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**Climate Change, farm level adaption measures and Impacts on Crop productivity and market participation: Implications for sustainable synergy between African and European Agriculture.**

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**Discussion Paper prepared for presentation at the 88th Annual Conference of the Agricultural Economics Society, AgroParisTech, Paris, France**

**9 - 11 April 2014**

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**Abstract**

It is widely known that climate change and agriculture are interrelated process, both of which take place on a global scale. In effect, crop and animal farming, fisheries, forestry, with the resultant access to food and fibre in many continents and regions of the world are projected to be severely compromised by climate variability and change. Several strategies aimed at reducing climate variability induced hazards abound. These include cultural and conventional food and farming systems to climate variability and these are aimed at enhancing the adaptive capacity and mitigation. In this study, we are investigating the separate and joint effects/impacts that the use of various climate change adaptation strategies have on crop yields and on the resultant marketed values of crops. We are applying instrumental variables method on a cross-sectional survey data of two states (Osun and Oyo) of south western Nigeria to evaluate these impacts. The findings suggest that the use of climate change adaptation strategies has impacted on expected yield and on marketed crop outcomes. Policy indicative variables suggest that sustainable crop production can be achieved in the face of climate change and this can effectively create a win-win situation from the synergy between African and European agriculture.

## **1. Introduction**

Adaptations are adjustments or interventions, which take place in order to manage the losses or take advantage of the opportunities presented by a changing climate (IPCC 2001). Adaptation is the process of improving society's ability to cope with changes in climatic conditions across time scales, from short term (e.g. seasonal to annual) to the long term (e.g. decades to centuries).

The IPCC (2001) defines adaptation capacity as the ability of a system to adjust to climate change (including climate variability and extremes), to moderate potential damages, to take advantage of opportunities, or to cope with the consequences. The goal of an adaptation measure should be to increase the capacity of a system to survive external shocks or change. The assessment of farm-level adoption of adaptation strategies is important to provide information that can be used to formulate policies that enhance adaptation as a tool for managing a variety of risks associated with climate change in agriculture. Important adaptation options in the agricultural sector include: crop diversification, mixed crop-livestock farming systems, using different crop varieties, changing planting and harvesting dates, and mixing less productive, drought-resistant varieties and high-yield water sensitive crops (Bradshaw et al. 2004).

Agricultural adaptation involves two types of modifications in production systems. The first is increased diversification that involves engaging in production activities that are drought tolerant and or resistant to temperature stresses as well as activities that make efficient use and take full advantage of the prevailing water and temperature conditions, among other factors. Crop diversification can serve as insurance against rainfall variability as different crops are affected differently by climate events (Orindi and Eriksen 2005; Adger et al. 2003).

The second strategy focuses on crop management practices geared towards ensuring that critical crop growth stages do not coincide with very harsh climatic conditions such as mid-season droughts. Crop management practices that can be used include modifying the length of the growing period and changing planting and harvesting dates (Orindi and Eriksen 2005). Use of irrigation has the potential to improve agricultural productivity through supplementing rainwater during dry spells and lengthening the growing season (Baethgen et al. 2003; Orindi

and Eriksen 2005). It is important to note that irrigation water is also subject to impacts from climate change. Use of irrigation technologies need to be accompanied by other crop management practices such as use of crops that can use water more efficiently. Important management practices that can be used include: efficient management of irrigation systems, growing crops that require less water, and optimizing of irrigation scheduling and other management techniques that help reduce wastage (Loë et al. 2001).

Resource limitations and poor infrastructure limit the ability of most rural farmers to take up adaptation measures in response to changes in climatic conditions. With resource limitations, farmers fail to meet transaction costs necessary to acquire adaptation measures and at times farmers cannot make beneficial use of the available information they might have (Kandlinkar and Risbey 2000).

Labor availability is considered an important input constraint. The expectation is that farm households with more labor are better able to take on various adaptation management practices in response to changes in climatic conditions compared to those with limited labor. Education and health are important factors that affect labor availability at the farm for different crop and livestock activities. Education is an important source of information for farm-level management activities. Sources of education are formal educational institutions such as agricultural colleges or informal education through extension services and learning from other progressive, neighboring farmers. Health factors determine the ability of the available labor force to work on different farm activities. A healthy labor force means that the household is able to take on various farm activities, including adaptation of crop and livestock management practices to climate change.

