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Farmer's Prioritization and Adoption of Climate-Smart Agriculture (CSA) Technologies and Practices

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Abstract

Climate change affects seriously household food security, especially in sub-Saharan Africa where agriculture is still using traditional methods of farming systems. As strategies against the impact of climate change and way to increase agricultural production, several Climate-Smart Agriculture (CSA) technologies and practices were introduced and experimented at sub-regional and national levels in Niger. The purpose of this study is to prioritize these technologies and practices using participatory assessment approach and to analyze the determinants of their adoption. Farmer Managed Natural Regeneration (FMNR), organic manure, forest management, Zaï pits and stone bunds are the most preferred technologies and practices by the farmers according to the three pillars of Climate-Smart-Agriculture. The results of econometric models revealed that access to credit/subsidy, access to training, membership of an organization, source of income, family size and ownership of animal of traction influence significantly and positively the adoption of these CSA technologies and practices. The government and other development agents should reinforce the access of credit and training to farmers to boost the adoption of these technologies and practices, and to build sustainable and climate resilient livelihoods in order to move out of chronic poverty and food insecurity.

Keywords: Climate-Smart-Agriculture (CSA) technologies and practices, adoption, probit models, Niger

1. Introduction

Climate change affects seriously household food security, especially in sub-Saharan Africa where agriculture is still using traditional methods of farming systems. FAO (2009) revealed that climate change is emerging as a major problem to agriculture development in Africa; the increasingly uncertain and erratic nature of weather systems on the continent has placed a more burden on food security in remote livelihoods. Climate change may affect food systems in several ways ranging from direct effects on crop production (e.g. Changes in rainfall leading to drought or flooding, or warmer or cooler temperatures leading to changes in the length of growing season), to changes in markets, food prices and supply chain infrastructure(Malikarjuna,2013).

In Niger, major challenges for agricultural production are continuous land degradation, climate changes, desertification and urbanization. The consequences of these threats are recurrent food insecurity in the country. To increase the population resilience to climate change, several climate-smart agriculture technologies and practices were developed and disseminated among farmers at national and sub-regional levels in Niger as strategies to increase agricultural production. In general, technology is defined as a sum total of knowledge of ways of doing things (Koontz et al. 1980). It includes inventions, techniques and the vast store of organized knowledge of how to do things. According to Rogers (1983), technology is a design for instrumental actions that reduce uncertainty in the cause-effect relationship involved in achieving a desired outcome. A technology has two components (a) hardware aspect consisting of the tool that embodies the technology as material and physical objects and (b) software aspect, consisting of the information base for the tool. Agricultural practices means the steps generally been done by farmers.

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These steps include preparation of soil, sowing/planting, adding manure and fertilizers, irrigation, protection from weeds, pests and diseases, harvesting and storage. By CSA technologies and practices, we understand the application of technology and practices in order to reduce the vulnerability, or enhance the resilience, of a natural or human system to face the impacts of climate change (UNFCCC, 2005).Improved crop varieties, Soil and water conservation techniques(Zaï,half-moon), tree planting are common CSA practices and technologies. According to Zougmoré*et al* (2016), these CSA technologies and practices contributed to an additional 500,000t of cereals, providing food for about 2.5 million people in West Africa. Trees contribute to climate change adaption by reducing wind speed and decreasing damage to crops from windblown sand.

The main objective of this paper is to identify the determinants of adoption of CSA technologies and practices in Niger for proper policy implementation.

