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Impact of strategic deployment of improved crop varieties on household food security and poverty in northern Nigeria

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Abstract

This study assessed the impact of deploying improved arable crop varieties on household food security and poverty in northern Nigeria. Four-stage sampling technique was employed to select 350 farmers. Primary data were collected from respondents using structured questionnaire and analyzed using instrumental variable with two stage least square estimation method. The parameter estimates of the regression model for the determinants of food security using food expenditure showed that age ($\beta = -0.002$, $p < 0.01$), distance of household to health centre ($\beta = -0.004$, $p < 0.10$), sex ($\beta = -0.20$, $p < 0.01$) and marital status ($\beta = -0.22$, $p < 0.01$) were negative and statistically significant. The parameter estimates using both protein consumption measure and calorie consumption measure showed that food expenditure ($\beta = 0.002$, $p < 0.01$), distance to market ($\beta = 0.01$, $p < 0.10$) and other crops grown ($\beta = 0.02$, $p < 0.01$) were all positive and statistically significant while influence of age ($\beta = -0.004$, $p < 0.05$) and distance to health centre ($\beta = -0.005$, $p < 0.05$) on protein and calorie consumption were negative and statistically significant. However, the parameter estimates of the regression model using total expenditure measure showed that age ($\beta = -0.001$, $p < 0.01$), sex ($\beta = -0.25$, $p < 0.01$) and marital status ($\beta = -0.21$, $p < 0.01$) were negative and statistically significant. The study concluded that the project had enhanced food security and contributed to poverty alleviation among adopters.

Keywords: Poverty; Food security; Adoption; Calorie consumption; Protein consumption.

1. Introduction

Poverty alleviation is the most difficult challenge facing any country in the developing world where on the average majority of the population is considered poor. Evidences in Nigeria show that more than 70% of Nigerians lived in poverty [1]. For this reason, most anti-poverty initiatives have focused on both rural and urban households with special focus on the rural sector. In a bid to overcome poverty in Nigeria, government has initiated different intervention programs since her independence. In 1960, almost 15% of Nigerian populace was poor, the proportion increasing to 27% in 1980 and very sharply to 67% in 1996. However, in 1999, it was estimated to be more than 70% a figure very close to the estimated 67% at the close of 2013 [1], [FAO, <http://www.unescap.org/stat/data/syb2013/D.1-Income-poverty-and-inequality.asp>, Last accessed on 08/09/2014]. Notably, poverty is especially severe in the rural areas where social services and infrastructure are limited [2]. This is due to the fact that agricultural production in Nigeria rural areas are characterized by depleting soil fertility, rain-fed agriculture resulting in poor yields, low income and poverty. In addition, Nigerian farmers are mostly using old agronomic practices and varieties for most staple crops. Despite all efforts of the government, Nigerian farmers are

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yet to realize the full potentials of cultivating certified improved varieties with the proper crop management practices. Thus in 2001, the Nigerian government with the support of Africa Development Bank (AfDB) initiated and funded an integrated community-based Agricultural and Rural Development Project tagged Community-Based Agriculture and Rural Development (CBARD), with the goal of reducing poverty by enhancing food security as well as the improvement of the living standards of the rural poor. The multi-dimensional project had an agricultural component aimed at reducing poverty through the dissemination of improved crop varieties that are location specific and associated complementary crop management options. The five-year project started in 2005 and was reviewed in 2010. The review recommended the formulation of Agriculture Outreach Program to be implemented by research institutes. Thus, International Institute of Tropical Agriculture (IITA) in collaboration with its national partners namely, the Institute of Agricultural Research (IAR) and National Agricultural Extension Research Liaison Services (NAERLS) of Ahmadu Bello University, both located in Zaria northwest Nigeria, the National Cereals Research Institute (NCRI) located in Bida and the University of Ilorin both located in north central Nigeria together with Agricultural Development Projects (ADPs) of the target States were involved. In 2011, IITA and its partner institution introduced recently released and improved varieties of cassava, cowpea, maize, soybean and yam into the five targeted project States. Improved varieties deployed were strategically tailored towards meeting each location's agro-climatic needs; mother and baby trials were conducted through the state ADP offices with the aim of demonstrating the appropriate crop management practices and the high yield potential of these varieties. Consequently, it becomes imperative to know the response of benefitted farmers to the varieties. Were the varieties adopted? Is there any difference in yield? Is there any difference in farmers' income? What is the contribution of this technology to household food security and poverty status? Hence, this study aims at estimating adoption rates of the CBARD improved arable crop varieties strategically deployed and then assessing the impact of adopting these technologies on some welfare indicators including productivity, household food security and poverty status.

