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Analyzing the determinants for the adoption of good practices as regards climate change adaptation in the Northern region of Burkina Faso

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Unfavorable agro-climatic and edaphic conditions have led to the development of many adaptation strategies to climate change in the northern region of Burkina Faso. This study analyzed the determinants of goods practices adoption as regards adaptation to climate change (GPACC). It used panel data (2016-2018) collected from a sample of 1,221 women and 335 men within the operational farmer's organizations in the provinces of Zondoma and Passoré. Results of the multinomial Logit model showed that adoption of GPACC is determined by the socio-economic characteristics of men and women including the institutional opportunities and farms characteristics. These factors included years of experience in farming, production costs, access to credit, the possession of ruminants, soils type and availability of inputs on time. However, the relevance of the variables and the meaning of their influence partially varied depending on GPACC and the smallholder' gender. Therefore, it is essential to build-up technical, socio-economic and institutional capacities to reach a massive adoption of GPACC. However, all these capacity-building actions should take into account the findings as regards the specificity of each producer category.

Key words: Determinants, adoption, goods practices, climate change, women, men, multinomial logit, Burkina Faso.

INTRODUCTION

Droughts of the 1970s and soils deterioration led the innovative farmers from the Northern region of Burkina Faso to develop water and soils conservation techniques (WSC) such as zaï, stone lines, mulching, half-moons, grassed strips, etc. (Belemviré et al., 2008; Sawadogo et al., 2008; Taonda et al., 2008). Since then, agricultural research has been improving such traditional techniques by putting in place other technologies such as improved seeds varieties and mineral and organic fertilization techniques likely to enhance their efficiency. Several studies showed that such techniques increased yields and agricultural incomes (Sawadogo, 2006; Belemviré et

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al., 2008). However, the combination of the integrated management of nutritive elements (combination fertilizers and organic manure) further amplified this yield (Zougmore et al., 2004, 2010).

Despite the multiple efforts achieved to disseminate these techniques, we qualify as good practices for adaptation to climate change (GPACC) (MAAH, 2018), food insecurity and poverty issue are still prevailing particularly in rural area. Indeed, the coverage rate of cereals need within the Northern region was 72% against 109% at the national level. This food insecurity derived either from the low adoption of GPACC or from the non-compliance with the technical form to implement these practices, resulting in low soil productivity. Unfortunately, the latest information on the current use of GPACC are missing as well as the favorable factors to their adoption. Several authors were dealing with the issue related to the adoption of the agricultural innovations in various African countries (Mounirou, 2015; Hassan and Nchemachena, 2008; Deressa et al., 2009; Ouédraogo et al., 2010; Folefack al., 2012; Salhi et al., 2012; Mabah-Tene et al., 2013; Mbétid-Bessane, 2014; Sale et al., 2014; Ouédraogo and Tiganadaba, 2015; Yabi et al., 2016; Rabé et al., 2017). The results of these studies showed that the social, economic, institutional and technical factors determined the adoption of strategies to adapt to climate change. However, the studies conducted in Burkina Faso were restricted to the either the strategies individually taken, or to the association of water and soil conservation (WSC) techniques, or their combinations with farmyard manure and/or with mineral fertilizers (Ouédraogo et al., 2010; Ouédraogo and Tiganadaba, 2015; Sigué et al., 2018). Unfortunately, these practices did not take into account the adoption of GPACC in terms of combining WSC techniques with organic matter and/or mineral fertilizers under cropping systems using seeds of improved varieties or even gender issue. Furthermore, most of these authors used annual data. Considering the previous works, this study aims to analyze the determinants of GPACC adoption by women and by men in the Northern region of Burkina Faso using panel data.

Based on the random utility theory, it assumes that the determinants of adoption of GPACC vary according to farmers' practices and gender issue. Gender analysis could provide useful information feeding decision-making tool for actors in the rural area. Practically speaking, women and men did not have the same socio-economic benefits (MPF, 2012). In Burkina Faso, unlike men, women had poor access to the production means, to financial and extension services (Ouoba et al., 2003; MPF, 2012). However, women represented more than 52% of the country's population (MPF, 2012). As a result, it will be difficult to reduce the rural communities' vulnerability without a strong involvement of women in the adaptation strategies. Finally, using the panel data improves the robustness of the results and therefore makes easier their dissemination or extrapolation.