A large number of literatures have been examined the adoption and diffusion of agricultural innovations in Africa. Among recent published works, Kassie, *et al* (2013) used multivariate probit methods to examine the factors that influence farmer's investment in sustainable agricultural practices in Tanzania. Their study revealed that rainfall, insects and disease shocks, government effectiveness in provision of extension services, tenure status of plot, social capital, plot location and size, and household assets, all influence farmer investment in sustainable agricultural practices. Shiferaw, et al (2014) evaluated the adoption of improved wheat varieties and its impact on household food security in Ethiopia. They concluded that their adoption increases food security. FAO (2013) analyzed the determinants of farmer adoption of conservation farming practices using panel data in Zambia and found that extension services and rainfall variability are the strongest determinants of adoption. Magrini and Vigani (2014) analyzed the impact of agricultural technologies on food security of maize farmers in Tanzania. They revealed that technologies have a positive and significant impact on food security. Nata, et al (2014) examined the linkage between food insecurity and the adoption of soil-improving practices in Ghana. Their results revealed that fertilizer, soil quality, and seeds are most likely associated with increased production. Ayanwale, *et al* (2014) studied the factors affecting adoption of agricultural technologies of cereal and leguminous crops in Sudan Savana of Nigeria and concluded that the location of the farmer, large family size and awareness encouraged adoption of new technologies across various sites. In Niger, little number of papers was published regarding adoption of CSA technologies and practices. The results can provide a useful framework for decision-making for producers and policymakers, thus, the importance of this present study.

II.2.Material and methods

II.2.1 Description of study area

The survey was conducted in the CGIAR Program on Climate Change, Agriculture and Food Security (CCAFS) benchmark site Fakara located at 75 km from the capital Niamey, in Kollo district, Southern Niger during the period of September-October 2016. Kollo district lies between longitude 1º30' and 2º 55' and latitude 12º 30' and 13º 53'. The population density is 30 to 40 inhabitants per kilometer square. High population pressure and expansion of agricultural lands entrain the abandon of fallow systems. Subsistence farming is the main economic activity of the high majority of the population in the area. Crop production relies mainly on 3 months raining season (July to September), followed by a long dry season. The average annual rainfall ranges between 350 to 450 mm. Temperatures are very high and vary considerably from one season to another, but even during the same day. Millet is the main crop cultivated in this area and often mixed with cowpea. Women are engaged in cultivation of crops such a groundnut, Bambara groundnuts and sesame on small pieces of land. Animal rearing is the second main occupation of local people often through transhumance.

II.2.2 Data collection

A random sampling approach was adopted, where the questionnaire was administered through individual structured interviews with the heads of the households in 8 selected villages. In the selected villages, two are climate-smart villages (CSV) namely Kampa-Zarma and Bankadey, which are CCAFS sites where the CSA technologies and practices were tested in the participatory manner with farmers. The six other villages are satellite villages surrounding the two CSV. In each CSV, 60 households were selected and 30 households were taken in each non-CSV making a total sample of 300 households. The survey gathered qualitative and quantitative data pertaining to social, demographic and economic aspects of households. The information revealed farmers characteristics (age, education, gender, ethnicity, experience in agriculture,), farming systems (crops, technologies and practices, production orientation), famers' perceptions on the attributes of CSA technologies and practices (advantages and constraints of technologies and practices), farmers indigenous practices related to CSA, etc.

II.2.3 Farmer's prioritization of CSA technologies and practices

A participatory assessment of promising technologies and practices was carried out in the two climate-smart villages. This was done in two steps:

-The first step in the process was to do the inventory of all promising technologies and practices. In each village, a focus group of men and women was created to discuss and identify all the technologies and practices farmers used. 28 and 24 CSA technologies and practices were identified in Kampa-Zarma and Bankadey respectively. A total of 32 CSA technologies and practices are being used by the farmers in the two villages.

- The second step was to prioritize these technologies and practices through scoring by voting according the three pillars (characteristics)of climate-smart agriculture namely productivity, adaptation and mitigation. Two separated groups of 15 men and 15 women were formed for the scoring. The name of each technology or practice was written on a paper and displayed on the ground so that the farmers can vote and give a score. The number of identified technologies and practices in each village was used for scoring (28 and 24 stones were used respectively in Kampa-Zarma and Bankadey for the scoring). During the scoring, the supervisor introduced the displayed technologies and practices to the farmer and asked him/her to give a score to each technology or practice of his/her preference in term of productivity, adaptability or mitigation.

II.2.4Econometric framework

The participatory assessment of promising technologies and practices revealed that there are several technologies and practices used by farmers in the study area. Because we cannot run the econometric models for all technologies and practices, we consider only the top 10 prioritized CSA technologies or practices promoted through CCAFS activities to analyze the determinants of their adoption.The decision of whether or not to use any technology or practice option could fall under the general framework of utility and profit maximization.

