Action levers for a sustainable farmland management in Niger

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ABSTRACT

This study aims to contribute to the understanding of factors influencing the sustainable farmland management in Niger. Specifically, it examines the determinants of adoption of sustainable land management practices including measures to combat erosion, and the use of manure, residues and fertilizer with a view to support the formulation of efficient land use policies based on evidences given fact that the impact of factors influencing farmland management appears to be specific to each context. The study is based on data from the National Survey of Household Living Conditions and Agriculture of 2011 (ECVMA-2011) analyzed within the framework of multivariate Probit model. The results show that there are unobservable interdependences between the decisions on farmland management practices. Furthermore, several types of factors related to access to physical, human, financial and biophysical capitals as well as infrastructure and services seem to play an important role. In addition, it appears that more security is needed in land tenure for a sustainable farmland management while farmland defragmentation can act negatively on sustainable farmland management.

Keywords: land, degradation, sustainable farmland management, poverty.

1. INTRODUCTION

In Niger, poverty reduction and social development in general is happening at a relatively slow pace compared to most countries in sub-Saharan Africa (SSA). For example, from 1993 to 2007 the poverty incidence fell marginally from 63% to 59.5% and the country was ranked in the last place based on Human Development Index in 2014 (UNDP 2014). This contrasted sharply with a decline in poverty incidence from 60.9% in 1993 to 49.7% in 2008 for SSA as a whole. It is instructive to note that agriculture is the largest employer of labour with more than 80% of the economically active population in Niger employed in this sector. Hence, economic and social development in Niger can be accelerated by improving the productivity of the agricultural sector whose impact on poverty seems to be well acknowledged in the literature. Yet, it should be pointed out that the Nigerien agricultural sector faces several challenges not only climatic characterized by soil erosion but also technological ones.

In Niger, there is a low use of fertilizers (less than 1 kg per hectare) and modern seeds (Nkonya *et al.* 2011). In addition, the level of mechanization of this activity is low. Furthermore, the rates of land management practices such as the use of organic and chemical fertilizers, animal manure, and incorporation of crop residues are low (Nkonya *et al.* 2011). This observation is also true for many developing countries (Wossen *et al*. 2015) and can be explained by the fact that investments in sustainable land management practices are influenced and constrained by many bio-physical, institutional and socio-economic factors (Shiferaw *et al*. 2009; Tesfaye *et al*. 2013).

As stated by Ovwigho (2014), land is the most important factor of crop production activities. Kassie *et al.* (2012), clearly, show that soil conservation and water harvesting play a crucial role in sustaining crop yields by increasing soil moisture. Accordingly, soil degradation, through the farmland productivity reduction, can undermine the economic role of agriculture and seriously harm the livelihoods of thousands of Nigerien households. Particularly, land degradation has its largest negative impact on the livelihoods and well-being of the poorest households in the rural areas of developing countries (Nachtergaele *et al.* 2010).

Aware of this challenge for the country food security, the land management policy is at the heart of the Government of Niger's development policies, which led to the establishment of the natural resources management project and more than 50 program were promoted by the government, NGOs and donors since 1980 (World Bank 2009). Yet, despite the urgent need for preventing and reversing land degradation, the problem has yet to be appropriately addressed (Lal *et al.* 2012).

Specifically in Niger, it seems that a lot of efforts are still needed to reduce the effects of land degradation, with estimates by Nkonya *et al.* (2011) showing the cost of soil degradation to be about 8% of the GDP of the country. Furthermore, according to Nkonya *et al.* (2011), policy actions for sustainable land management are lacking, and a policy framework for action is missing. Von Braun *et al.* (2013), points out that such a framework for policy action needs to be supported by evidence-based and action-oriented research: hence, the need for this study.

In this study we consider the adoption of a combination of sustainable farmland management practices as opposed to the adoption of a single component of sustainable land management practices. This was motivated by evidences in Teshome *et al.* (2014) which suggest that a successful farm production system requires a portfolio of practices because to take advantage of the synergy and/or complementarity and/or substitution effect among practices. Thus, the methodology is essentially empirical and based on estimation of a multivariate probit model to take into account the unobservable interdependences between practices. The study data were extracted from the National Survey of Household Living Conditions and Agriculture of 2011 (ECVM/A-2011) in Niger.