MATERIALS AND METHODS

The study area

This research has been carried out in the provinces of Zondoma and Passoré located in the Northern of Burkina Faso. These provinces have unfavorable agro-climatic and edaphic conditions. They belong to the Sudano-Sahelian agro-climatic domain with an annual rainfall ranging between 500 and 864 mm (Ganou, 2005; Tiama et al., 2018). Soils are mostly poor in nutrients and formed of lateritic plateaus and ferruginous cuirasses. Women represent in average 53.8% of the population (INSD, 2008). These two provinces were chosen because they hosted the project "Financial Services and Deployment of Agricultural Innovations in Burkina Faso (SFDIAB)" during which data was collected in 187 villages of 9 municipalities.

The choice of sample

For this study, a purposive sampling was used. A list of farmers' organizations (FOs) has been drawn up in collaboration with technicians of the agricultural department. After that, FOs were selected based on their farming practices, including their dynamism and market orientation. Data were collected over three consecutive years. 1,556 farmers (1,221 women and 335 men) participated to the three annual surveys. All selected farmers freely agreed to participate to this survey. Data collected focused on the farmers' socio-economic and institutional characteristics, the environment of the farms and the adaptation practices to climate change.

The analysis approach

This research basically assumes that farmers' socio-economic and institutional characteristics, the production environment of farms are the determinant factors for adopting GPACC. It is based on random utility theory stating that adoption is a function of the random utility perceived by producers from innovation. We assumed that this utility depends on the observable variables and unobservable characteristics captured by the error term. In designating U_{ij} as the utility that the producer (j) gets out of an option choice (j), β_j a set of parameters associated with the explanatory variables X_i of option j, ε_{ij} the error term and $\beta_j X_{ij}$ the deterministic part, the random utility function can be written as follows:

$$U_{ij} = \beta_j X_{ij} + \varepsilon_{ij} \quad \text{(McFadden, 1974)} \qquad (1)$$

The choice of the multinomial logit model

Logit and Probit are the most used models in the literature to model adoption when the dependent variable is dichotomous (Ouédraogo et al., 2010; Folefack et al., 2012; Salhi et al., 2012; Sale et al., 2014; Yabi et al., 2016; Rabé et al., 2017). However, Logit or Multinomial Probit is the most appropriate when the dependent variable has more than two modalities. But, because of its simplicity, in terms of calculating the probabilities of choice, its easy estimation and the globally concave form of its probability function, the Logit multinomial model is mostly used in Africa (Deressa et al., 2009; Mounirou, 2015; Ouédraogo and Tiganadaba, 2015). Our modeling was focused on unordered choices. To achieve this, we used the independent multinomial Logit model. It is a model for which the utility function is a linear function whose parameters differ according to the modalities and for which the explanatory variables vary only according to individuals (Ouédraogo and Tiganadaba,

2015).

Model specification

Based on the utility theory, the option j is chosen by the farmer against option (l) if only the utility associated with option j is greater than that of l ($U_{ij}>U_{il}$). However, this utility cannot be actually observed. Only the adoption of practice j by farmer i, materialized by yij can be observed. This dependent variable takes 1 if the producer chooses practice j and 0 if he does not. The model is based on the independence hypothesis of irrelevant alternatives (Ouédraogo and Tiganadaba, 2015). Let P be the probability the farmer i chooses practice j on time t, P can be written as follows:

$$P(y_{ijt} = 1) = P(U_{ijt} \geq U_{ilt}) \text{ for all l} \neq \text{j} \quad (2)$$

The multinomial model on time t can be expressed as follows:

$$P(y_{it} = j) = \frac{exp(\beta_j X_{ijt})}{\left[\sum_{i=0}^{J} exp(\beta_j X_{ijt})\right]} = \frac{exp(\beta_j X_{ijt})}{\left[1+\sum_{j=1}^{J} exp(\beta_j X_{ijt})\right]} \quad (3)$$

The parameters associated with the explanatory variables are interpreted as deviations compared to the non-adoption. Under the normalization hypothesis $\beta_0=0$, the probability associated with the non-adoption of GPACC is:

$$P(y_{it} = 0) = \frac{1}{\left[\sum_{j=0}^{J} exp(\beta_j X_{ijt})\right]} = \frac{1}{\left[1+\sum_{j=1}^{J} exp(\beta_j X_{ijt})\right]} \quad (4)$$