Let's assume a rational farmer who seeks to maximize the present value of expected benefits of production over a specified time horizon, and must choose among a set of *J* technologies options. If the perceived benefit from *J* is greater than the utility from *K*, then we can write:

$$U_{ij}\left(\beta_j' X_i + \varepsilon_j\right) > U_{ik}\left(\beta_{jk}' X_i + \varepsilon_k\right), k \neq j \quad (1)$$

where U_{ij} and U_{ik} are the perceived utility by household head i in selecting technologies *J* and *K*, respectively; X_i is a vector of explanatory variables (for example: level of education of the head of the household, household size, access to credit, etc.) that influence the choice of the options; β_j and β_k are parameters to be estimated; and ε_j and ε_k are the error terms.

We can relate the fact that a household prefers or selects a technology or practice for its utility maximization i.e. to maximize production or benefits and not choosing the other option to a discrete choice. The outcome Y is then a dichotomous dependent variable taking the value of 1 when the household head adopts an option and 0 otherwise. The probability that household i will adopt a technology j among the set of options could be defined as follows:

$$P\left(Y = \frac{1}{X}\right) = P\left(U_{ij} > \frac{U_{ik}}{X}\right)$$

$$= P\left(U_{ij} > \frac{U_{ik}}{X}\right) = P\left(\beta_j' X_i + \varepsilon_j - \beta_k' X_i - \varepsilon_k > \frac{0}{X}\right) \quad (2)$$

$$= P\left(\left[\beta_j' - \beta_k'\right] X_i + \varepsilon_j - \varepsilon_k > \frac{0}{X}\right)$$

$$= P\left(\beta^* X_i + \varepsilon^* > \frac{0}{X} = F(\beta^* X_i)\right)$$

Where ε^* is a random disturbance term, β^* is a vector of unknown parameters that can be interpreted as the net influence of the vector of explanatory variables influencing the choice of these technologies, and $F(\beta^* X_i)$ is the cumulative distribution of ε^* evaluated at $\beta^* X_i$.

Then we can estimate logit or probit model depending on the assumed distribution that the random term follows, several qualitative choice models such linear probability, logit or probit models, could be estimated (Greene, 2007; Glwadys,2009; Molua,2012).

In this study there are several technologies and practices the household head may be adopted, therefore a Multinomial probit is appropriate to estimate how the socio-economic and demographic characteristics of respondents influence their choice (Greene 2003; Greene, 2007; Glwadys, 2009**;**Molua,2012).

The probability of household i choosing coping option Yi and the set of explanatory variables Xi is specified as follows:

Thus the probability of household i choosing a technology option Yi and the set of explanatory variables Xi is specified as follows:

$$P_{ij} = prob(Y = 1) = \frac{e^{x'\beta}}{1+\sum_{j=1}^{j} e^{x'\beta}} \text{ , j=1….j,(3)}$$

Where β is a vector of parameters that satisfy ln(P_{ij}=P_{ik}) = X'(β_j - β_k) (Greene 2003, Greene, 2007).The marginal effects of the explanatory variables are given as:

$$ME_{ijk} = \frac{\partial Pr\,(y_i=j)}{\partial x_{ik}} = \frac{\partial F_j\,(x_i,\theta)}{\partial x_{ik}} \qquad (4)$$

Coefficients are interpreted as marginal effects relating to utility differences.

If a positive coefficient in equation means explanatory variable J has positive effect on utility difference. If the utility difference increases, then a household head is more likely to choose alternative J relative to the benchmark choice. Negative coefficient makes a household head less likely to choose option J.