The rest of the paper is organized thus: this introduction is followed by literature review in Section 2. Section 3 presents the study methodology, including the source and type of data used. Section 4 presents results of the descriptive and econometric analysis. The final section presents the study conclusions including the various implications of the main results.

2. LITERATURE REVIEW

Despite, a strong evidence that the adoption of land management practices are profitable in agriculture, the adoption rates of such profitable land management practices remain critically low (Di Falco & Bulte 2013; Shiferaw *et al.* 2009). Different types of factors have been highlighted as determinants of these land management practices adoption. The literature on those factors is extensive and covers different socioeconomic and environmental contexts and seems impossible to cover in its entirety. But, the fundamental link that the literature has focused on is that between access to physical, human, financial and biophysical capitals as well as infrastructure and services and the different practices of sustainable land management. The controversy in the findings in terms of positive or negative effect does not permit to conclude definitively on the impact of different factors.

First, it is found that human capital endowments can reduce the realization of the soil conservation activities due to the opportunity cost of labor in other activities (Pender & Kerr 1998). In other contexts, it appeared that education increases awareness of the importance of technical assistance and facilitates access to this service or relaxes credit constraints or any other constraints to the adoption of new agricultural practice (Mekuria & Waddington, 2002; Pender *et al.* 2004). For example, it is highlighted that education contributes to an increased use of fertilizer in an Ethiopian region (Benin 2006) and Uganda (Nkonya *et al.* 2004). Furthermore, a gender effect does exist. For example, it seems that the education of men has more influence on land management in Uganda (Pender *et al.* 2004).

Then, the composition of the household in terms of labor endowments influences farmland management and this is supported by many evidences. Pender and Kerr (1998) show that men's labor supply is correlated with major investments in soil water conservation practices in some Indian villages. In the same vein, Jagger and Pender (2006) find that the labor endowment of men increases the use of intensive farmland management practices in labor in Uganda while a female labor endowment increases fertilizer use. A similar result was highlighted by Kazianga and Masters (2002) in Burkina Faso. Place *et al.* (2002) found in western Kenya that households headed by women in which the husbands are absent are less likely to use fertilizer but more likely to use compost.

Another aspect concerns land tenure system (e.g. tenure arrangements and tenure security) which also influence the investment in farmland management practices (Deininger & Jin 2006;

Mekonnen 2009). Indeed, a lack of secure access to private property is commonly seen as a major constraint to sustainable land management. For some, land registration and titling can increase tenure security, promote investment and encourage better natural-resource management (Deininger *et al*. 2011). There are many studies that show that a non-secure private property is a problem for the poor in developing countries such as those of Feder *et al*. (1988) in Thailand; Alston *et al.* (1996) in Brazil; López (1997) in Honduras and Deininger and Chamorro (2004) in Nicaragua. However, other authors (Atwood 1990; Migot-Adholla *et al.* 1991; Place and Hazell 1993; Platteau 1996; Toulmin and Quan 2000; Deininger 2003) show that customary land tenure provides a sufficient security especially by promoting sustainable land management and land titling was inefficient.

The influence of access to infrastructure, markets, and services on land management was also highlighted with controversial effects. Indeed, households with more market access and infrastructure will tend to receive higher prices for their products and are thus more incited to invest and produce more valorous items. In addition, they benefit from lower input prices which leads to a more profitable production (Binswanger & McIntire 1987; Pender *et al.* 2006). However, more intensive labor land management activities may be compromised because the opportunity cost of labor tends to be higher with market access.

In addition, it is clear from the literature that non-farm activities can firstly affect the opportunity cost of labor and on the other hand the households' ability to finance the purchase of inputs and make other investments. This is why some authors find that these activities have a positive effect in certain contexts (Pender & Kerr 1998; Kazianga & Masters 2002) while for others non-agricultural incomes have a negative effect on land management practices intensive in labor in several contexts (Clay *et al.* 1998; Jansen *et al.* 2006). In the same vein, Shiferaw *et al.* (2008) and Suri (2011) highlight the effect of credit availability on the adaptation of land management practices.