2. Theoretical framework

Impact evaluation studies have been characterized by two major challenges; omitted variables and endogeneity of the explanatory variables. In solving the problem of missing variable, attempt is made in comparing two groups: treated and untreated group. However, the success of this method depends solely on finding an appropriate comparison group that is not treated. Quite a good number of methods have been used in impact evaluation studies; each method with its underlining assumptions specifying means of resolving selection bias when estimating the program treatment effect. Some of the methods include Randomized evaluations, Matching methods (especially propensity score matching (PSM)), Double-difference (DD) methods and Regression discontinuity (RD) design and pipeline methods. Others include Structural and other modeling approaches, Distributional impacts and Instrumental variable (IV) methods. The uniqueness of the latter is the ability to handle the problem of endogenous explanatory variables closely associated with the problem of omitted variables earlier mentioned. Moreover, independent variables found endogenous to welfare indicators may possibly influence poverty levels; in most cases, this remains unobserved by the researcher thereby causing a bias since the variable is correlated with the error term of the regression model. Addressing these problems, instrumental variables (IV) or Two-Stage Least Squares estimation (2SLS) is commonly applied. In this study, 2SLS was employed because of its ability in handling the problem of endogenous variables which Ordinary Least Squares (OLS) cannot handle. Standard linear regression models assume that errors in the non-explanatory variable are uncorrelated with the explanatory variable(s). However, when relationships between variables are bidirectional, linear regression using OLS no longer provides optimal model estimates. 2SLS regression uses IVs that are uncorrelated with the error terms in computing estimated values of the problematic predictor(s) in the first stage. Computed values obtained are used to estimate a linear regression model of the dependent variable in the second stage. Since the computed values are based on variables that are uncorrelated with the errors, the results of the two-stage model are optimal.

The strength of 2SLS as an econometric technique is expressed in its capability in estimating the parameters of simultaneous equation models when errors across the equations are not correlated and the equation(s) concerned is (are) over-identified or exactly identified. It is one of the members of the family of k-class estimators. Unlike the Three-Stage Least Squares, it does not estimate the parameters of all the equations of the model at once. The 2SLS estimates the parameters of an econometric model equation by equation, that is, one equation at a time. The 2SLS estimator for latent variable models was developed by Bollen in 1996. The technique separately estimates the measurement model and structural model of Structural Equation Models (SEM). One can therefore use it either as a standalone procedure for a full SEM or combine it with factor analysis; for example, establish the measurement model using factor analysis and then employ 2SLS for the structural model only. There are numerous advantages of using 2SLS over Maximum Likelihood (ML) method for SEM apart from the fact that it is computationally simple. The distributional assumptions for Right Hand Side independent variables is not required; it isolates specification errors to single in the context of a multi-equation non-recursive SEM [4]; and the use of numerical optimization algorithms

are not required; ability to cater for non-linear and interactions effects [5]. Furthermore, it permits the routine use of often ignored diagnostic testing procedures for problems such as heteroscedasticity and specification error [6]; and 2SLS perform better in small samples than ML method [3]. Substantive applications of the 2SLS estimator for latent variable models were included: [7, 8, 9, 10, 11, 12, 13].

The use of instrumental variables (IV) method is possible upon identification of a variable related to participation but not outcomes. This variable is tagged “instrument”. Its function is to introduce an element of randomness into the assignment which approximates the effect of an experiment. Where it exists, estimation of the treatment effect can proceed using a standard instrumental variables approach. Where variation in the impact of treatment across people is not correlated with the instrument, the IV approach recovers an estimate of impact of treatment on the treated (TT). The problem that arises in the use of IV approach is the difficulty in finding a suitable instrument. This is because, identifying the treatment effect, one needs at least one regressor which determines program participation but is not itself determined by the factors which affect outcomes [14, 15]. Furthermore, both OLS and IV estimation procedures impose a linear functional form assumption, which is arbitrarily *ad hoc* in that coefficients on control variables are restricted to be the same for participants and non-participants. Apart from these, IV approach stands out as the main solution to missing data and endogenous explanatory variables.