Specification of the model's parameters

Five modalities are retained for the dependent variable Y (technology groups or possible choices), which is the adoption of GPACC:

(i) ***Group 0*** = male and female producers who do not adopt any GPACC;
(ii) ***Group 1*** = male and female producers adopting one GPACC or the water and soils conservation techniques (WSC), or organic manure (OM) , or chemical fertilizer or improved seeds varieties (IS);
(iii) ***Group 2*** = male and female adopters of two GPACCs (WSC + OM or WSC + chemical fertilizers or WSC + IS or OM + chemical fertilizer or OM + IS or chemical fertilizer + IS);
(iv) ***Group 3*** = male and female adopters of three GPACC (WSC + OM + chemical fertilizer or WSC + OM + IS or OM+ chemical fertilizer + IS);
(v) ***Group 4*** = male and female adopters of four GPACC (WSC + OM + chemical fertilizer + IS).
The ***WSC techniques*** refer to the technologies which stock or reduce runoff and make it available for agricultural production in order to mitigate the effects of season variations and improve agricultural production reliability (FAO, 2011).
Organic matter (OM) is incorporated to soil as farmyard manure or compost.
Seeds of improved varieties (IS) refer to those created or developed in agronomic research centers.

The choice of explanatory variables was guided by the literature on the determinants of adoption of agricultural innovations and by statistical tests of multicollinearity. By adding the "robust" option to the multinomial Logit control on panel data (femlogit) during the estimation to correct the possible presence of heteroscedasticity and obtain more robust results, some variables have been eliminated because 'of they had zero (or almost zero) within-group variance. Therefore, the relevant explanatory variables are recorded in the Table 1.

RESULTS

Descriptive statistics of explanatory variables

Table 2 presents the descriptive statistics of the model explanatory variables. The results show that the households average size of our sample is 13 persons including both men and women. Women have an average of 11 years of experience in agricultural production compared to 17 years for men. The average number of visits by the extension agent per year is 1.4 for women and 1.6 for men. The average extra-agricultural income is 5,400XOF for women against 19,325XOF for men. The saving amount is 7,118XOF for women and 38,780XOF for men. The total average production costs are 49,151XOF and 148,605F XOF respectively for women and men. About 44% of the soils used by women are gravels compared to 55% for men. An approximate average of 28% of women and 21% of men has access to credit. The rates of participation to a specialized training are respectively 12.6 and 17.3% for women and men. Female and male producers said they have good quality inputs. About 77% of women and 75% of men said inputs are provided on time in their area. Most of our sample individuals have at least one small ruminant. The proportion of women owning a ruminant is 45.18% against 61.14% for men.

Adoption rate of good practices regarding adaptation to climate change

Adoption rate of GPACC varies according to the farmer' age and gender (Table 3). However, the GPACC are mostly adopted by men compared to women. During the survey (three years), an average of 87% of women and 96% of men has adopted at least one GPACC. The association of two GPACC is the option mostly adopted by women (32.05%) while men mainly adopt three GPACC (39.60%). the adoption rates of the combination of four GPACCs (CES + FO + SA + Fertilizers) considered in the literature as the best option is low; 6 and 14.13% respectively for women and men.

Results of econometric analyzes (results of multinomial logit model)

Table 4 shows the results of the multinomial Logit model estimation. The model is said to be globally significant,

Table 1. Explanatory/independent variables of the multinomial model.

Variables	Types of variable	Description of explanatory variables	Expected signs
Size	Quantitative	The number of persons in the household	+
Exp	Quantitative	Number of years of experience in agricultural production	+
Exrev	Quantitative	Non-agricultural incomes in XOF	+
Savings	Quantitative	The amount saved by the producer in XOF	+
Credit	Qualitative	Access to credit. This reaches value 1 if the farmer has access to credit and 0 if he has not.	+
Visit	Quantitative	Number of visits conducted by the disseminating worker in the farmers' farms	+
Forma	Qualitative	Participation to a specialized training. This reaches the value 1 if that is the case and 0 if not.	+
CTP	Quantitative	Production total cost expressed in XOF	-
Quali_Input	Qualitative	Farmers' perception on the input's quality. The variable reaches the value 1 if the input is deemed as of good quality by the farmers and reaches 0 if not	+
Input_time	Qualitative	Availability of inputs on due time. The variable reaches the value 1 if the producer affirms that the inputs are available on due time in their area and 0 if this not the case	+
Soil	Qualitative	Type of soil used by the farmer. Soil=1 if of the farm soil is mostly made up of gravels or laterites and 0 if not.	+
Prum	Qualitative	This variable represents the ownership of small ruminants (sheep, goats, etc). This reaches the value 1 if the farmer owns at least one small ruminant and 0 if he does not.	+
Rum	Qualitative	This represents the ownership of ruminants (oxen or donkeys). The value of this variable reaches 1 of the farer owes one ruminant and 0 if he does not	+