Finally, other determinants are related to the characteristics of the plot such as its size and topography or quality (Adimassu *et al.* 2012). Particularly, with respect to farm size there is a controversy in the literature due the ambiguous effect of land defragmentation on land sustainable management (Niroula & Thapa 2005; Sklenicka *et al.* 2014).On the one hand, land fragmentation increases the transaction cost of investments which can hinder investments (van Dijk 2002; Lisec *et al.* 2014). On the other hand, land fragmentation allows farmers with scattered plots to benefit through risk reduction, crop scheduling and use of multiple ecological zones (Tan *et al.* 2006; Sikor *et al.* 2009) or households with small piece of land can invest more in land improvement activities most intense in labor (Hagos & Holden 2006; Jagger & Pender 2006).

3. METHODOLOGY

3.1 Econometric Strategy

The theoretical foundation of our model is that developed by Nkonya *et al.* (2004) which is also based on agricultural household models developed by Singh *et al.* (1996); Janvry *et al.* (1991) and Carney (1998). Empirically, it is a multivariate probit model that is estimated which simultaneously models the influence of the set of explanatory variables on each of the different practices while allowing the error terms to be freely correlated (Greene, 2008). This is justified by the fact that there is a probable interdependence between different farmland management practices and possible simultaneity of these investment decisions. The rationale behind that is farmers are more likely to invest in a mix of technologies than in a single technology to cope with multiple agricultural production constraints (Kassie et al., 2013). Farmers might consider a combination of practices as complementary and others as substitution. Failure to capture unobserved factors and inter-relationships among investment decisions regarding different practices will lead to bias and inefficient estimate (Greene, 2008).

Formally the model is written as follows:

$$Y_j = \begin{cases} 1 \ if \ \ y_j^* = \left(X\beta_j + \varepsilon_j\right) \geq 0 \\ 0 \ if \ \ y_j^* = \left(X\beta_j + \varepsilon_j\right) < 0 \end{cases} \qquad j=1, 2, \ldots, m$$

Where Y_j is a binary variable that takes on the value one (Y_j =1) on adoption of the practice j, which in this study include anti-erosion measures as well as use of manure, residues and fertilizer (m=4) if the latent variable y_j^* is positive and zero if otherwise. β_j is the vector of parameters to be estimated and X is the vector of sociodemographic characteristics hypothesized as the determinants of adoption of the practices. This vector also includes endowments in physical, human and financial capitals, access to markets, information, technical services, climatic and geographical conditions and land tenure variables. While $\varepsilon' = [\varepsilon_1 \ \varepsilon_2 \ \varepsilon_3 \ \ \varepsilon_4]$ follows a multivariate normal distribution $MVN(O, \Delta)$ of Δ centered variance-covariance matrix.

The estimation is performed by the simulated maximum likelihood approach which requires to determine a sufficient number of simulation. As recommended by Caperlli and Jenkin (2003), we retain a number of simulation greater than or equal to the square root of the sample size. The correlation coefficients between the residuals will reflect the nature and the degree of interdependence between the unobserved factors of the different variables.

3.2 Data Sources

The data used for the study were extracted from ECVM/A-2011, a households' survey that covered about 4,000 farm households. ECVM/A took place in two passages, with each household visited twice. The first round took place between June and August 2011 during the planting season; the second round took place between October and December 2011, during the harvest period. During the first passage, household and agriculture/livestock questionnaires were administered as well as the community questionnaire that also captured community level prices. In the second passage, the household questionnaires and agriculture/livestock were administered.

In this study, interest was specifically on agricultural, community and households' socio-economic data. The data were analyzed at three levels: plots, households and community. The sample plot level consists of 4568 observations distributed among 1658 households in 148 municipalities. These three information were merged together to form the final database for the analysis.

Recall that the determinants that we are estimating jointly are those of the fight against the erosion that indicates if the household has at least built the Gabions/sandbags, Half moons, Zai, Trees Belt / Herbs Belts, Muret /or Cordon stone bunds. The second variable indicates whether the household has used manure or compost. The third dependent variable refers to the use of residues which is also an organic fertilizer. Finally fertilizer use refers to chemical fertilizers such as urea, DAP, NPK or mixture.

4. FINDINGS

4.1 Descriptive Statistics

Concerning the statistical description of the data, one can note that the use of residues is carried out on 38.8% of the plots, while the use of manure is carried out on 32.4% of the plots. The fight against erosion and fertilizer use are the least popular practices, with adoption rates of 3.3% and 12.7% respectively among the plots. Then, the average size of the plots is 1.32 ha and 80% of them are households' properties, while only 14% are in renting and 2.34% in mortgage. Regarding the topography, approximately 66.6% of the plots are in the plains against 12% in steep slope and 12.3% in the valleys. Finally, over 85% of the plots are reached on foot. The percentage of plots visited by a cart is about 10.27%.

