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Assessing the effects of good practices to adaptation to climate changes on food security for rural households in Northern Burkina Faso

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ABSTRACT

Burkina Faso, like other Sahelian countries, is very vulnerable to climate variability and change because of the essentially rain-fed nature of agriculture, its main economic sector. To improve the resilience of production systems to climatic hazards, improved varieties, organic manure, soil and water conservation techniques, seeds of improved varieties, microdose fertilization, agroforestry associated with agricultural intensification practices have been improved through various studies. These practices, so called Good Practices for Adapting to Climate Change (GPACC), have been disseminated in the Northern Burkina Faso for decades. However, food insecurity persists in the region. Hence, the present study aims to evaluate the effect of these GPACC on the food security of rural households after their adoption. Data collected from a survey conducted with 335 male farmers and 1221 female distributed in 113 villages in the region, was analyzed using a multinomial Logit model. The estimation of this model indicates that in female households, the adoption of one, two, three and four GPACC each have a positive effect on food security in terms of moderate vulnerability and non-vulnerability of households. For male households, the adoption of each of the four GPACC modalities considered also positively influences the status of non-vulnerability. In sum, the adoption of GPACC improves the probability of households to not being vulnerable. Therefore, to ensure sustainability of agricultural production systems and improve the socio-economic conditions of rural populations, strong decisions have to be taken by the policy makers to assure technical and financial capacities and necessary equipment for farmers.

KEYWORDS: Vulnerability, women, men, multinomial Logit, Burkina Faso

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INTRODUCTION

Despite the multiple innovations transferred to farmers by researchers and extension workers, food insecurity is a very acute problem in Burkina Faso. Indeed, food insecurity is affecting 45% of rural households [1]. In addition to the low productivity of agriculture, food insecurity is aggravated by the extreme poverty of the populations. Past researches conducted by the National statistics and demography Institute (INSD) indicated that 46.4% of the population of Burkina Faso lived below the poverty line [2] and therefore constitutes the most vulnerable group to food and nutritional insecurity. In addition, the recurrent climatic hazards combined with the continuous rising food prices further increase food insecurity for many households, particularly in the Northern Burkina Faso. In general, food insecurity is critical in the Northern region with an estimated coverage rate of 70% [2].

To reduce the rate of food insecurity and compensate for the multiple imports of foodstuffs, the state had made commitments at the major international summits and implemented various policies and strategies to reduce poverty and enhance food and nutritional security[1]. These strategies included the Accelerated growth and sustainable development strategy (SCADD), the National program for rural sector (PNSR), the National food security strategy (SNSA), the National nutrition policy (PNN), the National Agency for Social Protection (PNPS) [1]. However, hunger and malnutrition still persist in Burkina Faso. Therefore, the government has set up a National food and nutritional security policy (PNSAN) whose ambition is to achieve sustainable food and nutritional security by 2025. One of the ways to achieve this objective would be to large-scale the adoption of Good Practices for Adapting to Climate Change (GPACC). These practices include soil and water conservation techniques, seeds of improved varieties, organic manure, microdose fertilization [3, 4, 5], soil and water conservation techniques such as stone rows, grass strips of *Andropogon gayanus* filtering dikes, half-moons, rock bunds [6, 7] zaï, tied-ridging, compost, manual and mechanized zaï and ploughing [8, 9] and agroforestry.

Many scientific studies have shown the potential contribution of these strategies to increasing agricultural production [10, 11]. However, the majority of these studies focused on yields improvement, but not on surveys to understand farmers' perceptions of the effects of Good Practices for Adapting to Climate Change (GPACC) on the food security of rural households in this part of the country decades after their introduction. However, by referring to the theory of the appropriation of innovations, farmers cannot be forced to follow the promising technologies from research but can adapt them to their own practices [12]. To do this, the perceived effect may turn out to be different from the potential effect of the innovation. Thus, the evaluation of the effect of these adapted strategies set up by the farmer to face climate changes are to be considered when investigating on food security indicators.

The present study aims to assess and capitalize the farmers' perceptions of the GPACC on the food security of rural households and strategies adapted by farmers to face climate changes in the Northern of Burkina Faso.

METHODOLOGICAL APPROACH

Study area

The study was conducted in the Zondoma and Passoré provinces located in Northern Burkina Faso. These provinces hosted the "Financial and Scaling-up of Agricultural Innovations Services in Burkina Faso (FSSAIB)'' and the data used in this study were collected during the implantation. The Zondoma province is in between the rainfall isohyets 500 and 750 mm [13]. The soils in this province are semi-arid tropical type with a cuirass limiting considerably the soil depth and water infiltration [14]. The province has a higher proportion of women (53.97%) compared to men [2]. The Zondoma province is in deficit in terms of cereal grain and the needs are covered for 67% in 2019 [15], thus showing deficiencies. In the Passoré province, the annual rainfall, irregularly distributed in time and space, varies from 525.5 mm to 863.7 mm. Soil fertility management practices relate to soil and water conservation (SWC) techniques, organic fertilization and, to a lesser extent, chemical fertilizers [16, 17]. The Passoré province has also a higher proportion of women (53.69%) compared to men [2]. The population cereal grain needs are covered just for 69% [1]. The study covered 64 villages distributed in six communes in the Passoré province between 11°30' and 13°19' North Latitude and 1°30' and 2°45' West Longitude and 49 villages in four communes in the Zondoma province between latitudes 12°38' and 14°18' North and longitudes West 1°33' and 2°55' (Figure 1). Data base used for the realization of Figure 1 is from IGB/BNDT (2021) [18].

Sample size

This study was conducted among all members of 115 farmers' organization (FO) chosen with the participation of Village Development Committees (VDC) and based on the following criteria: (i) FO having more than 10 members; (ii) FO created before year 2014; (iii) FO possessing complete official creation documents (receipt, number of members, channels of intervention, etc.); (iv) FO having a well-defined market orientation. The sample size was set to 1556 individuals comprising 1221 women and 335 men.

