to understand deforestation processes. In this way, we use

[2] The poor implementation of the law is due to several reasons including: i) the importance of tradition (custom); ii) the high cost of land registration and; iii) the lack of awareness of the rural population about the new land law. Since the adoption of this law in 1998, less than 2% of rural land has been registered (Initiatives Côte d'Ivoire 2014).

[3] According to Barrow and Roth (1989), tenure security is defined as the perception of the likelihood of losing a specific right to a given parcel of land.

perennial cropland expansion as a proxy for deforestation in this study. Indeed, about 3/4 of the farmland is dominated by perennial crops such as cocoa and coffee and constitute by far the main cause of deforestation since they grow only in forest area. Even logging activities contribute to deforestation through agricultural expansion. Indeed, farmers generally use roads made by timber harvesters to infiltrate the forest area and develop their crops (Karsenty *et al.* 1994).

In this context, we are interested in identifying factors that affect farmer's decision to grow such crop and the area allocated to the chosen crop. Such a sequential decision is assumed to follow the selectivity models and can be estimated through either Tobit model or Heckman model. If the decision to choose the perennial crop is not independent of the land surface cultivated, then the appropriate estimation technique is the Tobit model. But if there is independence between these decision steps, then Heckman 2-step procedure is appropriate. In this study, the likelihood ratio test conducted cannot reject the null hypothesis of independence between these two levels of decision. Thus, Heckman sample selection approach will be used to deal with the selectivity bias resulting from, for example, the non-random subsets of perennial cropping farmers selected from all sampled farmers and Tobit model's problem. Another advantage for using the approach is that farmers may prefer perennial crop, because of some unobserved effects such as risk-aversion and skills. Practically, the Heckman sample selection model can be explained in two steps. At the first stage, the household's head decides either to grow the perennial crop or not (participation model). Then, based on its participation, we evaluate the area allocated to that perennial crop (evaluation model).

Formally, consider $y_{1i}$the surface area allocated to perennial crop by peasant i and $y_{2i}$the dichotomous variable taking the value 1 if the farmer i chooses the perennial crop and 0 otherwise. This decision is based on the comparison of the optimal profit from the perennial crop with the optimal profit from the annual crop. Indeed, if the profit from the perennial crop is higher than the annual crop profit, then, the farmer i will go for perennial crop and vice versa.

Let x and z be the vectors of explanatory variables for participation and evaluation models respectively. The model can be written as follows: $y_{1i} = x_i'\beta + \mu_i$ (1)

for evaluation equation where y_{1i} is observed only when $y_{2i} = 1$ according to the participation equation:

$$y_{2i} = \begin{cases} 1 \; if \; Z_i'\alpha + \varepsilon_i \geq 0 \\ 0 \; if \; Z_i'\alpha + \varepsilon_i < 0 \end{cases} \quad (2)$$

Where the joint distribution (μ_i, ε_i) is assumed to be bivariate normal with zero mean, variance equals to one and the coefficient of correlation ρ. The estimation procedure is carried out in two steps. At the first stage, we estimate the participation equation through a probit model which gives an estimate of the inverse of mills ratio $\lambda(z_i'\alpha) = \phi(z_i'\alpha)\Phi(z_i'\alpha)$ where ϕ et Φ are the standard normal density and standard normal distribution functions respectively. The second stage consists of the estimation of the evaluation equation (equation 1 including the inverse of mills ratio) using ordinary least squares method.

Empirically, the econometric model can be presented as follows:

<u>Evaluation equation</u>

$$\begin{aligned} Sup\_per = \beta_0 &+ \beta_1 educ + \beta_2 mig\_stat + \beta_3 \text{second}\_act + \beta_4 mod\_g + \beta_5 hhsize \\ &+ \beta_6 yield + \beta_7 yield\_sq + \beta_8 distance + \beta_9 distance\_sq + \beta_{10} age \\ &+ \beta_{11} age\_sq + \beta_{12} \text{sup}\_tot + \beta_{13} fallow\_dur + \beta_{14} resid + \mu_i \end{aligned}$$

Participation equation

$$typ\_cult = \alpha_0 + \alpha_1 educ + \alpha_2 mig\_stat + \alpha_3 \text{sec}\_act + \alpha_4 mod\_g + \alpha_5 hhsize + \alpha_6 distance + \alpha_7 age + \alpha_8 age\_sq + \alpha_9 \text{sup}\_tot + \alpha_{10} resid + \varepsilon_i$$

where sup_per is the surface allocated by farmer to perennial crop. Explanatory variables in the evaluation equation include education level (educ), migratory status (mig_stat), secondary activity (second_act), mode of land tenure governance (mod_g), household size (hhsize), a fallow duration (fallow_dur), age, age square (age_sq), distant residence-forest (distance) and its square (distance_sq), agricultural yield (yield) and its square (yield_sq), total land area owned (sup_tot) and resid (the residuals obtained from the estimation of endogenous explanatory variable equation).