3. Material and methods

3.1. Study area

The study was carried out in five States where the IITA/AfDB-CBARD project was implemented namely Adamawa, Bauchi, Gombe, Kaduna and Kwara. The project area covered about 200,000 km or 22 per cent of Nigeria which their population was estimated at 18 million in 2001, increasing by 2.7 per cent annually. The five states are located in woodland and tall grass Savannah vegetation zone of Nigeria having two distinct climates, the dry season (November – March) and the rainy season (April – October). Adamawa, Bauchi and Gombe falls in dry sub-humid agro-ecological zone, Kaduna falls in sub-humid while Kwara falls in humid zone. The project was implemented in nine Local Government Areas (LGAs) in each State and three village areas were involved in each LGA to give a total of 135 intervention points called Rural Village Areas (RVAs). Mother and baby type on-farm trials were conducted through the Agricultural Development Project (ADP) offices in each state.

3.2. Data collection

A four-stage sampling technique was used in the study. For the first stage, five low income states were purposively selected in Northern Nigeria based on the poverty status of each state in the federation [16]. Thereafter, all the RVAs in each State were stratified into participating and non-participating areas and in each group; seven RVAs were selected using simple random sampling technique. Finally, five farmers were selected randomly from each of the RVAs to give 70 farmers representing 35 participating and 35 non-participating farmers per State. Altogether, a total of 350 farmers were selected for the study.

3.3. Data analysis

Three analyses are involved in this study; socio-economic characteristics of respondents were analyzed using descriptive statistics. Selected socioeconomic characteristics were based on *a priori* expectations following existing literatures; this is presented in Table 1.

Table 1 Description, measurement and *a priori* expectations of the study variables

Variable	Description	Measurement	Expected sign
Age	Age of farmer	Years	+
Household size	Number of people in the household	Number of people living under the same roof	-
Education	Level of education obtained by household head	Years	+
Off-farm	The value of household off-farm income	Naira	+
Other asset	Sum total of assets owned by the household apart from livestock and land	Naira	+
Farm land	Quantity of farm land cultivated by household	Hectares (ha)	+
Total livestock unit	Total livestock owned by the household	Total livestock unit (TLU)	+
Association	Member of farmers' association	Dichotomous (Yes = 1; No = 0)	+
Credit	Access to credit	Dichotomous (Yes = 1; No = 0)	+
Extension	Access to extension services	Dichotomous (Yes = 1; No = 0)	+
Distance to health centre	Distance of household residence to health centre	Kilometer (Km)	+/-
Distance to market	Distance of household residence to major market	Kilometer (Km)	+/-
Other crops grown	Number of crops grown by household apart from the major crop	Number	+
Dependent ratio	The ratio of the dependent population to the total productive population within the households	Number	-
Sex	Gender of household head	Dichotomous (male = 1; female = 0)	+
Marital status	Marital status of household head	Trichotomous (single = 1; married = 2; separated = 3)	+
Food expenditure	Amount expended on food by the household on weekly basis	Naira	+
Total expenditure	Total amount expended by the household in a year	Naira	+
Awareness	Awareness of household head about CBARD	Dichotomous (Yes = 1; No = 0)	+

Secondly, logistic regression was employed to identify factors influencing adoption due to its advantage over Ordinary Least Square method in the analysis of dichotomous outcome variable. The third analysis involves impact assessment. The peculiarity of impact studies is often expressed by the exogeneity of the intervention program targeting a group of people. Assessment becomes challenging due to the threat posed by missing counterfactual. Closely related to this is the problem of endogenous explanatory variables. Handling this problem, the study employed Instrumental Variables (IVs) using two-stage least square (2SLS) estimation method. The study followed some approaches [17, 18, 19, 20].