Lack of market access can also limit the potential for farm-level adaptation. Farmers with access to both input and output markets have more chances to implement adaptation measures. Input markets allow farmers to acquire the necessary inputs they might need for their farming operations such as different seed varieties, fertilizers, and irrigation technologies. On the other end, access to output markets provide farmers with positive incentives to produce cash crops that can help improve their resource base and hence their ability to respond to changes in climatic conditions (Mano et al. 2003). Information concerning climate change forecasting, adaptation options, and other agricultural production activities remains an important factor affecting use of various adaptation measures for most farmers. Lack of and or limitations in information

(seasonal and long-term climate changes and agricultural production) increases high downside risks from failure associated with uptake of new technologies and adaptation measures (Jones 2003; Kandlinkar and Risbey 2000). Availability of better climate and agricultural information helps farmers make comparative decisions among alternative crop management practices and this allows them to better choose strategies that make them cope well with changes in climatic conditions (Baethgen et al. 2003).

Failure to implement adaptation options and poor agricultural performances by many African farmers has been blamed on lack of information and resources (Archer et al. 2007). Southern Africa for example, has early warning units and meteorological departments, but the information does not reach all intended users (Archer et al. 2007). Adaptation policy measures need to consider how information concerning adaptation measures, forecasts, and production cycles can best reach farmers to help them respond to changes in climate. Climate change policy measures regarding information need to put in place information pathways that ensure that important climate change information is timely disseminated to the farmers. Improving the adaptation capacity of disadvantaged communities requires ensuring access to resources, income generation activities, greater equity between genders and social groups, and an increase in the capacity of the poor to participate in local politics and actions (IISD 2006). Thus, furthering adaptation capacity is in line with general sustainable development and policies that help reduce pressure on resources reduce environmental risks, and increase the welfare of the poorest members of the society. The empirical estimation of the determinants of adaptation strategies takes into account the various issues and factors raised in the discussion above. Some of these factors are considered as explanatory variables in the model to help assess their impact on the propensity of adoption of various adaptation strategies. Examples of factors considered include farmer education level, access to markets and information (extension services) etc. Other limitations in Nigeria are: Reluctance among some stakeholders to accept the reality of climate change; Inability and reluctance to adopt new farming strategies; Lack of information (awareness) and knowledge (education) on the phenomenon of climate change; Lack of government preparedness and insensitivity to climate change; Lack of dedicated research institutions; Inadequate public policies that target adaptation for relevant stakeholders; Population growth; Widespread poverty which induces heavy and total dependence on the immediate environment for a livelihood; Land scarcity, leading to adoption of unsustainable

farming practices; and the existence of land tenure and land management systems that do not favour food security.

## **2. Conceptual and analytical framework**

### 2.1 Summary Concept of Climate change Adaptation

Identifying both the generic and climate-specific elements of farmers' adaptation behavior is vital in order to facilitate a societal response to the changes in climate that scientists have predicted. Tailoring adaptation practices to specific societies may make it possible to offset the adverse impacts of climate change (Apata et. Al, 2009). Moreover, assessments of economic adaptations show that in some cases returns on financial investments in adaptation are likely to exceed the returns from a baseline situation (Luna J. 1998)

Several comprehensive studies of farmers' adaptation to climate change focus on a few study sites or regions in one or two countries Among these studies are those of Pacala et al. 2004; Thomas et al. 2004. Other authors discussed particular aspects of farmers' adaptation to climate change, and some link their findings explicitly to adaptation to climate change. Mbilinyi et al. (2005), for example, discussed indigenous knowledge about rainwater harvesting; IFPRI (2009) assess the economic benefits of mosquito nets, road infrastructure, and rice production; and Reilly (1995) analyzes the implications of local knowledge for the adoption of agroforestry practices.