The participation (selection) equation, with typ_cult=1 if the farmer chooses to grow perennial crop, includes the same covariates as the main equation except fallow dummy variable and agricultural yield for the sake of identification.

In this study, some covariates may be endogenous especially the governance variable (the assurance of right) which is used as a proxy for land tenure security following Lavigne (2010). It is a dummy variable that takes the value 1 if the land is managed only by customary institutions (traditional authorities) and takes the value 0 if other structures or groups are involved (ethnic group, religious group, association of youth, political party). Indeed, as mentioned in the previous section, a strategy used by protagonists is the mobilization of people who belong to a social group or the same social organization (family, ethnic group, political party) to prove that they enjoys legitimacy. In general, the number of people who support a protagonist in a conflict sometimes influences the authority in charge of conflict resolution. In this way, the choice of a cash crop which has an average life of 30 years is not fortuitous to the extent that it has the ability to increase tenure security and a sense of ownership of that farmer. The simultaneity between these two variables creates problems of endogeneity that must be addressed when estimating the model. Moreover, the endogeneity of tenure security may come from the unobservable factors like skill or risk aversion of the farmer which are likely to jointly affect a land area allocated to perennial crop (evaluation equation), his probability of choosing perennial crop (selection equation) and his land tenure security feeling. Since these unobservable factors cannot be included as control variables in our econometric model, we have a typical situation of endogeneity as the land security variable will be correlated with the error terms of the main and the selection equation. Therefore, ignoring the presence of endogeneity of an explanatory variable leads to inconsistent parameter estimates.

To deal with such endogeneity problem, we performed a modified version of the Heckman selection model proposed by Schwiebert (2014). Instead of using a full information maximum likelihood (FIML) approach that is time consuming, this author suggested a limited maximum likelihood (LIML) approach. But contrary to Schwiebert (2014) who estimates the reduced form equations of endogenous explanatory variable on instrument and other covariates by OLS, we use a linear probability model as suggested by Angrist (2001) since the variable is dichotomous.

With mod_g (land tenure security) as a potentially endogenous variable, we performed in the first stage a reduced form equation for land tenure security variable. Explanatory variables are the exogenous variables from the main equation and the local organization dummy variable (org_l) as instrumental variable.

But before we proceed so far, we estimate a Heckman selection model which does not account for endogeneity with the mode of land acquisition as proxy for land tenure security.

Indeed, although there is some mode of land acquisition[4] in the area, we consider in this paper two alternatives: inherited land and other that include all lands that are not received by inheritance. Based on the definition used here for tenure security, inherited land as a measure of tenure security can be viewed as exogenous since it cannot be challenged by a third party both in statutory and customary regimes.

3.2 Data and descriptive statistics

The data used in the analysis were collected in 2012 in five villages (Assakro, N'grakon, Appouesso, Appoueba and Blekoum) adjacent to two protected forests[5] (Béki and Bossématié) in the district of Abengourou which is located in the Eastern region of Côte d'Ivoire. Although current land disputes are more common in the Western South, the study area was the former cocoa belt and constitutes a perfect case study of migration-land-deforestation relationship. This area experienced the same process of land colonization like the one that is currently underway in the Western Centre and Western South which has become the new cocoa belt. Indeed, the labor shortage with low density of the population in the area during 1950 has encouraged the migration of the labor force from other part of the country and even neighboring countries. In consideration for their work, tutors (actually autochthones) allocated plots to these migrants from which they derived substantial revenues that facilitated the accumulation of other parcels to enlarge their farms. This process of land colonization led to the disappearance of the forest and the decline in the cocoa and coffee production such that the cocoa belt moved to the western south where forest exists.

Thus, a stratified random sample of 471 farm households was selected through a questionnaire. The questionnaire comprises four sections. The first section of the questionnaire contains background information (socioeconomic and demographic information). The second concerns tenure system, land access and perceptions of tenure security information. The third part includes soil conservation practices information and the last section is related to the willingness of farmers to preserve forest.

After dropping households having irrelevant characteristics for the present study, the size of our sample is reduced to 436 households.

Table A1 in appendix provides descriptive statistics of the variables used in the study.