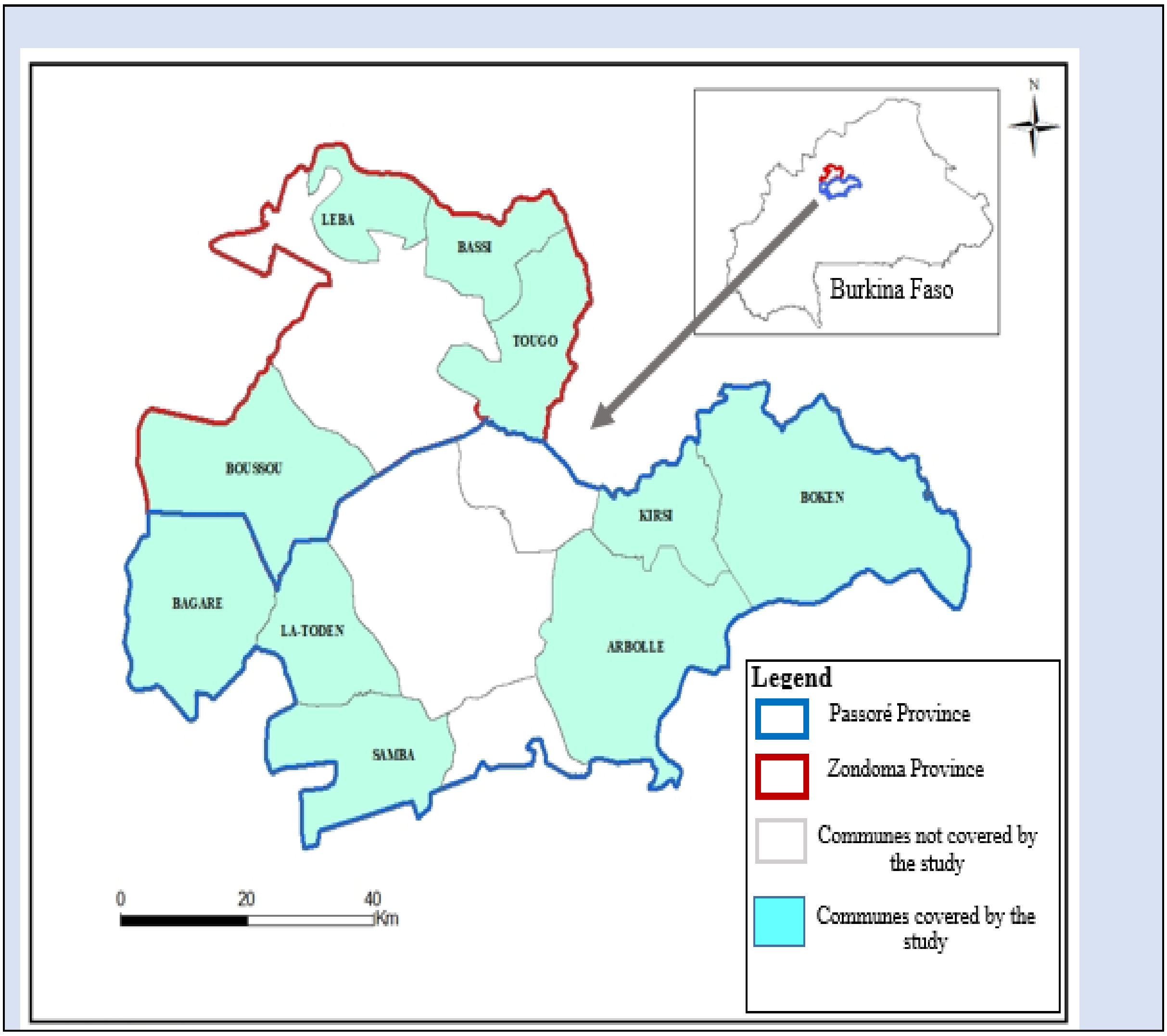

Figure 1. Map of Burkina Faso showing the Zondoma and Passoré provinces (*Source*: IGB/BNDT, 2021.

Data Collection

Data were collected through individual questionnaires over three successive growing seasons (2015-2016; 2016-2017; 2017-2018) from the same farmers in order to obtain a set of data. The data collected focused on production systems as well as practices developed by farmers to adapt to climate changes.

Data coding, examination and analysis

The software SPSS version 20 was used for coding the data recorded and performing the descriptive statistics. The Logistic Regression Model was estimated using the software Stata version 15.

Tool used for analyzing the effect of GPACC on food security

In the literature, the food security estimation generally takes into account the quantities of food produced, the quantities purchased and the quantities of food received through aid. However, for most African households, food security is perceived as the capability of the household to meet the food needs of all members together through the household's own production. Based on this understanding, we assume that food self-sufficiency determined by the total production after harvests appear to be the basic function of the household. In other words, the calculation of the food security status only takes into account the quantities of food produced. As a result, food self-sufficiency depends on the availability of the production factors and other socio-economic and institutional factors likely influencing food production. The status of food security expressed in terms of calorific energy, which is the dependent variable, has three unordered modalities (extremely vulnerable, moderately vulnerable and not-vulnerable). Therefore, a polytomous model is appropriate to estimate the household food security status. Let Yi be the status of household I; Yi = j if the household belongs to category j; j = 1, 2, 3. The probability that household i falls in the status j conditionally related to the explanatory variables Xi including the GPACC is termed P_{ij}. The theoretical multinomial model approach for estimating P_{ij} is given by equation 1.

Eq. 1: $P_{ij} = Pr(Y_i = j) = F_j(X_i, \theta)$, j = 1, 2, 3 ; I = 1, 2, …, N [19]

where θ, represents a set of parameters associated with the explanatory variables X_i of the status j, and μ corresponds to the error term.

The sum of the probabilities of the different modalities being equal to unity (1), the reference modality is obtained from equation 2.