### 2.2 Analytical Framework

To analyze the effect of the use of climate change adaptation strategies on expected yield and market participation outcomes, a two stage least square regression instrumental variable (2 S L S) IV was used. The study assumes an estimating equation that compares outcomes (expected yields and market participation-value sold) of treated and non-treated groups (farmers who consciously use climate change adaptation strategies and those who do not). Instrumental variables regression can be used to explain the variation in impact indicators among household farms while controlling for the effects of the underlying observable and unobservable factors. Instrumental variables models are special cases of simultaneous regression models in which the causality of the relationship is recursive but the interrelationship among the error terms of the

two equations is explicit (Smale, et al, 2010). In this case, participation affects outcome variables but outcome variables do not affect participation.

This study therefore adapts the two-stage least square (2sls) Instrumental variable (IV) regression framework to estimate the impact of use of climate change adaptation strategies on farmers' expected yields and on market participation. We consider the following model:

$$y_i = \beta_1 + X_{1i}\beta_2 + \mu_i \quad (1)$$

$$y_i = X_{1i}\Pi_1 + X_{2i}\Pi_2 + V_i \quad (2)$$

Here  $y_i$  is the dependent variable for the  $i$ th observation,  $y_i$  represents the endogenous regressors,  $X_{1i}$  represents the included exogenous regressors and  $X_{2i}$  represents the excluded exogenous regressors.  $X_{1i}$  and  $X_{2i}$  are collectively called the instruments.  $\mu_i$  and  $V_i$  are zero-mean error terms and the correlation between  $\mu_i$  and the element of  $V_i$  are presumably non zero. If we model expected yield and market participation (Yield/mktpart) as separate functions of use of adaption strategies (With\_without) and awareness of climate change adaptation strategies (adclimat) in the study area:

$$Yield_i = \beta_0 + \beta_1 withwithout_i + \beta_2 adclimat_i + \mu_i \quad (3)$$

Where  $i$  indexes crop farmers and  $\mu_i$  is an error term.

Because we are treating with\_without as an endogenous regressor, we must have one or more additional variables available that are correlated with with\_without but uncorrelated with  $\mu$ . Moreover, these excluded exogenous variables must not affect yield or market participation directly, because if they do then they should be included in the regression equation specified in (3). In the data set for this study, there are socio economic variables that are believed to be correlated with with\_witout but not the error term. Together, adclimat, socio economic, farm and farmer specific variables constitute our set of instruments. Because random effects that affect the yield and market participation in the study area probably also affect the use of climate change adaptation strategies then use of climate change adaptation strategies is treated as endogenous. On the other hand, we have no reason to believe that the correlation between adclimat and  $\mu$  is non-zero, so we assume that adclimat is exogenous.

### **3. Methodology**

#### **3.1 Study area, sampling and data**

. The study was carried out in Osun and Oyo States, Nigeria. These states are located in the South West geopolitical zone of Nigeria. Majority of the people in the study area are smallholders who are involved in farming and trading. They grow arable crops, (maize, yam, cassava, millet, rice, plantain, cocoa tree, palm tree, cashew, etc.), fruit crops, and also engage in small scale poultry, goat, cattle and fish farming. Agricultural activities follow the traditional system of mixed cropping. The favourable condition made the states to be agrarian, suited for the production of permanent crops such as cocoa, kolanut, oil palm as well as arable crops like yam, cassava, etc. Farmers in the two states are predominantly small scales who still depend on traditional method of farming. Besides farming, the inhabitants also engage in other occupations like trading and artisan. A multistage sampling procedure was used to select about 640 respondents across the two states. Three agricultural zones were selected from each of the two states. The second stage was the random selection of villages from farming communities/localities based on the proportional numbers of villages in the communities/localities. The third stage was the listing of households from the selected villages. The fourth and final stage involves the random selection of the required number of respondents which were interviewed. Six hundred and forty (640) respondents were selected based on probability proportional to sampling and this ensured representativeness across the six agricultural zones across the two states. However, about 635 copies of questionnaire were used for analysis. The rest were either badly filled or contained inconsistent entries.