On average, the total arable land per household is 14 ha and fallow duration is about 2 years and half. The average age in the sample was about 50 years. In terms of distance from a household unit to the forest area, the average was about 3km. The average size of the household was about 11 members. By migratory status, 38% of sampled households are native, 32% are allochtonous and 30% are foreigners. In terms of education, 2/3 of sampled households are illiterate and only 2% have higher education level when 22% have primary education. As far as gender is concerned, about 92% of the household heads interviewed were males while only about 8% were females.

As the respondents are divided into two subgroups (perennial growers and annual growers), it is necessary to determine whether excluding households who are not growing perennial crops would lead to a sample selection bias. To this end, we perform a simple t-statistics test on the difference on the mean of households' covariates between the two subgroups. The results are reported in table 1 and indicate that the difference between these two subgroups of households

[4] These modes are inherited land, land received from land chief, land received from other farmers, and land received from administration.

[5] A protected forest is the forest owned by the government.

is statistically significant for many variables. Therefore, the use of a Heckman sample selection model is appropriate to deal with the selectivity bias.

Table 1: Comparison of Means and Standard Deviations by Groups of Households according to type of crop.

	Perennial crop growers		annual crop growers		
Variables	mean	Sdt. Err.	mean	Sdt. Err.	difference
Migration status					
Native	0.38	0.486	0.33	0.5	-0.048
Allochtonous	0.32	0.468	0	0	-0.32**
Immigrant	0.29	0.456	0.66	0.5	0.37**
age	50.18	15.53	43.33	13.91	- 6.84*
Hhsize	10.54	5.923	7	3.67	-3.54*
Second_act	0.969	0.172	0.44	0.527	-0.525***
Sup_tot	13.89	16.331	14.45	32.16	0.557
Distance	3.035	3.927	4.55	2.128	1.52
Fallow_dur	2.41	3.129	3.33	2.738	0.92
Inherit_land	1.838	1.057	2.44	1.51	0.606*
Education	1.57	0.81	2.11	1.166	0.54**
Observations	427		9		

***, * *and * indicate that the difference is statistically significant at 1% , 5% and 10% level.

Author's calculation

4. Results and discussion

The results of the adoption and expansion of perennial cropland models (model I and model II) estimated using Heckman's 2-step approach are reported in Table 2 and 3 respectively. The model I uses the substance measure of property rights as proxy for tenure security which is considered here as exogenous, while the model II uses the assurance aspect of tenure security which is considered as endogenous variable. The estimation technique accounting for the endogeneity bias (table 3) is justified since the variable resid is significant with positive sign especially in the participation equation. Indeed, it seems to have latent factors which decrease the probability of adopting perennial crop while increase the tenure security. This may justify the assumption that people develop strategies (lobbying) to claim land.

In general, the variables that significantly influence the adoption and expansion of perennial crops (conversion of forests) differ, to some degree, according to the variable that captures the tenure security.

In the case where the mode of land acquisition is used as a proxy for tenure security and is considered as an exogenous variable (Model I), factors promoting the adoption of perennial crops are: illiteracy, migration status (native), household size and having a secondary activity. Indeed, the majority of cocoa and coffee producers are in rural area and are, in most of the cases, illiterate. As expected, being native has a positive and significant effect on the adoption of perennial. Being native gives a sense of ownership and renders less likely the probability of land expropriation compared to non-native. This result suggests that migration status (the origin of the farmer) can be the primary indicator of smallholder's feeling about land security in the context of the absence of land titling. In addition, having a secondary activity renders more likely the adoption of perennial crops to the extent that these crops do not require a permanent human presence compared to food crops especially garden crops.

As expected in the developing countries, household with a large size is more likely to adopt perennial. Indeed, perennial cultivation is a labor intensive activity and is suitable to a household with a large quantity of family labor. This last variable (hhsize) is also confirmed

by the second regression (model II) where the proxy variable related to the assurance of tenure security is used.

Table 2: Heckman's 2-step Estimates (Model I[1])

	participation model		valuation model	
Variables	Coef.	Sdt. Err.	Coef.	Sdt. Err.
Constant	0.837	(2.233)	6.973***	(2.65)
Education				
Primary	-0.198	(0.572)	0.633	(0.623)
secondary	-1.008**	(0.49)	1.09	(0.753)
Higher	-1.035	(0.86)	-4.22**	(1.682)
Age	0.038	(0.09)	-0.202**	(0.097)
Age_sq	-0.0003	(0.0009)	0.002**	(0.0009)
Hhsize	0.092*	(0.048)	0.234***	(0.047)
Sec_act	0.16*	(0.087)	0.077	(0.132)
Migration status				
immigrant	-1.441**	(0.595)	0.391	(0.616)
Sup _tot	-0.007	(0.01)	0.226***	(0.017)
Inherit_land	-0.228	(0.612)	-1.03*	(0.567)
Distance	-0.029	(0.029)	0.22**	(0.102)
Distance_sq			-0.0035	(0.003)
Yield			-0.008***	(0.001)
Yield_sq			1.68e-06***	(4.97e-07)
Fallow_dur			-0.069	(0.079)
Mills Lambda			0.037	(1.366)
Observations	436		436	
Prob > chi2 = 0.0000				

*, **, and *** indicate that parameters are significant at 10%, 5% and 1% level respectively.