The model was estimated separately for women and men using the likelihood maximum method (which follows a Chi-square law) with the software STATA version 15.

Table 2. Descriptive statistics of the explanatory variables introduced in the Multinomial Logit model among women and men.

Variable	Average	Standard deviation	Minimum	Maximum	Average	Standard deviation	Minimum	Maximum
			Women				**Men**	
Quantitative variables								
Size	13	7,19	1	66	12.6	7	1	50
Exp	11.1	9.3	0	90	16.8	12.44	1	75
Exrev	5400.4	22372.03	0	1000000	19315	62961.97	0	750000
Savings	7118.0	28702.20	0	750000	38780	332462.40	0	10000000
CTP	49151	38997	525	285018	148605	118647	1300	905753
Qualitative variables								
			Women				**Men**	
	Frequency		**Percentage**		**Frequency**		**Percentage**	
Credit	1024		27.96		208		20.7	
Soil	1617		44.14		552		54.93	
Input_time	2821		77.01		793		78.91	
Quali_input	3426		93.53		931		92.64	
Forma	462		12.61		174		17.31	
Prum	2803		76.52		916		91.14	
Rum	1655		45.18		613		61.14	
N	3663				1005			
N	1221				335			

N= observation number over three years; n= sample size.
Source: Survey data 2016-2018.

Table 3. Adoption rates of GPACC based on gender.

Methods	Frequency	Percentage	Frequency	Percentage
	Women		Men	
No GPACC	471	12.86	38	3.78
One GPACC	835	22.80	135	13.43
Two GPACC	1174	32.05	292	29.05
Three GPACC	969	26.29	398	39.60
Four GPACC	220	6.01	142	14.13
N	3663	100	1005	100
n	1221		335	

N= number of observation over three years; n= sample size.
Source: Source: survey data of agricultural campaigns 2015-2016, 2016-2017, 2017-2018

when the likelihood value is greater than that of the Chi-square at the same degree of freedom at a given threshold (1, 5 or 10%). The likelihood ratio test indicates that the two models are globally significant at 0.01% threshold with coefficients of determination (R2 of Mac Fadden) equal to 0.3967 and 0.3117 respectively for women and men. Thus, the hypothesis of simultaneous nullity of all the coefficients is rejected, implying that the variables introduced into the models contribute together to explain the decisions regarding the adoption of GPACC by women and men.

The analysis of the results reported in Table 4 shows that the coefficients of the extra-agricultural incomes and savings variables are zero regardless of the GPACC modality.

For the adoption of a GPACC, the coefficients of the variables “number of years of experience” in agriculture (Exp), total cost of production (CTP) and type of soil (Soil) are all positive and significant at a threshold of 10% among women. For men, the coefficients of the variables significant at 10% are “agricultural experience”, “total cost of production”, “access to specialized training” and “type of soil”. The coefficients of the variable’s “experience” and “total cost of production” are positive while those of the variables “access to specialized training” and “type of soils” are negative. For the probability of adoption of two GPACC among women, the coefficients of the variables “agricultural experience”, “total cost of production” and “ownership of ruminants (Rum)” are all positive and significant at 1% threshold. The coefficients of the variables “total cost of production”, “access to specialized training” and “type of soil” are significant at a threshold below or equal to 5% for men. At this level, only the coefficient of the variable “total cost of production” is positive. For the probability of adoption of three GPACC, the coefficients of the variables “experience in agricultural production”, “access to agricultural credit (Credit)”, “total production cost”, “type of soil, “availability of inputs on time” and ownership of ruminants are positive and significant at 10% threshold. Among men, the significant coefficients are those of the variables “agricultural experience”, “total cost of production” and “access to specialized training”. Except the coefficient of the variable “access to specialized training” which is negative, those of the other variables are positive.