Women headed households involved in agricultural activities represented 7.6% and the average age of household heads is approximately 44.5 years. The haoussa are relatively more numerous and represent 49.34% of the households, followed by the Djerma-Songhai ethnic group. The Touaregs represent 10.55%, the Kanuri-Manga in similar proportion and Fulani only 4.28% of the total. The households' heads are mostly monogamous and are around 70% of the total, while polygamous families represent 23.52%. Under the structure of households in terms of gender, it appears that, in average, 50.8% of household members are women. Regarding educational level, only 6.92% of households' members seem to have completed the primary level in average. These households have, in average, one family business enterprise with up to 6. In addition, they are geographically located at an altitude of 90.55 m and travel about 55.2 Km to reach the nearest market. The average annual rainfall is 386.45 mm and 28.3 ° C for temperature in their place of residence.

Regarding the variables at community level, there is an indicator of access to financial capital, which is the number of banking and microfinance structure in the area. On average, there is less than one structure per community. This level of availability is the same for agricultural technical centers and community radio stations. However, it is worth noting that some communities have up to 6 microcredit and banking centers, 2 technical centers or 3 community radios.

3.2 Econometrics findings

Table 1 presents the results of the econometric estimates of the Probit multivariate model. Several important results are noteworthy, such as the significance of the correlation coefficients indicating the interdependence of these different farmland management practices. More precisely, it appears that the unobserved factors that influence the decision in the fight against erosion are positively correlated with unobserved factors that influence the use of manure (or compost). A similar result is observed when comparing the use of manure and the use of residues or fertilizer with the use of fertilizers and residues. However, the correlation is negative between the fight against erosion and the use of manure or residues.

The main results of this study can be classified into three groups. The first group of results focuses on the influence of socio-demographic and economic characteristics of households. First, the fact that the household head is female positively impacts the decision to fight against erosion or to use fertilizers, even if household composition in terms of share of men and women is not significant. Then, the ethnic group - which is a social network indicator - shows that being Zarma-Songhai negatively influences the decision to fight against erosion and to use manure, as compared to other ethnic groups such as Hausa, Kanuri, Manga, Touareg and Peul. However, there is a reverse result as regards the use of fertilizers. The marital status of the household head influences positively the fight against erosion for married monogamous relatively to single, divorced or widowed and negatively among polygamous, regarding the use of manure. Finally, it appears that the possession of a non-agricultural business, which is an indicator of the diversification of household activities, positively impacts the decision to fight against erosion, to use manure and fertilizer. In other words, unlike some other contexts, in Niger, the presence of non-farm income has positive effects on agricultural farmland management by facilitating investment in the fight against farmland degradation.

The second group of results is related to household education and access to financial capitals, infrastructure, services and information. At this level, it appears that human capital is not significant, which indicates that the labor opportunity cost that increases with the human capital is not a constraint to the use of labor intensive farmland management practices or that education positive and negative effects are neutralized. Another important result is that access to credit has a negative impact on the use of different practices. This can be explained by climatic shocks suffered by agriculture, leading households to prefer other uses of these resources. In addition, the distance to market constitutes an obstacle to the use of manure and fertilizer. Finally, in respect to access to services and information, it appears that access to agricultural technical center acts positively on the use of residues, while access to community radio influences positively the fight against erosion.