$C_j = \lambda m_j + \gamma L_j + n_j$ and

$$L_j = \beta_0 + \beta X_j + \mu_i \quad \dots \quad (1)$$

Where

C_{j1} is the daily per capita food consumption of household j in Naira,

C_{j2} is the total expenditure of household j in Naira the local currency,

m_j is the set of exogenous determinants that include household and community characteristics,

n_j is the random error term,

L_j is the predicted values of L_j from Logit Regression Model in the first stage regression, and

β , X_j , and μ_i are as earlier stated. Because of the endogenous nature of L_j in C_j , the use of IVs is considered imperative; therefore, membership of association was used as IVs in this model. In measuring food security, food expenditure, calorie / protein consumption were used as proxies while total expenditure was used as proxy for income. The empirical model for food expenditure per capita per day (FEXP) and total expenditure per capita per day (TEXP) is as stated below:

$$\text{FEXP} = \Psi_0 + \Psi_1 Y_1 + \Psi_2 Y_2 + \dots \Psi_{12} Y_{12} + \Psi_{13} L_j + n_j \quad \dots \quad (2)$$

$$\text{TEXP} = \Psi_0 + \Psi_1 Y_1 + \dots \Psi_5 Y_5 + \Psi_6 L_j + n_j \quad \dots \quad (3)$$

In addition, Food Security Index (F_i) was estimated as

$$F_i = \frac{\text{Per capita food expenditure for the } i^{\text{th}} \text{ household}}{^{2/3} \text{ mean per capita food expenditure of all households}} \quad \dots \quad (4)$$

Where F_i = Food Security Index (FSI)

When $F_i \geq 1$ = food secure i^{th} household

$F_i < 1$ = food insecure i^{th} household.

4. Results and discussion

This section presents the results and discussion of the study.

4.1. Socio-economic characteristics of respondents

Among sampled respondents, 193 farmers adopted (55.14%); 166 (94.86%) among farmers who were formally informed about the technology, 9 (5.14%) among those who were not formally informed. Majority of the farmers in the study area were males (93%), between the ages 40 and 49 with 96% of them married and having an average household size of 6.67 (Table 2).

Table 2 Selected socio-economic characteristics of sampled respondents

Variables	Most prominent	Whole sample (N = 350)	Adopters (N = 193)	Non-adopters (N = 157)	t-value
Sex	Male	325 (92.86)	181 (93.78)	144 (91.72)	
Age (years)	40 – 49	119 (34.00)	69 (35.75)	50 (31.85)	
	Mean	48.01	49.40	46.31	- 3.03***
Marital status	Married	337 (96.29)	188 (97.41)	149 (94.90)	
Household size	6 – 10	204 (58.29)	117 (60.62)	87 (55.41)	
	Mean	6.67	6.79	6.52	- 1.04
Education	Mean	7.53	7.42	7.68	0.41
Farm size (ha)	0.1 – 7.5	189 (54.00)	91 (47.15)	98 (62.42)	
	Mean	8.48	9.63	7.06	- 4.18***
TLU	Mean	4.19	5.09	3.01	- 3.08***
Other assets	Mean	170,454.10	190,077.50	146,331.00	- 2.39***
Membership of association	Member	252 (72.00)	161 (83.42)	91 (57.96)	
Access to credit facilities	Access	131 (37.43)	88 (45.60)	43 (27.39)	
Access to extension services	Contact	291 (83.14)	182 (94.30)	109 (69.43)	
FSI food expenditure	Mean	1.49	1.58	1.38	- 1.99**
FSI protein	Mean	2.11	2.17	2.04	- 0.44
FSI calorie	Mean	3.73	3.78	3.66	- 0.22

NOTE: Values in parenthesis are percentages

The average number of years invested in formal education among sampled respondents was 7.53; but seventy-two percent of them belong to one farmers' association or the other. Average farm size cultivated among respondents was 8.48 ha, 83% had access to extension services while few (37%) had access to credit facilities. Table 3 presents the household classification into food secure and food insecure group using food security index and the minimum recommended dietary intake of 65g protein / 2,250 kcal. The mean daily per capita food expenditure for the entire household in study area was estimated at 185.14, therefore two-third of this was 124.05. The proportion of food secure respondents using food expenditure, protein and calorie dietary intake were 73.58%, 75.13% and 93.26% for adopters while non-adopters were 63.06%, 65.61% and 89.17%, respectively. This implies that adopters of CBARD improved crop varieties have better and easy access to quality and safe food more than non-adopters. Values for poverty measures namely Head-count index (H), Poverty Gap index (PG), and Foster-Greer-Thorbecke's measure of poverty severity (P₂) used in this study are also presented in Table 3. The headcount index (incidence of poverty) computed for both adopters and non-adopters were 0.4301 and 0.4395 respectively. That is, respondents whose per capita income fell below the poverty line were slightly more among non-adopters (44%) as compared to adopters (43%); thus, buttressing the result obtained on FSI. The poverty gap index that measures depth of poverty and calculated as the mean distance of the income of poor households from the poverty line for adopters and non-adopters were 10 % and 14 %, respectively (Table 3); while the squared poverty gap index was 0.03 and 0.05 for adopters and non-adopters, respectively. This result underscores the advantage of adopters in terms of severity of poverty as compared to non-adopters.