Finally, for the probability of adoption of four GPACC, the coefficients of the variables “access to credit”, “total cost of production” and “type of soil” are all significant at 5% threshold and are positive. For men, the coefficients of the variables “access to credit”, “total cost of production”, “access to specialized training” and “ownership of small ruminants” are significant at 10% threshold. Except the coefficient of the variable “access to specialized training” which is negative, those of the other variables are positive.

DISCUSSION

Interpretation only concerns significant coefficients. Descriptive statistics show that men adopt GPACC more than women. This situation can be explained by the low access of women to production factors compared to men (MPF, 2012). The econometric results show that the determinants for adopting GPACC depend on the farmer’s practices and gender.

Probability for adopting one GPACC

Analyzing these results shows that the experience in the agricultural production has a positive influence on the probability to adopt one GPACC among men and women. The positive influence of this variable can be explained by the fact that women’s experience in farming is essential to improve their capacity in appraising and mastering GPACC. It provides an understanding of the challenges for adopting agricultural innovations. This result is in line with that of Debalke (2014) and Mbétid-Bessane (2014) respectively in Ethiopia and the Central African Republic. Nkamleu and Coulibaly (2000) and Mbétid-Bessane (2014) believe that experienced farmers

Table 4. Results of the multinomial Logit model estimation .

BPACC	Coefficients	Std. Err.	z	P>z	Coefficients	Std. err.	z	P>z
		Women				Men		
One GPACC								
Size	0.0199	0.0204	0.98	0.329	-0.036	0.097	-0.37	0.711
Exp	0.0260*	0.0152	1.7	0.089	0.0423*	0.0256	1.65	0.098
Exrev	0	0	-0.3	0.762	0	0	-1.05	0.295
Credit	0.1137	0.2471	0.46	0.645	-0.7706	0.8732	-0.88	0.378
Savings	0	0	0.37	0.708	0	0	-0.14	0.892
Equi	0.7854	0.7369	1.07	0.287	-0.1026	1.1929	-0.09	0.931
CTP	0.0001***	0	8.35	0.000	0.0001***	0	2.76	0.006
Soil	0.4639**	0.2077	2.23	0.026	-0.9852*	0.5397	-1.83	0.068
Intput_time	-0.0597	0.2512	-0.24	0.812	-1.3301	0.829	-1.6	0.109
Quali_Intrant	0.1017	0.409	0.25	0.804	-1.1095	1.1438	-0.97	0.332
Forma	-0.1716	0.3689	-0.47	0.642	-2.8368**	1.1757	-2.41	0.016
Prum	0.071	0.293	0.24	0.809	0.0135	1.1661	0.01	0.991
Rum	0.2042	0.2216	0.92	0.357	0.1419	0.7225	0.2	0.844
Two GPACC								
Size	-0.0046	0.0248	-0.19	0.852	-0.0134	0.0939	-0.14	0.886
Exp	0.0447**	0.016	2.79	0.005	0.0426	0.0282	1.51	0.131
Exrev	0	0	-2.36	0.018	0	0	-0.8	0.424
Credit	0.1975	0.2601	0.76	0.448	-0.4411	0.8485	-0.52	0.603
Savings	0	0	0.74	0.46	0	0	-0.08	0.936
Equi	0.3192	0.7289	0.44	0.661	-0.3533	1.1477	-0.31	0.758
CTP	0.0001***	0	12.67	0.000	0.0001***	0	2.98	0.003
Soil	0.3492	0.2196	1.59	0.112	-1.1848**	0.5257	-2.25	0.024
Input_time	0.1877	0.2649	0.71	0.478	-1.3146	0.8605	-1.53	0.127
Quali_Input	0.3676	0.4235	0.87	0.385	-0.8622	1.0945	-0.79	0.431
Forma	0.0669	0.391	0.17	0.864	-3.2482***	1.2189	-2.66	0.008
Prum	0.1368	0.3253	0.42	0.674	1.5772	1.1683	1.35	0.177
Rum	0.6392***	0.2299	2.78	0.005	0.3777	0.7031	0.54	0.591
Three GPACC								
Size	-0.0346	0.027	-1.28	0.2	-0.0377	0.0969	-0.39	0.697
Exp	0.0368**	0.0178	2.07	0.039	0.0556*	0.0288	1.93	0.054
Exrev	0	0	-2.6	0.009	0	0	-0.77	0.441
Credit	0.5674*	0.2917	1.95	0.052	0.3936	0.8581	0.46	0.646
Savings	0	0	1.86	0.062	0	0	-0.18	0.854
Equi	0.1188	0.7903	0.15	0.88	-0.0087	1.2071	-0.01	0.994
CTP	0.0002****	0	15.17	0.000	0.0001***	0	3.41	0.001
Soil	0.5589**	0.2458	2.27	0.023	-0.7748	0.5599	-1.38	0.166
Input_time	0.5800*	0.3208	1.81	0.071	-1.0819	0.8673	-1.25	0.212
Quali_Input	0.5261	0.5461	0.96	0.335	-0.5579	1.05	-0.53	0.595
Forma	0.1562	0.4305	0.36	0.717	-3.5395***	1.1961	-2.96	0.003
Prum	-0.008	0.3905	-0.02	0.984	0.1653	1.2048	0.14	0.891
Rum	0.8077**	0.2639	3.06	0.002	1.0177	0.7241	1.41	0.16
Four GPACC								
Size	0.0103	0.0346	0.3	0.766	-0.0095	0.0997	-0.1	0.924
Exp	0.0226	0.0232	0.97	0.33	0.0387	0.0313	1.23	0.217
Exrev	0	0	-2.17	0.03	0	0	-1.12	0.265
Credit	1.0926***	0.3973	2.75	0.006	2.3895**	0.9622	2.48	0.013