II.2.5.Explanation of variables and hypotheses

- **Age of head of household:** there is no agreement in the adoption literature on the effect of age (Adesina and Forson,1995; Teklewold et al. 2006).
- **Gender of the household head:**men have more access to production inputs and extension services than women (De Groote and Coulibaly 1998; Quisumbing et al. 1995; Traoré&Dabo 2012),), therefore male head household have positive impact on the adoption of technologies and practices.
- **Education:** Higher level of education is often hypothesized to increase the probability of adopting new technologies (Daberkow and McBride 2003; Adesina and Forson 1995). Indeed, education is expected to increase one's ability to receive, decode, and understand information relevant to making innovative decisions (Wozniak 1984).
- **Household size**: Household size is a source of labor and is associated positively with the adoption of technologies.
- **Income**: This is expected to have positive impact on adoption of technology package.
- **Land tenure**: Land ownership is widely believed to encourage the adoption of technologies.
- **Farm size:** Adoption of an innovation will tend to take place earlier on larger farms than on smaller farms. Therefore the larger farm size is expected to have positive effect on adoption of technologies and practices.
- **Training in farming**: the training agencies of farmers have impact on adoption of technologies and practices. These agencies facilitate the access of information to farmers on production inputs and technologies, thereby enhance their adoption
- **Credit or subsidy**: the access to credit and subsidy increase farmer's ability to purchase production inputs and facilitate the adoption of technologies and practices.
- **Experience:** Farming experience increases the probability of uptake of all adaptation options because experienced farmers have better knowledge and information on changes in climatic conditions and cropand livestock management practices (Nhemachena and Hassan,2007).
- **Membership in social institutions**: social networks facilitate the exchange of information, enable farmers to access inputs on schedule, and overcome credit constraints. Membership in farmers' groups or associations (Group) is therefore hypothesized to be positively associated with adoption.
- **Farm equipment:** the availability of farm equipment is expected influence positively the adoption of technologies and practices.

Table2.1Definition of variables included in the probit models

Explanatory variables	Definition	Hypothesis
Age	Age of household head (years)	+
Gender	Gender of the head of the farm household 1= male, 0=female	+
Education	1= formal schooling attained by the head of the household, 0 otherwise	+
Household size	Number of family members of a household	+
Source of income	Source of income other than agriculture(1= yes, 0= agriculture)	(+ or -)
Land tenure	Access to land (1=Ownership, 0= rental or borrowing)	+
Farm size	Area in hectare	+
Number Livestock	Number of animals	+
Training in farming	1=access to training, 0 otherwise	+
Credit or subsidy	1 = access to credit or subsidy, 0 otherwise	+
Experience	Number of years of farming experience	+
Membership in social institutions	1= member of an organization, 0 otherwise	+
Traction animal	Number of traction animal	+
Farm equipment	Number of farm equipment	+
Locomotion tools	Number of bicycle, motorcycle,car	+
Communication tools	Number of TV,radio,phone	+

III.3. Results and Discussion

III.3. 1 Prioritization of CSA technologies and practices

As stated earlier, a participatory assessment of promising technologies and practices was carried out in climate-smart villages in the study area. After the identification of all promising technologies and practices, the farmers were grouped in two groups of men and women and proceeded to vote with stones and give a score to each technology or practice according to three pillars of climate-smart agriculture namely productivity, adaptation and mitigation. Scoring and final ranking of promising technologies by farmers are presented on Table 3.1. Farmer Managed Natural regeneration (FMNR) is ranked first among all these practices and technologies used in these villages. FMNR is a practice of selecting and preserving a few stems and cutting the remainder during land preparation before sowing. Natural regeneration helps increasing the number of trees on the farm, thus has potential to improve soil fertility. Trees on farms also facilitate tighter nutrient cycling than mono- culture systems, and enrich the soil with nutrients and organic matter.

Organic manure is the second agricultural practice ranked by famers according to the criteria of climate-smartness. In the Sahel in general and particularly in Niger, the majority of farmers use organic manure to increase soil fertility and to improve their productivity. As unexpected, forest management is ranked third by farmers among these technologies and practices. Indeed forest helps to reduce Greenhouse Gas (GHG) emissions from agricultural activities and also enhance resilience to climatic stresses.

Zaï is an important water conservation technology and ranked fourth according to farmer's preference. The Zaï concentrates both nutrients and water and facilitates water infiltration and retention. The technique helps to combat land degradation and improve productivity of abandoned bared soils.