Eq. 2: $F_m(X_i, \theta) = 1 - \sum_{j=1}^{m-1} F_j(X_i, \theta)$

where,

m represents the number of modality. In this case, m = 3;

Fj (.) is a given functional form of multinomial models;

θ represents a set of parameters associated with the explanatory variables X_i of option j.

Food security indicators and calculation method

The ministry in charge of agricultural sector of Burkina Faso regularly uses the coverage rate for cereal needs to assess the food security status in rural households which is based on the households' own production [14]. Information regarding the ability of households to cover the cereal needs of their members between two harvests, is frequently provided in the literature, both for their own productions and acquisitions as well (purchases, gifts received). These coverage rates in cereal needs are estimated based on household's own cereal production, the quantities of cereal grain purchased, the quantities of grain received as gifts, the number of household members and the quantities of cereal needed capita^{-1} year^{-1}. In this context, a household will be considered "food secured" if and only if the quantities of grain received as gifts and the quantities of grain purchased added to its own production is greater than or equal to the quantities of cereal required to cover the household total consumption.

Of course, this indicator of food availability and accessibility gives an idea of the ability of households to meet the cereal needs for their members. However, coverage of the grain quantities needed does not necessarily reflect assurance of food security. The cereal consumption standard does not indicate the quality component of food security. Therefore, it is necessary, but not sufficient, to indicate systematic food security [20]. Food security integrates both quantities of cereal grain for household consumption and grain quality for energy needs. In this case, a household can be considered "food secured" if and only if the availability of calorific energy within the household is greater than or equal to the energy requirements for its members. Thus, the concept of poverty in calorific energy is the best way for characterizing individuals who are not capable to meet their minimum energy requirements [21].

In this investigation, the coverage rate for energy requirements is used to determine the food security status of northern rural households in Burkina Faso. The consumption standard for vegetable products is 2097 Kcal/individual/year [22]. Since our data do not include sugars, vegetable oils, fruits, non-timber forest products and beverages, we refer to the energy consumption standard for cereals, pulses, tubers and vegetables which is estimated 1757 Kcal/individual/year [22].
The calculation of the coverage for calorific energy needs requires the calculation of the energy availability at the household level and the calculation of the energy needs for the members of the households as well.

Calculation of household calorific energy needs (BEM)

The standard of energy consumption is established in the literature by age group, by sex and according to the activity carried out by the individual. Given the data that was available, we have taken the average standard for one individual in a year. Expressed in Kcal year^{-1} individual^{-1}, this average standard represents the amount of energy needed per year to maintain good health and remain active. Let NM be the number of members of household i, the calorific energy requirement of household i (BEM_i) is given by equation 3.

Eq. 3: $BEM_i = NM_i * norme$

Calculation of household calorific energy availability

The available calorific energy (DeT) represents the energy value of food consumed by households. Based on the available data for the analysis, and since the aim is to evaluate the effect of GPACC on food security, only the agricultural production is here considered. Therefore, the estimation of energy availability only focused on household's consumption. For each product j, the energy availability (De) corresponds to the quantity of food produced (Q_j) multiplied by the extraction rate of the product (T_{ej}), then multiplied by the quantity of energy per unit of product (q_{ej}). The energy availability (De) of product j is obtained from equation 4:

Eq. 4: $D_{ej} = Q_j * T_{ej} * q_{ej}$

The total energy availability of household i (DeT_i) is obtained from equation 5:

Eq. 5: $DeT_i = \sum_{j=1}^{J} De_j$

where J is the number of crops.

Determination of household food security status

Any household that fails to cover at least 100% of the energy needs of its members is considered "food unsecured". According to the classification of individuals based on the coverage rate for their minimum energy requirements (MER) established by the World Food Program (WFP), individuals are said to be extremely vulnerable when their calorific energy requirement rate is less than 90% of their energy needed, moderately vulnerable when coverage rate is in between 90% and 100% and not-vulnerable when coverage rate is equal or more than 100%. For this purpose, three categories of households are distinguished: extremely vulnerable, moderately vulnerable and not-vulnerable households. The rate of calorific energy covered (Tc) for each household is given by equation 6.

Eq. 6: $Tc = DeT_i / BEM_i * 100$

Specification of model used to analyze the food security

The two main functional forms used in modeling an unordered multi-category dependent variable are the Probit and the Multinomial logit. Based on the benefits of these different specifications, a multinomial Logit seems more indicated for assessing the effect of GPACC on food security. The multinomial logistic specification of the probability that household i is in status j looks like this (Equation 7):

Table 1: Summary of the explanatory variables introduced in the multinomial Logit form

Variables	Nature	Definition	Expected signs
Age	Quantitative	Age of farmer given in years	-
Household (Hsize)	Quantitative	Number of members in the household to which the farmer belongs	-
Experience EExp)	Quantitative	Farmer's experience in agriculture expressed in years	+
Credit (Cred)	Qualitative	Access to credit set to 1 if received and 0 if not	+
Extra-agricultural income (Eaincome)	Quantitative	Extra-agricultural income in XOF	+
Income (Aincome)	Quantitative	Income from agricultural activities in XOF	+
Mechanized Equipment (Equi)	Qualitative	Level of equipment set to 1 if the operator has mechanized equipment and 0 if not	+
Visit	Quantitative	Number of visits by the extension agent	+
Feld size (Fsize)	Quantitative	Total area planted in ha	+
Soil	Qualitative	Type of cultivated soil set to 1 if the cultivated soil is gravelly and 0 if not	-
Small ruminants (Srum)	Qualitative	Possession of small ruminants set to 1 if possessing and 0 if not	+
Big ruminants Brum)	Qualitative	Possession of big ruminants set to 1 if possessing and 0 if not	+
Training (Train)	Qualitative	Participation in specialized training set to 1 if trained and 0 if not	+
Input time (Itime)	Qualitative	Availability of inputs on time set to 1 if available and 0 if not	+
GPACC	Qualitative	GPACC1 set to 1 for adoption of a GPACC1 and 0 if not	+
		GPACC2 set to 1 for adoption of a GPACC2 and 0 if not	+
		GPACC3 set to 1 for adoption of a GPACC3 and 0 if not	+
		GPACC4 set to 1 for adoption of a GPACC4 and 0 if not	+