#### **3.2 Data**



Primary data were collected. The information elicited from the respondents include the following: (i) Socioeconomic and demographic variables of the respondents like sex, level of education, marital status, household size, occupation including type of primary and secondary occupation, access to climate information and its source, access to credit, income, distance of farm to market etc. (ii) Production data in terms of size of farm land, type of enterprise, assets on farm, use of fertilizer and other agrochemicals like herbicides, type of labour employed, quantity of output, sources of inputs, quantity of outputs and amount sold, consumed, gifts etc. These were collected in quantity and value terms. (iii) Climate adaptation data for the respondent with /without adaptation, type of adaptation measures used and their financial implications.

**Table 1: Definition of some selected Variables**

<b>Variables</b>	<b>Definitions</b>
<b>Dependent variable</b>	
Impacted outcome: yield	expected yield
Impacted outcome: market participation	(value sold)
Number of adaptation strategies used by farmer	Code actual of number used per famer
Intensity of use of adaptation strategies used by farmer	Proportion used by farmer
<b>Explanatory Variables</b>	
Treatment: With_without (1,0)	Conscious use of climate change adaptation strategies or not
Credit access (dummy:1,0)	Access to credit for the use of adaptation strategies
Age	Age of respondents
Sex	Gender of respondent, 1 for male and 0 for female
Formal education (1,0)	Whether respondent has formal education or not
Household size	Total number of members of the household
Farming experience	Number of years respondent has been farming
Farm size	Area of land cultivated
Agric. Practices (mixed cropping) (1,0)	Whether respondent practices mixed cropping or not
Farming as main occupation (1,0)	Whether respondent mainly into farming or not
No. of ext. visits received	Number of visits received from any extension

Table 2 shows the mean comparison statistics of some selected variables that are thought to be having some bearing with the use of climate change adaptation strategies. The mean age of respondents using climate change adaptation strategies is significantly higher than the mean age of those not using climate change adaptation strategies. Similarly, mean farming experience and farm size for the respondents using climate change adaptation strategies are significantly higher

than for those not using adaptation strategies. However, the number of respondents with formal education, the household size and the number of farmers practicing mixed cropping are significantly lower than those of the respondents not using climate adaptation strategies.

Table 2: Mean comparison of some selected socio-economic variables (of respondents using climate change adaptation strategies)

Variable	With	Without	Difference	t-value
	Mean	Mean		
Age	45.91(0.59)	51.52(0.70)	5.61(0.98)	5.75*
Sex: male (proportion)	0.65(0.02)	0.61(0.03)	-0.04(0.04)	-0.97
Formal education	0.80(0.02)	0.72(0.03)	0.77(0.02)	-2.11**
Household size	3.86(0.11)	3.56(0.14)	3.76(0.09)	-1.65***
Farming experience	15.77(0.63)	24.46(0.87)	8.69(1.10)	8.00*
Farm size	1.70(0.04)	1.82(0.07)	0.18(0.07)	2.47**
Credit access (yes)	0.55(0.02)	0.57(0.03)	0.02(0.04)	0.40
Agric. Practices (mixed cropping)	0.85(0.02)	0.67(0.03)	-0.18(0.03)	-5.30*
Farming as main occupation	0.60(0.02)	0.66(0.03)	0.06(0.04)	1.35
No. of ext. visits received	3.55(0.07)	3.62(0.12)	0.06(0.14)	0.49

## 4. Results and discussion

### 4.1 Determinants of use and intensity of use of climate change adaptation strategies

The use and intensity of use of the climate change adaptation strategies in the study area refer to the number of adaptation strategies and the proportions/rate of use out of the commonly available ones by the respondents. For this, two important models necessary for analyzing these were used. These are the Poisson and the Tobit regression models. The most common regression models used to analyze count data among the others is the Poisson Regression Model (PRM). Green (2003) argues that PRM models (for analyzing count data) are much closer to OLS regression model than other discrete models. For modeling the intensity of use of the climate change adaptation strategies, the Tobit model appears to be appropriate since some households have censored values of the intensity of use indices taking a value of zero in some cases. The regression results for Poisson and Tobit (marginal effects) for the factors that drive the use and intensity of the use of the climate change adaptation strategies in the study area are presented on Table 1. A Poisson regression model is estimated to examine the factors affecting the extent of