Stone lines or stone bunds ranked fifth after Zaï in term of climate-smartness according to farmers. The technique is efficient improving rainwater infiltration and in reducing soil erosion and downward particle transport (Zougmoré *et al*, 2004; Zougmoré *etal*, 2014). The vegetation that grows also contributes towards the mitigation by absorbing carbon dioxide from the atmosphere (Zougmoré*etal*, 2014).

Agro forestry means a mixed cultivation of trees and grown on the same plot of land.More than 1.2 million people practice agro forestry worldwide by integrating plants with annual crop cultivation, livestock production and other farm activities ranging from close imitation of tropical rain forests with dense tree cover to polycultures with only few plant species(Seneviratne*et al* ,2015). Agro forestry ranked seventh in term of climate-smartness according to farmers.A combination of indigenous and exotic tree foods in agro forestry systems supports nutrition, the stability of production, and farmer income (FAO, 2013).

Indeed, the CSA options integrate traditional and innovative practices, technologies and services that are relevant for particular location to adopt climate change and variability (CIAT, 2014). All these technologies and practices are considered as climate-smart as they can help to achieve at least one pillar of CSA (either increases productivity or increases resilience or reduces GHG emission). Therefore CSA is a basket of agricultural practices and techniques that not only aims at increasing profits and resilience for farmers but does so without harming, often even bettering, environmental parameters (FAO, 2016).

Table 3.1 Prioritization of CSA technologies and practices

Technology/Practice	Score	Rank
Farmer managed natural regeneration (FMNR)	783	**1**
Organic manure	666	**2**
Forest Management	355	**3**
Zaï	321	**4**
Stone lines	292	**5**
Mulching	243	**6**
Agroforestery	236	**7**
Croprotation	211	**8**
Improved seed varieties	159	**9**
Mixed cropping	152	**10**
Rainwater harvesting (RWH)	144	**11**
Off-season farming	130	**12**
Firebreak	119	**13**
Minimum Tillage	94	**14**
Half moon	90	**15**
Protected Community forest	88	**16**
Controlled clearing	87	**17**
Grass Band	72	**18**
Composting	68	**19**
Drought tolerant crops	65	**20**
Fodders	57	**21**
Wind break	51	**22**
Intensive livestock feeding	42	**23**
Cultivated fodders(ex: cowpea)	35	**24**
Corralling livestock on fields	33	**25**
Complementary livestock feeding	30	**26**
Crop residual treatment	14	**27**
Integrated Pest Management	14	**28**
wells	12	**29**
Alternative treatment	11	**30**
Vaccination	4	**31**
Transhumance	2	**32**
Total	**4680**	

III.3.2Adoption of CSA technologies and practices

As mentioned above, we considered ten CSA technologies and practices for the study of adoption. As we can notice on Table 3.1, mixed cropping, organic manure, FMNR and mulching are common practices of the majority of the respondents. Because the performance of these technologies and practices varies (given characteristics of land, climate, agriculture, farmer, etc.), the adoption of these practices also varies, depending on climate variability (Kassie, *etal*, 2013).The farmer may use a particular technology or practice one or two seasons, then later abandon it. The reasons of abandon or non-adoption given by respondents are related to lack of appropriate materials to build the technology, high cost of investment, low productivity and extra-labor demanding. Zaï and stone lines are all soil water conservation techniques and are labour intensive which may be an important constraint for their adoption (Zougmoré*etal*, 2014).

Table 3.2Adoption of CSA technologies and practices

Technology/practice	Adopter		Non-adopter	
	Frequency	percent	Frequency	percent
Improved seed	132	44	168	56
Agroforestry	131	43.67	169	56.33
Zaï	93	31	207	69
FMNR	243	81	57	19
stone lines	57	18.7	244	81.3
Mixed cropping	277	92.3	23	7.7
Corporation	32	10.67	268	89.33
Organic manure	239	80	61	20
Mulching	205	68.5	95	31.5
Off-season farming	64	21.33	236	78.67

III.3.3 Estimation of the adoption models

The results of probit models for the determinants of adoption of CSA technologies and practices are reported on Table 3.3. The results revealed that agricultural training influences positively and significantly the adoption of improved seed, Zaï,off-season farming, FMNR and stone lines. Agricultural development agents are main source of training and information on how to use these technologies and practices. Access to extension agents will increase farmers' awareness and information on the importance of technology adoption (Akpan*et al*., 2012, Martey,*etal,* 2014). Thus farmer's training is associated positively with adoption of these technologies and practices.