Table 1: Econometric Estimates

	Fight against erosion	Use of manure	Use of residues	Use of fertilizer
Female gender	0.432(0.219)**	-0.199(0.152)	0.137(0.139)	0.358(0.162)**
Household head age	-0.004(0.003)	0.001(0.001)	0.001(0.001)	-0.005(0.002)***
Haoussa (Djerma-Songhai)	0.405(0.125)***	0.674(0.069)***	0.185(0.071)***	-0.490(0.085)***
Kanouri-Manga	0.379(0.205)*	0.629(0.111)***	-0.023(0.111)	-0.198(0.135)
Peul	0.630(0.236)***	1.056(0.142)***	0.023(0.144)	-0.450(0.167)***
Touareg	0.113(0.164)	0.433(0.091)***	0.081(0.090)	-0.289(0.119)**
Monogamous (Sep-Sin-wid)[a]	0.555(0.287)*	-0.262(0.161)	0.056(0.146)	0.229(0.178)
Polygamous	0.383(0.286)	-0.345(0.163)**	0.060(0.148)	0.206(0.180)
Women share	0.107(0.226)	-0.026(0.127)	-0.006(0.128)	0.228(0.158)
Primary schooll share	-0.129(0.344)	0.257(0.164)	0.174(0.166)	0.189(0.199)
Secondary school and + share	-0.297(0.731)	-0.194(0.256)	-0.190(0.286)	0.250(0.321)
Dist. Parcel. household (km)	0.025(0.014)*	-0.095(0.009)***	-0.026(0.008)***	-0.036(0.011)***
Cart (Foot)	-0.315(0.148)**	0.298(0.067)***	-0.241(0.070)***	-0.024(0.087)
Others	-0.616(0.314)**	0.138(0.113)	-0.114(0.111)	0.262(0.124)**
Plain (Hill)	0.077(0.172)	-0.056(0.091)	0.230(0.100)**	-0.185(0.118)
Gentle slope	0.290(0.192)	-0.123(0.106)	0.356(0.112)***	-0.408(0.152)***
Steep slope	0.267(0.244)	-0.234(0.143)	0.602(0.139)***	-0.215(0.183)
Valley	0.598(0.185)***	0.096(0.105)	0.512(0.111)***	0.234(0.129)*
Land size (ha)	0.080(0.036)**	0.188(0.019)***	0.043(0.019)**	0.149(0.023)***
Free Ready (Property)	0.444(0.218)**	-0.336(0.181)*	-0.490(0.176)***	-0.058(0.222)
Mortgage/pledge	-0.194(0.302)	-0.552(0.149)***	-0.065(0.133)	0.135(0.150)
Renting	-0.250(0.136)*	-0.281(0.064)***	-0.213(0.063)***	0.070(0.073)
Other	0.811(0.239)***	0.010(0.167)	-0.852(0.230)***	-4.319(0.086)***
Dist. maket (Km)	-0.002(0.001)	-0.005(0.001)***	0.000(0.001)	-0.002(0.001)*
Temperature (°C*10)	0.057(0.012)***	0.024(0.006)***	-0.028(0.006)***	-0.054(0.008)***
Pluviometry (mm)	0.001(0.001)	0.004(0.000)***	0.000(0.000)	0.003(0.000)***
Altitude (m)	0.004(0.001)***	0.001(0.001)***	0.001(0.000)*	-0.004(0.001)***
Nber of non agri. Enterprise	0.062(0.031)**	0.049(0.019)***	-0.027(0.018)	0.045(0.023)**
Nber of Banke/microcredit	-0.137(0.052)***	-0.115(0.034)***	-0.631(0.070)***	-0.133(0.055)**
Nber of Agri. tech. centre	0.221(0.165)	0.162(0.112)	0.590(0.119)***	0.111(0.119)
Nber of community radio	0.226(0.132)*	-0.138(0.121)	-0.005(0.135)	0.073(0.119)
Constant	-20.767(3.539)***	-8.845(1.838)***	6.726(1.758)***	13.883(2.479)***
Rho_{ij}	0.252(0.046)***			
	-0.218(0.049)***	0.051(0.026)*		
	-0.037(0.063)	0.278(0.031)***	0.088(0.032)***	
Observations	4568	4568	4568	4568

Source: Author. Robust standard deviation in brackets. *** P <0.01, ** p <0.05, * p <0.1

[a] Separated-Single-Widowed

The last group of results concerns the characteristics of the plots themselves and climatic factors to which they are subject. A first important result is that the size of the plots positively influences the development of land management practices. In other words, large parcels are more likely to be managed. This can be explained by the fact that land fragmentation can increase the transaction cost of investments, which can discourage farmers to invest in land management practices as stated in the literature. In addition, it is noted that the topography of the land influences the different farmland management decisions. For example, fight against erosion and use of fertilizer on plots are more likely to take place in the valley than on the hill. A result similar to the previous one is also found concerning the comparison between the use of residues in the hill position and other types of topography. However, the use of fertilizer is less likely on a plot situated on a gentle slope compared to one located on a hill. The geographical position of the field in terms of accessibility acts negatively on manure, fertilizer and residues use practice, after controlling the type of transportation to get there. In the same vein, there is the effect of the altitude, according to the type of practice. Climatic factors are also very important elements in the development of different land management practices. Indeed, warming has a positive impact on the fight against erosion and the use of manure, but a negative one on the use of residues and fertilizer. Rainfall, in turn, positively influences the use of manure and fertilizer. In other words, good rainfall acts positively on the use of organic and inorganic fertilizers. The last important result of this study is related to land tenure system. It follows that the fact that the plot is in renting negatively impacts the decision to fight against erosion, to use manure or residue. A result similar to the previous one for the use of manure in case of mortgage or pledge is also found. This may be due to the fact that the current land tenure system does not guarantee enough security, especially for non-owners. Therefore, investing in farmland management practice seems risky for these farmers.