Table 3 Food security and poverty status of sampled respondents

Variable	Status	Whole sample (N = 350)	Adopters (N = 193)	Non-adopters (N = 157)
Awareness	Aware	175	166 (94.86)	9 (5.14)
	Not aware	175	31 (17.71)	144 (82.29)
Food security index	Food secure	241 (68.86)	142 (73.58)	99 (63.06)
	Food insecure	109 (31.14)	51 (26.42)	58 (36.94)
Food security status using minimum recommended protein dietary intake	Food secure	248 (70.86)	145 (75.13)	103 (65.61)
	Food insecure	102 (29.14)	48 (24.87)	54 (34.39)
Food security status using minimum recommended calorie dietary intake	Food secure	320 (91.43)	180 (93.26)	140 (89.17)
	Food insecure	30 (8.57)	13 (6.74)	17 (10.83)
Poverty indices	Headcount (%)	43.43	43.01	43.95
	Depth (%)	0.12	0.10	0.14
	Severity (%)	0.04	0.03	0.05

NOTE: Values in parenthesis are percentages

4.2. Impact of adoption on food security status

The Logit model estimate of the determinants of adoption of improved varieties is presented in Table 4. The log likelihood ratio of - 99.84 indicates the fitness of the model between the dependent variable and the set of explanatory variables. In addition, the significant Chi-square (281.81) is indicative of the strength of the joint effect of the covariates on the probability of adoption among technology adopters in the study area. The Logit model showed that respondent's age ($\beta = 0.06$, $p < 0.05$), awareness ($\beta = 4.81$, $p < 0.01$) as well as farm land ($\beta = 0.09$, $p < 0.05$) positively and significantly influenced adoption decisions of improved varieties in the study area. This means that farmers who had bigger farm land are more likely to adopt new technology as compared to others. Similarly, farmers who were older and were aware of the technology are likely to adopt. Farm land and age are significantly different among the two groups. From this result, probability of adopting new technology in the study area in the future will be more successful if farmers are well informed. The result from first-stage regressions of the determinants of food security using food expenditure, protein consumption and calorie consumption as well as income is presented in Table 5. For the second stage regression procedure, food security was considered in three perspectives namely food expenditure, calorie and protein consumptions. The parameter estimates of the regression model for the determinants of food security through the food expenditure measure are presented in Table 6. The coefficient of determination (14%) as well as the Wald Chi-squared value (63.48) indicates that all the explanatory variables jointly have a significant influence on food expenditure in the study area. Parameter estimate of age ($\beta = - 0.002$, $p < 0.01$), distance of household to health centre ($\beta = - 0.004$, $p < 0.10$), sex ($\beta = - 0.20$, $p < 0.01$) and marital status ($\beta = - 0.22$, $p < 0.01$) were negative and significant (Table 6).

Table 4 Logit model estimates of the determinants of adoption of improved varieties

Variable	Coefficient	Standard error	P[Z >z]
Constant	-2.67	2.18	0.22
Age	0.06**	0.02	0.01
Household size	-0.03	0.08	0.73
Education	0.02	0.04	0.57
Off-farm income	-0.08	0.12	0.48
Other assets	-0.59	0.43	0.17
Farm land	0.09**	0.04	0.02
TLU	0.05	0.04	0.24
Association	0.65	0.46	0.15
Credit	-0.12	0.42	0.78
Extension	0.15	0.54	0.79
Awareness	4.81***	0.49	0.00
Log likelihood function	- 99.84	Chi-squared	281.81

Note: ***, **, and * indicate significance at 1%, 5% and 10% levels, respectively

Table 5 Results from first-stage regressions of the determinants of food security using (food expenditure, protein consumption and calorie consumption) and income