The results also show that being member of a social organization influence positively and significantly farmer's adoption of improved seed, Zaï,off-season farming and FMNR. Through association or organization, farmers get a lot of benefits such production inputs, information about new technologies and practices, credit and subsidies, etc. Farmer association served as platform for accessing and dissemination of information and technology. Meanwhile access to credit/subsidies influences strongly the farmer's decision of the adoption of improved seed, Zaï and crop rotation. Usually the cost of agricultural inputs is high; most farmers cannot afford to purchase them. So when the credit is available to farmers, it will facilitate the adoption of these CSA technologies.

The results revealed also that ownership of traction animal influences positively and significantly the adoption of organic manure, improved seed and mixed cropping. The traction animal facilitates transportation and provides labor supply. As unexpected, the possession of traction animal influences negatively the adoption of agro forestry.

None of these variables used in the analysis influence mulching practice. Land characteristics and intensity of rain may be important factors which can determine the use of mulching.

The source of income other than agriculture of respondents influences positively and strongly the adoption of crop rotation and agro forestry practices. Meanwhile, land tenure has significant and positive effect on the use of improved seeds and off-season farming.

Table 3.3 The marginal effects of probit models of the determinants of adoption of CSA technologies and practices (standard errors in parenthesis).

Explanatory variables	Dependent variables			
	Improved seeds	Zaï	Off-seasonfarming	FMNR
Gender	0.1461(0.235)	0.1179(0.145)	0.1090(0.093)	0 .0973(0.234)
Age	0.0008(0.003)	**0.0058(0.003)***	0.0022(0.001**)**	0.0034(0.002)
Education	0.1328(0.276)	0.1330(0.237)	0.229(0.219	-0.1505(0.212)
Membership	**0.2884(0.067)*****	**0.1676(0.056)*****	**0.098(0.0417)****	**0.1553(0.046)*****
Family Size	**0.0176(0.005)*****	-0.0036(0.004)	0.001(0.002)	**-0.0069(0.003)****
Source of income	0.0412(0.081)	0.0890(0.065)	0.021**(0**.052**)**	0.0389（0.057）
Farm equipment	0.0744(0.054)	0 .0114(0.033)	0.025(0.019)	-0.0334（0.023）
Locomotion tools	-0.0064(0.095)	0 .0601(0.075)	0 .0(0.049)	0.0311(0.065)
Communication tools	**-0.0488(0.024)****	-0.0113(0.018)	0.0141(0.0108)	0 .0088(0.012)
Experience in farming	0.0047(0.003)	-0.0027(0.002)	-0.0041(0.002)	-0.0005（0.002）
Land Tenure	**0.2500(0.095)****	0 .1485(0.075)	**0.1161(0.35)***	-0.0491(0.062)
Farm size	**0.0063(0.003)***	-0.0009(0.003)	0.0015(0.002)	0.0020(0.002)
Number of Livestock	**-0.0523(0.027)***	0.0044(0.017)	**0 .0141(0.05)****	0.0057(0.014)
Traction animal	**0.0872(0.045)***	0.0095(0.034)	-0.035(0.023)	0 .0217（0.026）
Training in farming	**0.3963(0.064)*****	**0.2847(0.055)*****	0.1096(**0**.0428**)****	**0 .0986(0.050)***
credit	**0.2392(0.071)*****	**0.1306(0.061)****	-0.0516045(0.0452)	0.0697(0.050)