5. CONCLUSION

Since agriculture is the main source of income of the population of Niger, farmland degradation can undermine their livelihoods. To this end, by using the data of ECVM/A 2011 of Niger, this study aims to determine the levers to promote sustainable management of farmland in Niger. A multivariate probit model was estimated to take into account the interdependences among unobservable land management practices considered here: the fight against erosion, the use of manure, residues and fertilizers.

The results show that there is indeed an interdependence among the decisions of farmland management practices. In addition, there is an influence of socio-demographic characteristics of the household head and geographical position of the household in terms of market access. In addition, formal education is not a requirement for the adoption of these different land management practices. However, access to the technical agricultural service and access to information via community radios play a significant role for the adoption of farmland sustainable management practices. With respect to the access to financial capital, it appears that access to credit led households to invest less in farmland management. However, the presence of income from non-agricultural activities has a positive influence. In other words, households prefer to use their own resources for farmland management instead of credits, due to climatic hazards likely. It should also be noted that the characteristics of the plot such as its size and topography, its geographical position and weather conditions, play an important role. The last important result of this study is related to land tenure system which shows that tenure is crucial by indicating that more security is needed in land tenure for the adoption of practices that contribute to the reduction of land degradation.

Thus, as noted in the literature review, the results on the factors influencing farmland management seem specific to each context. Therefore, the government of Niger should consider these results in the formulation of policies aiming to increase good management of farmland for a more productive agriculture.

BIBLIOGRAPHY

Adimassu Z, Kessler A & Hengsdijk H. (2012). Exploring determinants of farmers' investments in land management in the Central Rift Valley of Ethiopia. Applied Geography 35: 191–198.

Alston LJ, Libecap GD & Schneider R, 1996.The determinants and impact of property rights: Land titles on the Brazilian frontier. Journal of Law, Economics and Organization 12:25–61.

Atwood DA, 1990. Land registration in Africa: The impact on agricultural production. World Development 18: 659–671.

Benin S, 2006. Policies and programs affecting land management practices, input use, and productivity in the highlands of Amhara Region, Ethiopia. In Pender J, Place F & Ehui S (eds), Strategies for sustainable land management in the East African Highlands. Washington, D.C.: International Food Policy Research Institute.

Binswanger HP & McIntire J, 1987. Behavioral and material determinants of production relations in land abundant tropical agriculture. Economic Development and Culture Change 35:73–99.

Clay DC, Reardon T & Kangasniemi J, 1998. Sustainable intensification in the highland tropics: Rwandan farmers' investments in land conservation and soil fertility. Economic Development and Cultural Change 46:351–378.

De Soto H, 2000. The mystery of capital: Why capitalism triumphs in the West and fails everywhere else. In Toulmin J and Quan J (eds), New York: Basic Books in Africa. London: International Institute for Environment and Development and Natural Resource Institute.

Deininger K, 2003. Land policies for growth and poverty reduction. Policy Research Report n°26324. Washington DC: World Bank.

Deininger K & Chamorro JS, 2004. Investment and income effects of land regularization: The case of Nicaragua. Agricultural Economics 30:101–116.

Di Falco, S. & Bulte E. 2013. The Impact of Kinship Networks on the Adoption of Risk-Mitigating strategies in Ethiopia. World Dev. 4, 100–110.

Feder G, Onchan T, Chalamwong Y & Hongladaron C, 1988. Land policies and farm productivity in Thailand. Baltimore, Md., U.S.A.: Johns Hopkins University Press.

Hagos F & Holden S, 2006. Tenure security, resource poverty, public programs, and household plot-level conservation investments in the highlands of northern Ethiopia. Agricultural Economics 34:183–196.