Variable	Coefficient for food expenditure	Coefficient for protein consumption	Coefficient for calories	Coefficient for income
Constant	0.11 (0.234)	0.15 (0.25)	0.15 (0.25)	0.11 (0.23)
Age	0.005*** (0.002)	0.005*** (0.002)	0.005*** (0.002)	0.005*** (0.002)
Education	0.001 (0.003)	0.001 (0.003)	0.001 (0.003)	0.001 (0.003)
Total livestock unit	0.001 (0.003)	0.001 (0.003)	0.001 (0.003)	0.001 (0.003)
Distance to health centre	0.001 (0.003)	0.001 (0.003)	0.001 (0.003)	0.0009 (0.003)
Distance to market	-0.0005 (0.004)	-0.0003 (0.004)	-0.0003 (0.004)	-0.0005 (0.004)
Other crops grown	-0.001 (0.007)	-0.001 (0.007)	-0.001 (0.007)	-0.001 (0.007)
Farm land	0.006* (0.003)	0.006* (0.003)	0.006* (0.003)	0.006* (0.003)
Dependent ratio	-0.02 (0.032)	-0.02 (0.03)	-0.02 (0.03)	-0.02 (0.03)
Sex	-0.03 (0.074)	-0.03 (0.08)	-0.03 (0.08)	-0.03 (0.07)
Marital status	-0.09 (0.094)	-0.09 (0.10)	-0.09 (0.10)	-0.09 (0.09)
Off-farm income	-0.01 (0.010)	-0.01 (0.01)	-0.01 (0.01)	-0.01 (0.01)
Awareness	0.77*** (0.033)	-0.00*** (0.0001)	-0.00*** (0.0002)	0.77*** (0.03)
R-squared	0.66	0.66	0.66	0.66
F	53.41	49.18	49.18	53.41

Note: ***, **, and * indicate significance at 1%, 5% and 10% levels, respectively. Figures in parentheses are the standard errors

Table 6 Results from second-stage regressions of the determinants of food security using (food expenditure, protein consumption and calorie consumption) and income.

Variable	Coefficient for food expenditure	Coefficient for protein consumption	Coefficient for calories consumption	Coefficient for income
Constant	2.77*** (0.17)	1.81*** (0.20)	3.59*** (0.20)	2.92** (0.17)
Adoption	0.11 (0.03)	0.03 (0.03)	0.02 (0.03)	0.07 (0.03)
Age	-0.002*** (0.001)	-0.004** (0.002)	-0.004** (0.002)	-0.001*** (0.001)
Education	0.008 (0.002)	0.003 (0.002)	0.003 (0.002)	0.01 (0.002)
Total livestock unit	0.003 (0.002)	0.004 (0.002)	0.004* (0.002)	-0.0001 (0.002)
Distance to health centre	-0.004* (0.002)	-0.004** (0.002)	-0.005** (0.002)	-0.001 (0.002)
Distance to market	0.003 (0.003)	0.01* (0.003)	0.006* (0.003)	0.003 (0.003)
Other crops grown	0.006 (0.005)	0.02*** (0.006)	0.02*** (0.01)	-0.004 (0.01)
Farm land	-0.003 (0.002)	0.0002 (0.002)	0.0003 (0.002)	0.005** (0.002)
Dependent ratio	-0.04 (0.02)	-0.01 (0.03)	-0.01 (0.03)	-0.04* (0.02)
Sex	-0.20*** (0.05)	-0.09 (0.06)	-0.08 (0.06)	-0.25*** (0.05)
Marital status	-0.22*** (0.07)	-0.01 (0.08)	-0.01 (0.08)	-0.21*** (0.07)
Off-farm income	0.008 (0.007)	0.007 (0.008)	0.01 (0.01)	0.01 (0.007)
Food expenditure	NA	0.002*** (0.0001)	0.002*** (0.00)	NA
R-squared	0.14	0.49	0.49	0.12
Wald chi-squared	63.48	337.37	336.45	54.00

Note: ***, **, and * indicate significance at 1%, 5% and 10% levels, respectively. Figures in parentheses are the standard errors