The estimation of the empirical model is made by the Maximum likelihood method.

$$Eq.\ 7 : P_{ij} = \frac{exp(X_i'\beta_j)}{\sum_{l=1}^{m} exp(X_i'\beta_j)}, \qquad j = 1, \ldots\ldots, m$$ [19]

By introducing the variable t to take into account the nature of the data set, the model obtained is expressed by equation 8.

$$Eq.\ 8: P_{ijt} = \frac{exp(X_{it}'\beta_j)}{\sum_{l=1}^{m} exp(X_{it}'\beta_j)},$$

where X'_i is a set of explanatory variables including GPACC and βj, the vector of parameters to be estimated, with modality one (Extremely vulnerable households) being the reference. The coefficients of the other modalities are interpreted in relation to this category of Extremely vulnerable households.

$0 < P_{ij} < 1$ et $\sum_{j=1}^{m} P_{ij} = 1$

Variables introduced into the model

The variables used in this research are summarized in Table 1.

RESULTS

Famers' socio-economic and institutional characteristics

The socioeconomic and institutional characteristics of women and men surveyed are shown in Table 2.

Table 2: Socio-economic and institutional characteristics of male and female farmers

		Women			Men	
Quantitative variables						
Variables		Mean	Standard deviation		Mean	Standard deviation
Active members (Amemb)		7,3	4,66		7,72	4,76
Exp		16,84	12,44		11,11	9,3
Visit		1,63	3,07		1,41	2,57
Fsize		3,86	2,51		1,12	0,58
N		1005			3663	
n		335			1221	
T		3			3	
Qualitative variables						
Variables		Frequency	%		Frequency	%
Active members (Amemb)		428	42,59		1964	53,62
Cred		208	20,7		1024	27,96
Equi		894	88,96		764	20,86
Itime		793	78,91		2821	77,01
Train		174	17,31		462	12,61
Srum		916	91,14		2803	76,52
Brum		613	61		1655	45,18
Soil		552	54,93		1617	44,14
Not any		471	12,86		38	3,78
GPACC1		835	22,8		135	13,43
GPACC2		1174	32,05		292	29,05
GPACC		969	26,29		398	39,6
GPACC4		220	6,01		142	14,13

Note: **N** = Number of observations; **n** = sample size; **T** = number of years of data collection.

Household food security status

Descriptive statistics of food security status in terms of coverage of energy needs are shown in Table 3.

Table 3: Status of coverage of household energy needs by sex of household leader

		Women			Men	
Status		Frequency	%		Frequeny	%
Extremely vulnerable		145	20,14		71	8,17
Moderately vulnerable		136	18,89		196	22,55
Not vulnerable		439	60,97		603	69,31
Total		720	100,00		870	100
N		240			290	

Source: Results of analysis of survey data from the 2015-2016, 2016-2017 and 2017-2018 growing seasons.

Note: **n** = sample size.

Results indicated that, about 61% of households with women being the leaders (female households) were able to cover more than 100% of their calorific energy requirements, while 69% of households with men being the leaders (male households) could cover this rate (Table 3). Only 20% of female households and 8% of male households are extremely vulnerable.

Evaluation of the effect of GPACC on food security

Stepwise regression was carried out to come to convergent models. Thus, depending on the type of farmer, some variables were removed during the analysis. Results obtained from the estimation of the multinomial Logit model with the explanatory variables used according to the sex of the farmer are shown in Table 4.

Economic validity of the coefficients

The likelihood ratio test indicated that the two models that reflect the relationship between food security status and GPACC were globally significant at $p \leq 0.1$ (Table 4). This indicates that all the explanatory variables introduced in the models contributed to the food security status explanation in rural households. Pseudo R2 were 0.6513 for women and 0.6557 for men. Consequently, the introduction of the independent variables into the multinomial Logit model explained the variations in the probability that a household falls in a given food security status. Consequently, the food security status of rural households is explained by 65.13% of women in female households and 65.57% of men in male households. These results indicated that the econometric estimates are appropriate for making economic interpretations.

Table 4: Results from the Multinomial Logit regression model.

Variable	Coefficient	Stderr	Z	P>|z|	Coefficient	Stderr	Z	P>|z|
	Women				Men			
Moderately vulnerable								
Hsize	-0,07*	0,04	-1,68	0,093	0,27**	0,11	2,36	0,018
Exp	0,01	0,03	0,19	0,849	0,00	0,03	0,07	0,947
Inc	0,00	0,00	0,32	0,753	0,00	0,00	0,98	0,326
Equi	3,17**	1,38	2,3	0,021	3,84***	1,12	3,43	0,001
Visit	0,11	0,10	1,02	0,305	1,48**	0,69	2,16	0,031
Fsize	0,36	0,44	0,82	0,415	0,19	0,20	0,94	0,349
Srum	2,16***	0,81	2,67	0,007	0,88	0,99	0,89	0,376
Brum	0,01	0,60	0,02	0,98	-	-	-	-
Itime	0,51	0,70	0,73	0,465	1,78	1,12	1,58	0,113
GPACC1	3,92***	1,14	3,45	0,001	5,77***	1,98	2,91	0,004
GPACC2	4,54***	1,15	3,94	0,000	3,36	2,22	1,51	0,131
GPACC3	4,16***	1,20	3,47	0,001	6,36***	2,08	3,06	0,002
GPACC4	7,51***	2,72	2,76	0,006	9,16***	2,72	3,37	0,001
Not vulnerable								
Hsize	-0,07**	0,04	-2	0,045	0,25**	0,10	2,44	0,015
Exp	0,01	0,02	0,25	0,799	0,00	0,02	-0,19	0,846
Inc	0,00	0,00	1,47	0,142	0,00	0,00	2,11	0,035
Equi	3,69**	1,56	2,36	0,018	3,84***	1,08	3,55	0,000
Visit	0,19**	0,08	2,4	0,016	1,55**	0,68	2,26	0,024
Fsize	0,47	0,37	1,28	0,202	0,15	0,21	0,71	0,479
Srum	2,31**	0,91	2,54	0,011	1,07	1,00	1,07	0,285
Brum	2,10***	0,60	3,48	0,001	-	-	-	-
Itime	1,70***	0,64	2,66	0,008	1,66	1,03	1,62	0,105
GPACC1	2,22**	1,02	2,19	0,029	7,32***	1,94	3,77	0,000
GPACC2	2,10**	0,88	2,38	0,017	5,68***	2,13	2,67	0,008
GPACC3	2,35**	0,98	2,41	0,016	9,25***	2,07	4,48	0,000
GPACC4	7,37**	2,93	2,51	0,012	12,07***	2,88	4,2	0,000
Log maximum likelihood	-84,67***				-90,49***			
Pseudo R2	0,6513				0,6557			
Wald chi-square	155,31				116,31			
n	240				290			
N	720				870			
T	3				3			