Table 4. Contd.

Savings	0	0	1.74	0.082	0	0	-0.36	0.721
Equi	-0.4093	1.2173	-0.34	0.737	1.5674	1.3523	1.16	0.246
CTP	0.0002***	0	16.34	0.000	0.0001***	0	3.72	0
Soil	0.7257**	0.3611	2.01	0.044	-0.4465	0.6403	-0.7	0.486
Input_time	0.4322	0.4676	0.92	0.355	-0.9665	0.951	-1.02	0.309
Quali_Input	0.5624	0.8014	0.7	0.483	-1.3671	1.1923	-1.15	0.252
Forma	0.5653	0.5303	1.07	0.286	-4.5738***	1.2832	-3.56	0
Prum	0.2521	0.5196	0.49	0.628	-0.4495	1.3024	-0.35	0.73
Rum	-0.1197	0.365	-0.33	0.743	1.4226*	0.8134	1.75	0.08
Log Vraisemblance	-885.23702				259.7438			
Pseudo R2	0.3967***				0.3117***			
Wald Khi-2	474.01				133.05			
N	3246				879			
n	1221				335			

***: significative value to 1 %; ** significative value to 5 %; * significative value to 10%

had time to actually feel the positive effects of technologies on yields. The total production costs also influence the probability of women and men adopting a GPACC. The influence of this variable is positive indicating that the higher the cost, the higher the probability that women and men adopt a GPACC. This influence, contrary to the expected theoretical effect, could be linked not only to the personal adoption decision (one of the fundamental assumptions of the adoption model), but also to the technical and material assistance of farmers' organizations through sustainable rural development programs and mutual aid between farmers in the realization of the WSC (Ouédraogo, 2009). These assistances encourage adoption because these costs are partly borne by these programs. As for the soil type variable, the probability for adopting one GPACC increases more when the soil in the woman's field is of gravel type. These techniques are well suited to degraded and generally gravelly soils. However, among men, gravelly soils negatively influence the probability for adopting one GPACC among women. This apparent contradiction could be linked to the fact that men, being generally the household's heads and having several types of soil, do not make a choice in practicing one GPACC; for these one, families 'foods needs are covered by the adoption of one GPACC. Therefore, they perform their GPACC, regardless of the type of soil. Finally, the adoption of one GPACC also decreases when man has an access to a specialized training. A plausible explanation to this result would be that man having received such training prefer to invest more in other activities than in agricultural production.