This means that the younger the household head, the more food secured the household unit; thus, the physical strength of the household head plays a crucial role in the welfare of his members. Additionally, the closer the household to health centre, the more their access to health information which may assist the household in maintaining good health, resulting to savings through avoidable health expenses which could add up to household food expenses. The role of marital status and sex in household food security is evident among sampled farmers; households that are married spend less on food likewise households that are female headed. This reveals the role female household members play in reducing cost of feeding, proper food price negotiation at the local markets. Furthermore, estimates of the regression model for the determinants of food security using protein and calorie consumption measure were found similar as presented in Table 6. Food expenditure ($\beta = 0.002$, $p < 0.01$), distance to market ($\beta = 0.01$, $p < 0.10$) and other crops grown ($\beta = 0.02$, $p < 0.01$) were all positive and statistically significant for both protein consumption and calorie consumption. Conversely, influence of age ($\beta = -0.004$, $p < 0.05$) and distance to health centre ($\beta = -0.005$, $p < 0.05$) on protein and calorie consumption were negative and statistically significant. These results imply that increase in the amount expended on food within the household most likely lead to increase in protein and calorie consumption of the household. As well, increase in the number of other crops grown by the household leads to increase in protein/ calorie consumption; consequently, households that diversify are likely to be more food secure than others. Conversely, the influence of market proximity to the household is observed to be negative on food security; implying that the tendency of undernourishment among households that are closer to markets are higher probably due to neglect, assumptions and child labour. Besides, consumption among such households may be imbalance; thus, being close to the market does not guarantee food security. However, as the household head grows old, the likelihood of him/her providing the minimum required dietary intake for the household decreases; this may be as a result of decline in strength. The predicted values (representing the technology) was statistically significant for food expenditure only at 1 % level of probability, implying that adoption of improved crop varieties and crop management practices introduced by CBARD had influenced on food security status of the farmers. This result is consistent with earlier studies [21, 22, 23, 24, 25].

4.3. Impact of adoption on income

The parameter estimates of the regression model for the determinants of income using total expenditure measure are also presented in Table 6. The coefficient of determination (R-value) was 12 % while the Wald Chi-squared was 54.00. The estimates showed that age ($\beta = -0.001$, $p < 0.01$), sex ($\beta = -0.25$, $p < 0.01$) and marital status ($\beta = -0.21$, $p < 0.01$) were negative and statistically significant. Although the parameter estimates of other explanatory variables were not significant; farm land was positive while dependant ratio was negative. This means that increase in farm land cultivated increases income. However, increase in the number of dependents leads to decrease in household income. The role of marital status on family income is associated with marriage or divorce/widowhood, its increase/decrease influences family labour resulting to increase or decrease of family income. Besides, controlling for endogeneity in the second stage regression through the use of IV, the result shows that the predicted values were statistically significant at 5 % level of probability meaning that technology introduced positively influences income among farmers. Comparing this result with Foster-Greer-Thorbecke's measure of poverty, it could be deduced that, although the CBARD project tended to have reduced poverty depth among the adopters through the use of improved varieties, it has not totally lifted the poor out of poverty but had significantly narrowed the resource gap for the adopters and could gradually improve their income and consumption to the level required to escape from poverty. The result is consistent with findings of Alwang and Siegel, Mendola and Kassie *et al* [26, 27, 28] that agricultural technology has a role in alleviating poverty. Therefore, since the parameter estimate for the adopted technology was observed to be statistically significant for both food security (using food expenditure) and income, adoption of deployed CBARD technologies can be said to have improved food security and reduced poverty among farming households in the study area.

In Nigeria, the average annual Human Development Index (HDI) growth as reported by UNDP between 2010 and 2014 was 1.06. Besides, life expectancy at birth recorded a rise of 1.5 for the same period. In addition, using Gross National Income (GNI) per capita as a measure of standard of living, expressed in constant 2011 international dollars converted using purchasing power parity (PPP) rates also recorded an upward shift from 0.493 to 0.514 [UNDP Human Development Report, http://hdr.undp.org/sites/all/themes/hdr_theme/country-notes/NGA.pdf, Last accessed on 07/06/2016]. It is obvious from this study that execution of interventions such as CBARD project in Northern Nigeria between 2011 and 2013 contributed to the improvement in the records.

5. Conclusion

This study, which assessed the impact of adoption of Community-Based Agriculture and Rural Development project's improved arable crop varieties on household food security and poverty, concludes that the adoption of CBARD

technology of improved crop varieties and crop management practices had enhanced food security and contributed to poverty reduction among adopters.

Compliance with ethical standards

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Disclosure of conflict of interest

All the authors have all participated in the design, execution, and analysis of the paper, and have approved the final version. Additionally, there are no conflicts of interest in connection with this paper, and the material described is not under publication or consideration for publication elsewhere.

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