***: Significant value at $p \leq 0.01$; ** Significant value at $p \leq 0.05$; * Significant value at $p \leq 0.1$.

Source: Results from the analysis of the survey data collected during the growing seasons 2015-2016, 2016-2017 and 2017-2018.

Note: **N** = Number of observations; **n** = sample size; **T** = number of years of data collection.

Statistical significance of the coefficients

Results showed that the coefficients of significance varied according to the food security status and the sex of the farmer (Table 4).

Moderate vulnerability status

Results indicated that the probability of being in the category of moderately vulnerable households among women, the coefficients of the variables GPACC1, GPACC2, GPACC3, GPACC4 and possession of mechanized equipment were all significant and positive at $p \leq 0.01$ (Table 4). In addition to the GPACC, the coefficient of the household size variable (Size) was significant but negative at $p \leq 0.1$, while that of possession of small ruminants was significant and positive at $p \leq 0.05$. For men, the coefficients of GPACC1, GPACC3 and GPACC4 were significant and positive at $p \leq 0.1$ (Table 4). In addition, the coefficients of the variables size, possession of mechanized equipment and number of visits by the extension agent (Visit) were also significant and positive at $p \leq 0.05$.

Non-vulnerability status

Results indicated significant and positive coefficients for all four GPACC modalities (GPACC1, GPACC 2, GPACC3, GPACC4) in female households at $p \leq 0.05$ (Table 4).

Coefficients for variables Hsize, Equi, Visit, Srum, Brum and Itime also showed significance at $p \leq 0.05$ with negative value for Hsize but positive for Equi, Visit, Srum, Brum and Itime.

Results indicated significant and positive coefficients for all four GPACC modalities (GPACC1, GPACC 2, GPACC3, GPACC4) $p \leq 0.01$, while, those of variables Hsize, Equi and Visit were significant and positive at $p \leq 0.05$

Economic interpretation of the results from Multinomial Logit Model analysis

For greater clarity, the interpretation of the results is done by food security status.

Effect of GPACC on the moderate vulnerability of households

Results from the estimation of the Multinomial Logit Model showed that the adoption of each of the four modalities of GPACC had influenced the probability of the female households to be moderately vulnerable in terms of food security which is indicated by the positive coefficients (Table 4). Indeed, assuming that everything is equal, results from the analysis let observe a probability for these female households to move from the status of extreme vulnerability to that of moderate one with the adoption of one GPACC. The same trend is observed with the adoption of two GPACC, three GPACC and four GPACC. It is concluded that the adoption of GPACC by women could improve the food security status in the female households.

Similar to the female households, the adoption of one GPACC, three GPACC and four GPACC in the male household had positively influenced the probability of these households to move from extreme vulnerability to moderate one. This is shown through the coefficients associated with the positive coefficients associated GPACC variables being. Indeed, the adoption of each of these modalities by men increased the chance for moving from extremely vulnerable households to moderately vulnerable.

Furthermore, socio-economic and institutional variables also contributed to explain the food security status in male households and female as well.

The presence of Equi and Srum in the household positively improved the food security status in the female households in terms of moderate vulnerability (Table 4). The negative coefficient observed for the Hize influenced the household food security status causing a household with moderately vulnerable status to become extremely vulnerable. In male households, Hsize, Equi and Visit had positively influenced the probability of the households which were moderately vulnerable to turn to extremely vulnerable.

Effects of GPACC on the non-vulnerability of households

Results from the multinomial Logit model estimation showed that each of the four modalities of GPACC improved household food security in terms of non-vulnerability, since the coefficients of these modalities were positive for both female and male households (Table 4). Indeed, the adoption of one GPACC increased the probability of households to assure food security. Similar results were also observed when female and male households had adopted two GPACC with a higher probability compared to households not adopting this modality of GPACC. In addition, farmers who were adopting three or four GPACC provided a greater chance to their households to be non-vulnerable than those not adopting. Therefore, the adoption of GPACC appears to be a good way for improving the food security of households in Northern Burkina Faso.

Results indicated that variables such as Hsize, Equi, Visit, Srum, Brum and Itime had affected the vulnerability status of female households. Indeed, the larger the Hsize, the lower the probability for the household to not be vulnerable and this is explained by the negative coefficient observed for this variable Hsize (Table). In male households, the variables Hsize, Equi and Visit were reported to affect their vulnerability status. Results indicated that a large Hsize was associated with a high probability for the household to not -being vulnerable. The variable Equi appeared to be associated with a high probability for male as well as female households to be non-vulnerable. Similar observations could be noted with the variable Visit in both male and female households. Moreover, Srum in the female households is a good indicator with a high probability showing food security that is encountered in these households. Results also indicated that the possession of Brum by female households demonstrates the capacity of a given household to successfully cover the energy needs of its members compared to those not possessing Brum. The timely availability of inputs also had a positive influence on the female household food security.