Explanatory variables	Dependent variables			
	Stone lines	0rganic manure	Crop rotation	mixed cropping
Gender	-0.1497(0.239)	-0.0820(0.086)	0.0268(.0839)	0.0003(.001)
Age	0 .0025(0.002)	-0.0000(0.002)	.001(0008)	-0.0556(.121)
Education	0.0698(0.103)	-0.0120(0.160)	0.0611(.132)	0.0003(.001)
Membership	0.0196(0.048)	-0.0314(0.041)	.0187(.026)	-0.0193(.022)
Family Size	0.0021(0.003)	0.0040(0.003)	-.0012(.002)	0.0026(.001)
Source of income	-0.0534(.053)	0.0224(0.053)	**.1057(.054)****	-0.0249(.021)
Farm equipment	-0.0069(0.027)	0.0222(0.037)	-0.034(0.019)	-0.0008(.018)
Locomotion tools	0.0339(0.062)	**0.2127(0.114)***	0.046(0.029)	0.0345(0.040)
Communication tools	-0.0023(0.014)	0.0203(0.015)	**0.013 (.006)****	-0.0074(0.006)
Experience in farming	-0.0026(0.002)	-.0012(0.002)	0.0016(.003)	-0.0008(0.001)
Farm size	0.0016(0.002)	0.0003(0.002)	0.0009 (.001)	-0.0011(0.001)
Land tenure	0.0365(0.075)	-0.005(0.065)	0.006**(**.0428**)**	-0.0043(0.034)
Number of Livestock	-0.0035(0.014)	0.0113(0.021)	-0.008 **(**.006**)**	0.0034(0.011)
Traction animal	0.0085(0.026)	**0.0836(0.034)****	0.014**(**.015**)**	**0 .0369(0.0178)***
Training in farming	**0.2103(0.047)*****	0.0162(0.046)	0.0224**(**.028**)**	-0.0070(0.023)
credit	-0.0526(0.053)	0 .0408(0.047)	**0.0613(.029)****	0.0326(0.026)

Explanatory variables	Dependent variables	
	Mulching	Agroforestry
Gender	-0.0144(.231)	.036(0.233)
Age	-0.0010(.003)	0.002(.002)
Education	-0.0672(.205)	-0.179 **(**.173**)**
Membership	0.0206(.058)	-0.050(.062)
Family Size	-0.0034(.004)	-0.0006(.004)
Source of income	-0.0009(.063)	**0.362(.075)*****
Farm equipment	0.0099(.037)	**0.098(.043)****
Locomotion tools	0.0813(.086)	0.005(.086)
Communication tools	-0.0015(.016)	**0.036(.019)***$^{}$
Experience in farming	0.0050(.003)	**0.0058(.003)***
Farm size	-0.0023(002)	0.001(.003)
Land tenure	0.0584(.099)	-0.141(.108)
Number of Livestock	-0.0054(.017)	-0.0002(.0109)
Traction animal	0.0174(.035)	**-0.084 (.037)****
Training in farming	-0.0344(.063)	0.0895 **(**.066**)**
credit	0.0390(.064)	0.065**(**.066**)**

IV.4. Conclusion and policy implication

Recurrent food insecurity continues to affect much population in Sub-Saharan Africa, particularly in Sahelien region. The development of strategies to increase agricultural production is therefore a prerequisite to provide enough food to meet the population demand. For this purpose, various CSA technologies and practices have been disseminated in Sub-region and national level by several institutions. The main objective of this present study was to analyze the determinants of adoption of these CSA technologies and practices in Niger. The results of econometric analyses revealed the heterogeneous effects of the factors that influence the adoption of various CSA technologies and practices. The key determinants of adoption of these CSA technologies and practices are affiliation to an organization, access to credit/subsidy, farmer training and source of income other than agriculture. The significance and positive influence of access to credit and training on adoption of these CSA technologies and practices suggests that public policies that increase farmer's access to credit and training are likely to boost adoption of these practices by farmers. The government and other actors involved in rural development should strengthen their capacities in terms of agricultural credits/subsidies and also train producers to facilitate the adoption of these CSA technologies and practices in order to increase agricultural production and eradicate food insecurity in Niger.

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