Probability adopting two GPACC

In addition to experience in agricultural production and total cost of production, ownership of ruminants (donkey and / or oxen) improves the probability of women to adopt two GPACC. Ruminants are not only used in animal traction for plowing but also provide manure for soil amendment. Previous studies have shown that manure is used in crop fertilization in Burkina Faso (Belemviré et al., 2008; CRDI, 2014). The adoption of two GPACC among men is influenced by total production costs, soil type, and access to a specialized training. As with a GPACC, the gravel-type soil and access to a specialized training reduce the probability for adopting two GPACC. However, unlike adopting one GPACC, the total production costs are positively related to the adoption of two GPACC. The positive effect of the production costs for men and women's adoption of two GPACC results from the technical and financial partners support and mutual aid among farmers of the study area.

Probability for adopting three GPACC

The probability for women to adopt three GPACC increases with experience, production cost, soil type, and ownership of ruminants. In addition to these already interpreted variables, the availability of inputs on time (Input-time) and access to credit improves the probability for women to adopt three GPACC. The relevance of the variable "availability of inputs on time" could be explained by the fact that, rural women have a lot of responsibility; in addition to their domestic work, they work in their husbands 'farms. As a result, the more inputs are available in time, the better they can adjust the period of use. Furthermore, they have few financial capacity and limited areas (MPF, 2012) so that they would prefer not to waste their resources when respecting the cropping calendar becomes impossible due to the unavailability of inputs on time. The positive effect of "access to credit" is

likely related to the fact that adopting three GPACC requires more investment than the others mentioned above. As a result, access to credit improves women's financial capacity and therefore their ability to adopt three GPACC. This result is in line with Ouédraogo et al. (2010), Mbétid-Bessane (2014), Rabé et al. (2017), Ouattara et al. (2018) and Traoré et al. (2019) in different African countries (Central African Republic, Burkina Faso and Niger). However, the insignificant effect of this variable among men suggests that they do not need any external financial support to adopt three GPACC.

Probability for adopting four GPACC

Variables “soil type”, “total production costs”, and “access to credit” positively influence the probability for women to adopt four GPACC. As in the case of three GPACC, access to credit improves women's cash flow and therefore their ability to adopt four GPACC. “Access to credit” also increases the probability for men to adopt four GPACC. Compared to the other modalities where this variable was not significant among men, this result seems to indicate that even if men have incorporated it extensively in their farming systems, adopting four GPACC implies to have strong cash. In other words, they need external financial support to adopt this GPACC method. In addition to credit, the total costs of production and ownership of ruminants positively influence the probability of adoption of four GPACC. The requirement of this modality in terms of economic need is confirmed by the variable “ruminant ownership” which is only significant for the adoption of four GPACC among men. Like the other GPACC modality, the “access to a specialized training” variable reduces probability for men to adopt four GPACC.

Conclusion

This study has showed that GPACC are adopted more by men than women. Determinants of adoption vary partially depending on the type of GPACC and farmer’s gender. Therefore, the adoption of a GPACC among women is determined by the number of years of experience of women in agricultural production, the total costs of production and the type of soil. These variables increase the probability for women to adopt GPACC. As for men, experience in production, total costs of production, soil type, and access to specialized training determine the adoption of a GPACC. While production costs improve the probability for adoption, soil type and specialized training decrease it.

Adoption of two GPACC among women is determined by years of experience, production costs and ruminant’s ownership. These variables favor the adoption of two GPACC. As for men, the adoption of this modality is determined by the total costs of production, the type of soil and access to specialized training.

As for the adoption of three GPACC among women, the following variables improve their adoption: the number of years of experience, production costs, ruminant ownership, access to credit, type of soil and availability of inputs on due time improve. As for men, the determinants factors for adopting this modality are “experience in production””, total production costs and access to specialized training. Production costs and experience favor adoption, while specialized training negatively affects it.

Adoption of four GPACC among women is determined by production costs, access to credit, and soil type. Determining variables for men to adopt four GPACC are: access to credit, production costs, access to specialized training, and ownership of ruminants. Except the access to training, all other variables increase the probability for adopting four GPACC. As an overall, the socio-economic variables of the producers, the institutional opportunities of the production environment and the farms characteristics determine the adoption of GPACC. However, the relevance of these variables varies according to GPACC and gender even if some appear to be common to all GPACC for a given category of farmers. Therefore, projects and programs aimed at promoting the large-scale adoption of GPACC must take into account these factors and the specificity of needs according to the producers’ categories to better achieve their objective.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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