DISCUSSION

The analysis of the results indicates that the adoption of GPACC has a positive influence on food security. However, the influence of socio-economic and institutional variables varies partially according to the household's food security status.

Moderate vulnerable household

The adoption of one GPACC by women and men has a positive effect on food security showing moderate vulnerability in the households. Thus, the adoption of this one GPACC modality increases the food security status. The same effect also occurs with the adoption of two GPACC, three GPACC and four GPACC in female households. In male households, the positive effect resulted from the adoption of three and four GPACC. This positive influence of the three and four GPACC modalities in both female and male households is consistent with the expected effect for each of these GPACC modalities. This result confirms the fourth hypothesis of this thesis which states that the adoption of GPACC has a positive effect on the coverage of calorific energy requirements for rural households favored by increased production in the household. Indeed, the adoption of GPACC is a key to improvement of agricultural productivity, so leading to the availability of food in the households. This corroborates past agronomic findings that showed the great benefit when using SWC techniques, improved seeds and organic and mineral fertilizers in agricultural production [9, 23, 24, 25, 26]. According to these previous authors, the adoption of GPACC increases yields by more than 100% when they are combined. An increasing farm size through the use of SWC techniques as well as their combination with the assisted natural resources regeneration in Burkina Faso, Niger, Senegal and Mali allowed adaptation of farmers to climate change and improvement in food security in these countries [27]. Other authors [28, 29] mentioned that GPACC promote the development of diverse activities to improve food security.

The negative effect of Hsize on moderate vulnerability in female households implies that the larger the size of the households, the more these households are food insecure. This confirms the expected theoretical effect of the model in Nigeria [30, 31, 32], Ghana [33] and South Africa [34] showed that

Hsize negatively influenced food security. These authors believe that an increase in household size means more efforts to develop by households to assure their members' food requirements. Therefore, when households depend on less productive agricultural land, increasing their size results in the reduction of the availability of calorific energy per person. However, the positive effect of this variable on the ability of male households to moderately cover their energy needs depends on the type of farmer. The plausible explanation for this result would be that large male households may have more agricultural workers, therefore higher production favored by the probable availability of labor. This strong correlation between Hsize and the number of agricultural workers has been highlighted in this research and also in work previously published [35]. In addition, men have large fields to exploit which allows them to have more diversified productions. Authors [33] indicated that with large farms, households can produce more and also diversify their productions. However, results from the present study corroborate those of [36] in Côte d'Ivoire, which positively related Hsize to food security.

The positive influence of Equi on moderate vulnerability in female and male households confirms the expected theoretical effect. Indeed, in the study area, the Equi allows farmers to conduct certain farm operations, particularly weeding and ridging on time. This respect of the cropping calendar makes it possible to obtain good production and therefore an improvement of the food security status of households. This result corroborates that of [20] in Burkina Faso who emphasized that the fact of moving from manual to animal-drawn or motorized farming reduces the level of food insecurity.

Results indicated that in the female households, the moderate vulnerability encountered in these households was positively affected by the presence of Srum, as shown by the positive coefficient of this variable which corresponds to the expected theoretical effect of the model. Indeed, manure collected from the Srum is used to fertilize fields which increases crop production [9, 26].
The model showed a positive effect of the variable Visit on the moderate vulnerability of the female households explained by the positive coefficient in accordance with the expected theoretical effect. Indeed, meetings with extension workers are suitable extension tools for training, sharing knowledge and experiences. Many authors had reported the benefit of contact or visits by extension workers in agricultural development [37, 38, 39]. These authors believe that the visits received from the extension workers allow farmers to get information about agricultural innovations being implemented elsewhere and also be trained on farm management. Indeed, farmers will obtain good yields through the good production skills they have achieved which allows their households to move from extreme

vulnerability to moderate food security status. In contrast, [40] mentioned that the contact of the farmer with the extension services negatively influenced the dietary diversity score in Benin.

Not-vulnerable households

In both male and female households, the four GPACC modalities have a positive effect on non-vulnerability status, thus improving the household food security of the members in the farmers' organization in Northern Burkina Faso. The positive effect of GPACC on the status of non-vulnerability also indicates that these practices really make it possible to get households out of food insecurity. This further confirms the last hypothesis stated in the present research. The increase in crop yields in the household due adoption of GPACC had been demonstrated in recent years [23, 41, 42] releasing means for tackling food insecurity in the country.

Other socio-economic variables contribute to explain the non-vulnerability of households. In addition to Hsize, Equi and Srum discussed above, Visit, and Itime had a great influence on the non-vulnerability status in female households regarding food security. The frequent visits received by farmers from the extension workers have a positive effect on the food security status in the female households which is shown by the positive coefficient corresponding to the expected effect. The visits by the extension workers made it possible for women to capitalize knowledge and valuable advice in farm management.

The positive effect of ruminant ownership on non-vulnerability status of the household confirms the expected theoretical effect. Indeed, the possession of ruminants can contribute to increase agricultural productivity in various ways particularly the use of oxen and oxen as animal power for field activities and for transportation. Therefore, possessing these animals helps farmers to realize farm operations on time to improve soil and crop productivity when this is combined with fertilization. In addition, cattle manure is used to fertilize fields, thus leading to the improvement of productivity [9, 25, 43]. The timely availability of inputs also makes it possible for female households to move from extreme vulnerability to non-vulnerability. Indeed, the more fertilizers are available in time, the more women can apply them respecting the appropriate cropping calendar. In rural areas, women are not likely to be provided with means for transportation, especially motorbikes, compared to men. Such situation renders difficult women's travels to other localities (village) in order to get inputs for their farms

In male households, results indicated that the variables Hsize, Equi and Visit had positively influenced the status of the non-vulnerability of the households. These socio-economic and institutional variables could improve the food security in these households. Their significance both in explaining the status of moderate vulnerability and that of not vulnerable demonstrate the relevance in the constitution of household food security by men. This positive effect of household size on food security corroborates results of [36] in Côte d'Ivoire.