Jagger P. & Pender J, 20006. Impacts of programs and organizations on the adoption of sustainable land management technologies in Uganda. In Pender J, Place F & Ehui S (eds), Strategies for sustainable land management in the East African Highlands. Washington, D.C.: International Food Policy Research Institute.

Jansen HG. P, Pender J, Damon A & Schipper R, 2006. Rural development policies and sustainable land use in the hillside areas of Honduras: A quantitative livelihoods approach. Research Report 147. Washington, D.C., International Food Policy Research Institute.

Kazianga H & Masters WA, 2002. Investing in soils: Field bunds and microcatchments in Burkina Faso. Environment and Development Economics 7:571–591.

Lal, R., Safriel, U., & Boer, B. (2012). Zero Net Land Degradation: A New Sustainable Development Goal for Rio+ 20. [A report prepared for the Secretariat of the United Nations Convention to Combat Desertification].

Lisec A, Primozic T, Ferlan M, Sumrada R & Drobne S. 2014. Land owners' perception of land consolidation and their satisfaction with the results— Slovenian experiences. Land Use Policy 38: 550–563.

López R, 1997. Land titles and farm productivity in Honduras. Washington, D.C.: World Bank.

Mekuria M & Waddington S, 2002. Initiatives to encourage farmer adoption of soil fertility technologies for maize-based cropping systems in Southern Africa. In Barrett CB, Place F & Abdillahi A (eds) Natural resources management in African agriculture: Understanding and improving current practices. Wallingford, U.K.: CAB International.

Migot-Adholla S, Hazell P, Blarel B & Place F, 1991. Indigenous land right systems in sub-Saharan Africa: A constraint on productivity? World Bank Economic Review 5:155–175.

Nachtergaele F, Petri M, Biancalani R, Van Lynden G & Van Velthuizen H (2010) Global Land Degradation Information System (GLADIS). Beta Version. An Information Database for Land Degradation Assessment at Global Level. Land Degradation Assessment in Drylands Technical Report, no. 17. FAO, Rome, Italy.

Nkonya E, Pender J, Jagger P, Serunkuma D, Kaizzi C & Sali H, 2004. Strategies for sustainable land management and poverty reduction in Uganda. Research Report 133. Washington, D.C.: International Food Policy Research Institute.

Nkonya, E., Gerber N, Baumgartner P, von Braun J, De Pinto A, Graw V, Kato E, Kloos J, Walter T. (2011) The Economics of Land Degradation: toward an integrated global assessment, Development Economics and Policy Series vol. 66, Heidhues F, von Braun J and Zeller M (eds), Frankfurt a.M., Peter Lang GmbH.

Niroula GS &Thapa GB. 2005. Impacts and causes of land fragmentation, and lessons learned from land consolidation in South Asia. Land Use Policy 22: 358–372.

B. O. Ovwigho 2014. Influence of Agricultural Extension Contact on Control of Farmland Degradation among Yam Farmers in Delta North Agricultural Zone of Delta State, Nigeria. Mediterranean Journal of Social Sciences. 5:33-39.

Pender J & Kerr J, 1998. Determinants of farmers' indigenous soil and water conservation investments in India's semi-arid tropics. Agricultural Economics 19:113–125.

Pender J, Ehui S & Place F, 2006. Conceptual framework and hypotheses. In Strategies for sustainable land management in the East African highlands. In Pender J, Place F & Ehui S. Washington, D.C.: International Food Policy Research Institute.

Pender J, Sewanyana S, Kato E & Nkonya E, 2004. Linkages between poverty and land management in rural Uganda: Evidence from the Uganda National Household Survey, 1999/2000. Environment and Production Technology Division Discussion Paper 122. Washington, D.C.: International Food Policy Research Institute.

Place F, Franzel S, Dewolf J, Rommelse R, Kwesiga F, Niang A & Jama B, 2002. Agroforestry for soil fertility replenishment: Evidence on adoption processes in Kenya and Zambia. In Barrett CB, Place F & Abdillahi A (eds), Natural resources management in African agriculture: Understanding and improving current practices. Wallingford, U.K.: CAB International.

Place F & Hazell P, 1993. Productivity effects of indigenous land tenure systems in sub-Saharan Africa. American Journal of Agricultural Economics 75:10–19.

Platteau JP, 1996. The evolutionary theory of land rights as applied to sub-Saharan Africa: A critical assessment. Development and Change 27:29–86.