1. In the model I, the tenure security variable is related to substance of property rights and is considered as exogenous.

Source: Author's calculation.

Regarding agricultural land's expansion, the same variables, except only one variable, significantly influence the expansion of perennial crops (conversion of forests) in both models regardless the variable capturing the tenure security. These statistically significant variables are illiteracy, age, yield, family's total land and hhsize.

As expected, illiteracy and large household size are significant determinants of forest conversion to agricultural land. The addition of one unit of household size is associated with more cleared forest land for agricultural purposes. This result supports the argument that more household members stimulate greater demand for crops for household consumption and, in this case, for sale to market.

Table 3: Heckman's 2-step Estimates (Model II[1])

	participation model		valuation model	
Variables	Coef.	Sdt. Err.	Coef.	Sdt. Err.
Constant	2.48	(2.47)	4.76	(3.13)
Education				
primary	0.021	(0.512)	0.625	(0.657)
secondary	-0.64	(0.434)	0.648	(0.835)
higher	-1.179	(0.832)	-4.931***	(1.891)
Age	0.028	(0.086)	-0.17*	(0.103)
Age_sq	-0.0002	(0.0009)	0.002**	(0.0009)
Hhsize	0.094**	(0.047)	0.269***	(0.054)
Second_act	0.13	(0.092)	0.163	(0.157)
Migration status				
immigrant	-0.52	(0.413)	0.501	(0.581)
Sup_tot	-0.011	(0.01)	0.224***	(0.019)
Mod_g	-2.485*	(1.324)	0.22	(1.99)
Resid	2.99**	(1.412)	-0.084	(2.13)
Distance	-0.035	(0.033)	0.176	(0.11)
Distance_sq			-0.003	(0.003)
Yield			-0.008***	(0.001)
Yield_sq			1.7e-06***	(5.17e-07)
Fallow_dur			-0.077	(0.08)
Mills Lambda			5.005	(4.402)
Observations	436		436	
Prob > chi2 = 0.0000				

*, **, and *** indicate that parameters are significant at 10%, 5% and 1% level respectively

1. In the model II, the tenure security variable is related to assurance of property right and is considered as endogenous.

Source: Author's calculation.

Households whose head had attended school at some point clear less forest land for crop production. The result supports the idea that a minimum level of education is required for agricultural intensification.

Thus, this process of forest conversion is stimulated, in one hand, by the labor intensive technology in use in the agricultural sector and, in the other hand, by the fact that low level of education leads to low probability of adoption of new intensification technology and offers low off-farm activity opportunities.

Factors such as crop yield and age are crucial to forest preservation regardless to the measure of land tenure security. Specifically, there is a nonlinear relationship between forest conversion and agricultural productivity on one hand and with age on the other hand. Indeed,

the crop yield and age variables have an important negative effect on conversion of forest land into agriculture while their squared terms have positive signs.

As regards the crop yield, this statistic association implies that increasing crop yield results in less forest conversion at an increasing rate. These findings confirm the Borlaug hypothesis which postulates that increasing crop yields reduces the expansion of agricultural land (Balmford *et al*. 2005, Mattison and Norris 2005, Matson and Vitousek 2006, Ewers *et al*. 2009, Holden *et al*. 2009, Burney *et al*. 2010, Djezou 2013).

Concerning the age, as it can be a proxy for farmer's experiences in farming, more experienced farmers clear less forest land. Indeed, by increasing their technical skills in growing perennial crop with new intensive technologies, farmers are prone to convert less forest land.

Thus, the experience acquired through age and improving agricultural yields are the key factors for agriculture stabilization policy and forest preservation.

Another source of the excessive conversion of forests to perennial crops is related to the distance separating the protected forest to villages. Indeed, the distance between forest and place of residence has an important positive effect on conversion of forest land into agriculture. The negative sign on the squared term indicates that the positive effect declines with distance. This result is similar to the early one obtained by Place and Otsuka (2001) who found that deforestation is higher where village forest areas occupied a larger share of the area. This result raises the problem of the presence of the human population around protected forests. Indeed, the rural population[6] (the poor) depends on natural resources in general and forest resources in particular for their survival.