CONCLUSION

Effects of Good Practices for Adapting to Climate Change (GPACC) on the food security of rural households after their adoption were assed using a multinomial Logit model, a socio-economic analytical tool. Results from the investigation revealed that the adoption of GPACC has a positive effect on the households' food security in Northern Burkina Faso. These effects showed that all four GPACC modalities considered in the study had positively affected the food security status in terms of moderate vulnerability and non-vulnerability in female households. In male households, it had been observed that adoption of one, three and four GPACC resulted in a positive influence on the moderately vulnerable status of these households in terms of food security. These practices favored the transition from extremely vulnerable to moderately vulnerable status. Results indicated that the non-vulnerability status of male households was positively affected by the adoption of each of the four GPACC modalities (one, two, three, four). In general, the adoption of GPACC to improve the likelihood of members in the households in Northern Burkina Faso by allowing farmers to move from vulnerable status to non-vulnerable or moderately vulnerable has been well demonstrated in the present investigation. In other words, the adoption of these practices increases the chances for households to assure food security and thus cover the calorific energy requirements of their members. These results confirmed the fourth hypothesis which was stated as follows: "the adoption of GPACC has positive effects on the coverage of the rural households' food requirements".

Socio-economic and institutional variables also contributed to explain the households' food security status according to the sex of the household leader. Based on the results from the study, the necessity to scale-up GPACC, taking into account the socio-economic factors that contribute to the explanation of food security, appears to be a must in Northern Burkina Faso and other parts of the country.

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REFERENCES

1. MAAH. Revue stratégique « faim zéro » au Burkina Faso : Etat des lieux de la situation alimentaire et nutritionnelle. Rapport. 2017 ; 131.
2. INSD. Annuaire statistique 2018. Burkina Faso. 2019 ; 396.
3. CILSS. Bonnes pratiques agro-sylvo-pastorales d'amélioration durable de la fertilité des sols au Burkina Faso. Rapport. 2012 ; 194.
4. Bagayoko M, Nouri M, Palé S et al. Microdose and N and P Fertilizer Application Rates for Pearl Millet in West Africa. Afr. J. Agric. Res. 2011; 6: 1141-1150.
5. Tabo R, Bationo A, Gerard B, Ndjeunga J, Marchal D, Amadou B, Garba MA, Sogodogo D, Taonda JBS, Hassane O, Diallo MK, Koala S. 2007. Improving cereal productivity and farmers' income using a strategic application of fertilizers in West Africa. In: Advances in integrated soil fertility management in sub-Saharan Africa: Challenges and opportunities. Springer, Dordrecht; 2007: 201-208.
6. Zougmoré R, Kaboré D, Lowenberg-Deboer J. Optimal Spacing of Soil Conservation Barriers: Example of Rock Bunds in Burkina Faso. Agric. J. 2000; 92: 361-368.
7. Zougmoré R, Jalloh A, Tioro A. Climate-smart soil water and nutrient management options in semiarid West Africa: A review of evidence and analysis of stone bunds and zaï techniques. Agric. Food. Secur. 2014; 3 (16): 1-16.
8. Palé S, Mason SC, Taonda SJB. Water and fertilizer influence on yield of grain sorghum varieties produced in Burkina Faso. South Afr. J. Plant Soil. 2009; 26: 91-97.
9. Sawadogo H, Bock L, Lacroix D et al. Restauration des potentialités des sols dégradés à l'aide du Zaï et du compost dans le Yatenga (Burkina Faso). Biotechnol. Agron. Soc. Environ. 2008; 12(3): 279-290.
10. Bambara D, Bilgo A, Traoré H et al. Evaluation des effets des aménagements du zaï et des diguettes de longue durée sur la productivité céréalière au nord du Burkina Faso. BRAB. 2012 ; (71) : 13-29.
11. Barro A, Zougmoré R, Taonda JBS. Mécanisation de la technique du zaï manuel en zone semi-aride. Cah. Agric. 2005 ; 14 (6) : 549-559.
12. Millerand F. « Usages des NTIC, les approches de la diffusion, de l'innovation et de l'appropriation (1er et 2e parties) ». COMMposite. 1999 ; 98 (1) et 99 (1).

13. Ganou I. Monographie du Zondoma. Burkina Faso. Rapport. 2005 ; 85.
14. Tiama D, Kaboré B, Nanema KR et al. Systèmes de culture et caractérisation paysanne des ignames du Passoré au Burkina Faso. ResearchGate. 2018 ; 38 : 201-211.
15. MAAH. Serie de donnée du ministère de l'agriculture du Burkina Faso. Rapport. 2019.
16. Sigué H, Labiyi I A, Yabi J A et al. Facteurs d'adoption de la technologie "Microdose" dans les zones agroécologiques au Burkina Faso. Int. J. Biol. Sci. 2018; 12 :2030-2043.
17. Yabi AJ, Traoré A, Ayedegue DP. Impact of Water Collection and Management techniques (CGE) combined to microdose and to warrantage system on cowpea productivity in North and East Center of Burkina Faso. Int. j. sci. res. rev. 2017 ; 6 (1): 01 -15.
18. IGB/BNDT. Base de données spatiales du Burkina Faso. Ouagadougou, Burkina Faso, IGB/BNDT. 2021. [online]. 2021[Cited 2022 August 18]. Available from: https://www.igb.bf.
19. Cameron A C, Trivedi KP. Microeconometrics using Stata. Revised Edition. Stata Press, 4905 Lakeway Drive, College Station: Texas 77845. 2010.
20. Thiombiano B. Analyse de la contribution des cultures de saison sèche à la lutte contre la pauvreté au Burkina. Mémoire de fin de cycle. Université Polytechnique de Bobo-Dioulasso. 2008 ;72.
21. Kiénou B. Mise en œuvre d'un modèle d'insécurité alimentaire et d'estimation du groupe de population vulnérable. Mémoire d'ingénieur. Université polytechnique de Bobo-Dioulasso. 2005 ;75.
22. CILSS. Normes de consommation des principaux produits alimentaires dans les pays du CILSS. 2004 ;67.
23. Ouattara B, Somda BB, Sermé I et al. "Improving agronomic efficiency of mineral fertilizer through microdose on sorghum in the sub-arid zone of Burkina Faso". In: Bationo A, Ngaradoum D, Youl S et al. (Eds.). Improving the profitability, Sustainability and Efficiency of Nutrients Through Site Specific Fertilizer Recommendations in West Africa Agro Eco systems. Springer International Publishing, AG; 2018; 241-252.
24. Gnoumou XN, Yaméogo JT, Traoré M et al. Adaptation aux changements climatiques en Afrique sub-saharienne : impact du zaï et des semences améliorées sur le rendement du sorgho dans les villages de Loaga et Sika (province du Bam), Burkina Faso. IJIAS. 2017 ; 19(1) : 166-174.
25. Somé D, Hien E, Assigbetse K et al. Culture d'une légumineuse et d'une céréale dans le système Zaï avec différents amendements organo-minéraux : productivité et impact sur les