PNUD, 2014. Pérenniser le progrès humain : Réduire les vulnérabilités et renforcer la résilience. Rapport sur le développement humain.

Shiferaw, B., Okello, J. & Reddy R., 2009. Adoption and adaptation of natural resource management innovations in smallholder agriculture: Reflections on key lessons and best practices. Environ. Dev. Sustain. 11, 601–619.

Sterk G, 2003. Causes, Consequences and Control Of Wind Erosion in Sahellan Africa: A Review. Land Degradation & Development 14:95-108.

Sklenicka P, Janovska V, Salek M, Vlasak J & Molnarova K. 2014. The Farmland Rental Paradox: extreme land ownership fragmentation as a new form of land degradation. Land Use Policy 38: 587–593.
Tesfaye A, Negatu W, Brouwer R & van der Zaag P. 2013. Understanding soil conservation decision of farmers in the Gedeb watershed, Ethiopia. Land Degradation & Development. DOI: 10.1002/ldr.2187.
Teshome A., de Graaff J., Ritsema C. and Kassie M. (2014), farmers' perceptions about the influence of land quality, land fragmentation and tenure systems on sustainable land management in the north western ethiopian highlands, Land Degrad. Develop., doi: 10.1002/ldr.2298.
Toulmin C & Quan J, 2000. Registering customary rights. In Toulmin C & Quan J (eds), Evolving land rights, policy and tenure. Washington, D.C., and Oxford, U.K.: World Bank and Oxford University Press.
Von Braun J., Gerber N., Mirzabaev A. & Nkonya E. M., 2013. "The Economics of Land Degradation," Working Papers 147910, University of Bonn, Center for Development Research (ZEF).
World Bank, 2009. Impacts of Sustainable Land Management Programs on Land Management and Poverty in Niger. Country Report 48230-NE. Washington DC, World Bank.
Wossen T, Berger T & Di Falco S. (2015). Social capital, risk preference and adoption of improved farm land management practices in Ethiopia. Agricultural Economics 46 (2015) 81–97.

ANNEX

Annex: Descriptive Statistics

Variable	Obs	Mean	Std. Dev.	Min	Max
Fight against erosion	4568	0.0333	0.1794	0	1
Manure use	4568	0.3244	0.4682	0	1
Residues use	4568	0.3879	0.4873	0	1
Fertilizer use	4568	0.1276	0.3337	0	1
Female gender	1658	0.0760	0.2651	0	1
Household head age	1658	44.4674	14.6985	17	95
Haoussa (Djerma-Songhai)	1658	0.4934	0.5001	0	1
Kanouri-Manga	1658	0.0995	0.2994	0	1
Peul	1658	0.0428	0.2025	0	1
Touareg	1658	0.1055	0.3074	0	1
Monogamous (Sep-Sin- Wid)	1658	0.6960	0.4601	0	1
Polygamous	1658	0.2352	0.4243	0	1
Share Women	1658	0.5079	0.1709	0	1
Share primary	1658	0.0692	0.1344	0	1
Share secondary and higher	1658	0.0241	0.0748	0	1
Distance to market	1658	55.1935	28.9073	0.2	121.4
Distance to plot	4568	2.9864	2.5973	0	10
Cart (Foot)	4568	0.1027	0.3036	0	1
Others	4568	0.0392	0.1941	0	1
Temperature (°C*10)	1658	282.9530	7.7237	267	296
Rain fall	1658	386.4548	83.6998	162	577
Altitude	1658	329.4674	90.5497	181	535
Nber of non agri. Enterprise	1658	1.0344	1.0615	0	6
Plain (Hill)	4568	0.6662	0.4716	0	1
Gentle slope	4568	0.1193	0.3242	0	1
Steep slope	4568	0.0370	0.1888	0	1
Valley	4568	0.1237	0.3293	0	1
Land size	4568	1.3164	1.0853	0	4.300
Free Ready (Property)	4568	0.0153	0.1229	0	1
Mortgage / pledge	4568	0.0234	0.1513	0	1
Renting	4568	0.1394	0.3465	0	1
Other	4568	0.0127	0.1120	0	1
Nber of Banke/microcredit	148	0.4189	0.9967	0	6
Nber of Agri. tech. centre	148	0.1284	0.3740	0	2
Nber of community radio	148	0.1689	0.4268	0	3

Source: Own calculations