As regards the institutional factors, the study shows that tenure security plays a very important role in forest preservation regardless the proxy used for tenure security. Nevertheless, the mechanism differs according to the variable used to capture tenure security. In general, the institutional factors significantly affect specifically the expansion equation in model I while they do influence the adoption equation in model II.

In model I, the method of acquiring land by inheritance significantly reduces the conversion of forest land. Indeed, inherited land confers tenure security to their holders. So, they have incentives to use their plots in a rational and sustainable manner. This result confirms the hypothesis that tenure security promotes forest preservation through investments (Pichón 1997, Deacon 1999, Bohn and Deacon 2000, Bhattarai and Hammig 2001, Cattaneo 2001, Otsuki *et al*. 2002, Culas 2007, Robinson *et al*. 2011).

In model II that is when the tenure security refers to the consensus rules and land management institutions in the view of Lavigne (2010), land insecurity significantly increases the probability of adopting perennial crops which comes at the expense of forest cover. In this view, the perennial culture is a way of securing the rights to the land and reflects the endogenous characteristic of land tenure security variable. This is typically the case when the mode of land acquisition is outside the customary arrangement. For example, as it is popular in that region, some plots (part of the protected forest) are granted by administrative authorities to some people against their political support without consulting local authorities. Indeed, the interference in the customary land management results in tenure insecurity that drives the expansion of perennial crops land by beneficiary in order to strengthen its rights on the plot. Therefore, this strategy reinforces land tenure security and the smallholder's sense of ownership. This result confirms earlier ones (Libecap 1999, Angelsen 2001, Alston *et al*. 2001, Place and Otsuka 2002, Brassell *et al.* 2002, Araujo *et al.* 2009) and formerly by Place and Otsuka (2001) who especially found that woodland conversion is higher in areas where some changes have been made to traditional tenure systems.

[6] Poverty is most severe in rural area with a poverty rate of 62.45% in 2008 (DSRP 2009).

Whatever the proxy used, both results strongly point to the need for tenure security for forest preservation in Côte d'Ivoire.

5. Conclusion

The high rate of deforestation due to farmland exploitation has attracted interest in research on the main causes of the loss of forest cover. In this perspective, we analyzed the relationship between tenure security and the expansion of perennial crops which are presented as the main cause of deforestation in Cote d'Ivoire. The application of the Heckman selection model taking into account the endogeneity of the land security variable has pointed out several factors.

Firstly, the paper demonstrates that land tenure is inextricably linked to forest outcomes. Indeed, tenure insecurity and the interference of modern administration with custom law significantly promote the conversion of forest land to agriculture. In addition to these institutional factors, other socio-economic factors were found to be relevant. These are the size of the household, the illiteracy of the farmer and the proximity of the villages to the forests. Furthermore, the study showed that the preservation of the forest depends significantly on the increase in agricultural yields, the security of land tenure, the high level of education, and the number of years of experience of the farmer. Therefore, we recommend an improvement in the land tenure security and the level of education of the rural population in addition to an increase in crop yields and the distance between villages and forest reserves.

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Appendix

Table A1: Descriptive Statistics for the Sampled Households'

Variables	Description of variable	mean	Sdt. Dev
Migration status	Migration status of the household (native=1, otherwise=0)	0.381	0.486
Yield	Agriculture yield (kg/ha)	337.88	314.606
typ_cult	Dummy for type of crop (perennial=1, otherwise=0)	0.979	0.142
age	Age of the head of household (number of years)	50.036	15.514
sex	Sexe of the head of the household (male=1, female=0)	0.917	0.275
Marital status	Marital status of the head of household (married=1, otherwise=0)	0.848	0.358
Hhsize	Household size	10.47	5.904
Second_act	Whether a household has a secondary activity or not (secondary activity=1, otherwise=0)	0.958	0.199
Sup_per	Land area under perennial (ha)	6.819	6.915
Sup_tot	Total surface of arable land owned by the household (ha)	13.89	16.74
Distance	Distance from house to forest area (km)	3.066	3.903
Fallow_dur	Duration of fallow (number of years)	2.431	3.121
inherit_land	Mode of land acquisition (inherited land=1, otherwise=0)	0.314	0.464
Mod_g	Dummy variable for land tenure governance (custom =1, otherwise=0)	0.594	0.491
Org_l	1 if the household head belongs to a social organization, 0 otherwise	0.608	0.489
primary	1 If the of household head has primary education, 0 otherwise	0.22	0.415
secondary	1 If the of household head has secondary education, 0 otherwise	0.145	0.352
Higher	1 If the of household head has tertiary education, 0 otherwise	0.023	0.149
Observations		436	

Source: Author