propriétés biologiques d'un sol ferrugineux dégradé dénudé en Région nord Soudanienne au Burkina Faso. Tropicultura. 2016; 34 (1): 56-58.

26. Belemviré A., Maiga A., Sawadogo H et al. Evaluation des impacts biophysiques et socioéconomique des investissements dans les actions de gestion des ressources naturelles au Nord du Plateau Central. Rapport de Synthèse, Burkina Faso. 2008 ; 94.
27. Subsol S, Sarr B, Bilgo A. Fiche sur les techniques innovantes d'agriculture intelligente face au climat au Sahel. [online]. 2014 [Cited 2018 June]. Available from: https://www.inter-reseaux.org/ressource/fiche-sur-les-techniques-innovantes-dagriculture-intelligente-face-au-climat-au-sahel/
28. Botoni E, Reij C. La transformation silencieuse de l'environnement et des systèmes de production au Sahel : Impacts des investissements publics et privés dans la gestion des ressources naturelles. Burkina Faso. 2009 ; 61.
29. Andres L, Bodé S, Dambo L et al. La résilience des ménages face aux changements climatiques dans la région de Maradi au Niger : le cas de la Régénération Naturelle Assistée. Rencontre de partage d'expérience et premier résultat du partenariat Programme-Niger FIDA, UAM, Ulg Gembloux Agro Bio Tech. 2016 ; 17.
30. Otunaiya OA, Ibidunni SO. Determinants of food security among rural farming households in Ogun State, Nigeria. J. Sustain. Dev. Afric. 2014; 16 (6): 33-44.
31. Oyebanjo O, Ambali OI, Akerele EO. determinants of food security status and incidence of food insecurity among rural farming households in Ijebu division of Ogun State Nigeria. J. Agric. Sci. Environ. 2013; (13) : 92-103.
32. Oluwatayo IB. "Explaining inequality and welfare status of households in rural Nigeria: Evidence from Ekiti State." Hum. Soc. Sci. J. 2008; (3): 70-80.
33. Mensah OJ, Aidoo R, Thomas T. Determinants of Household Food Security in the Sekyere-Afram Plains District of Ghana. Glob. Adv. Res. J. Agric. Sci. 2013; 2(1): 347-353.
34. Sikwela MM. Determinants of Household Food security in the semi-arid areas of Zimbabwe: A case study of irrigation and non-irrigation farmers in Lupane and Hwange Districts. Thesis for the degree of Master of Science in Agriculture, University of Fort Hare: Republic of South Africa. 2008; 119.
35. Ayena LR. Adaptation au changement climatique et Sécurité Alimentaire : Cas des ménages ruraux producteurs de maïs de la commune de Tchaourou au Nord-Bénin. Mémoire de Master, CILSS : Niger. 2017 ; 82.
36. Yabilé KR. Déterminants de la sous-alimentation des ménages en Côte d'Ivoire : cas des Régions centre et centre-est. Eur. Sci. J. 2013 ; 9 (14) : 207-228.

37. Mabah Tene G L, Havard M, Temple L. Déterminants socio-économiques et institutionnels de l'adoption d'innovations techniques concernant la production de maïs à l'Ouest du Cameroun. Tropicultura. 2013 ; 31 (2): 137-142.
38. Guodaar L, Beni A, Asante F, et al. Analysing the Determinants of Adaptation Practices to Climate Variability among Tomato Farmers in the Offinso North District in Ghana. Int. J. Innov. Res. Dev. 2016; 5(12): 169-177.
39. Debalke N M. Determinants of Farmers' Preference for Adaptation Strategies to Climate Change: Evidence from North Shoa Zone of Amhara Region, Ethiopia. Am. Int. J. Soc. Sci. 2014; 2 (4): 56-66.
40. Savi MOMM. Changement climatique et sécurité alimentaire des ménages ruraux producteurs de maïs au Nord Bénin. Mémoire de Master en : Economie des Ressources Naturelles, Université de Parakou : Bénin. 2016 ; 80.
41. Traoré A, Ouattara B, Sigué H et al. Economic Efficiency of Sorghum Microfertilizing in Smallholder Farms in the North-Sudanian Zone of Burkina Faso. In: Bationo A, Ngaradoum D, Youl S et al. (Eds.). Improving the profitability, Sustainability and Efficiency of Nutrients Through Site Specific Fertilizer Recommendations in West Africa Agro Eco systems. Springer International Publishing, AG; 2018; 275-286.
42. Traoré H, Barro A, Yonli D et al. Water Conservation Methods and Cropping Systems for Increased Productivity and Economic Resilience in Burkina Faso. Water. 2020 ; 12 (976) : 1-13.
43. Somé D, Zombré PN, Zombré G et al. Impact de la technique du zaï sur la production du niébé et sur l'évolution des caractéristiques chimiques des sols très dégradés (zipellés) du Burkina Faso. Sécheresse. 2004 ; 15 (3) : 263-269.