the use of farm level climate change adaptation strategies by the respondents. Results show that an increase in age decreases the number of adaptation strategy that a farmer in the study area use by 23 percent. This could be due to lack of proper understanding about the usefulness of the available climate change adaptation strategies that are important to either prevent, mitigate or cope with risks involved. Longer distance to market decreases the number of strategies to be used by up to 42 percent of the common available strategies in the study area. This is expected as crop outputs which have to be sold will involve incurring some transport cost in order to get them to the market. Longer distance to the market coupled with bad roads which is characteristic of most rural area in Africa could act as impediment. This will further discourage farmers from using their limited capital resources on using the adaptation strategies to produce. However, further results for the Poisson regression show that squared age and labour increases the number of adaptation strategies used by 0.25 and 0.00000009 times respectively. These figures appear to be very minimal and can hardly be said to be important. The Tobit regression results indicate that older farmers are likely to use less of the available climate change adaptation strategies. Longer distance to market makes the farmers in the study area to also use less of the adaptation strategies. The Tobit results further show that squared age, farming households with larger household size, farmers who use of additional labour and who learn more about the climate change adaptation strategies will likely use more of the climate change adaptation strategies in the study area.

Table 3: Drivers of use and intensity of use of climate change adaptation strategies (Poisson and Tobit regression models)

Variables	Poisson Regression			Tobit Regression (marginal effects)		
	Coef.	Std. Errr.	P-value	Coef.	Std. Errr.	P-value
Age	-0.023	0.013	0.081	-0.0038	0.0020	0.056
Age2	0.00025	0.00014	0.063	0.000041	0.0002	0.041
Sex	0.0029	0.062	0.96	-0.00024	0.0085	0.977
Formal education	0.099	0.072	0.167	0.012	0.0096	0.221
Household size	0.179	0.013	0.160	0.003	0.0019	0.071
Farming experience	-0.004	0.0031	0.256	-0.0006	0.00043	0.172
Farm size	0.0022	0.034	0.948	0.0004	0.0046	0.931
Credit access	-0.0368	0.601	0.540	-0.0056	0.0083	0.498
Agric. Practices (mixed cropping)	0.085	0.082	0.299	0.0099	0.011	0.346
Farming as main occupation	0.0078	0.059	0.896	-0.00089	0.0083	0.914
No. of ext. visits received	-0.0160	0.019	0.395	-0.0018	0.0025	0.462

Labour	9.11e-08	2.89e-08	0.002	9.76e-09	0.00000	0.019
Capital	2.38e-07	7.41e-07	0.748	4.87e-08	0.00000	0.624
Land	-1.21e-07	1.55e-07	0.436	-1.19e-08	0.00000	0.538
Awareness of strategies	19.12	868.50	0.982	0.169	0.011	0.000
Distance to market	-0.0415	0.014	0.003	-0.0051	0.0017	0.003
constant	-17.77	868.50	0.98			
No. of observations	621					
LR Chi2 (16)	529.41					
Prob. > chi2	0.0000					
Pseudo R2	0.2207					
Goodness-of-fit Chi2	652.3942					
Prob.>chi2 (604)	0.0844					

## 4.2 Impact models

### a. Determinants of Use of climate change adaptation strategies

The results for the first-stage regressions are presented in Table 4. The results describe the variables which are important in determining the use of the available adaptation strategies that the respondents employ either to prevent or mitigate or cope with weather variability. Our proxy for the use of adaptation strategies is premised on the discussion we had with the respondents concerning their perceptions about weather variability as a major cause of climate change consequences. Some of the respondents feel that there is actually little or nothing about the consequences of climate change, so they care less about it and do not give adequate attention to manage it. On the basis of this preliminary and important response from the samples of farmers interviewed, the respondents who consciously employed one or some of those adaptation strategies were considered to be the users of the available climate change adaptation strategies. For the model on expected yield, findings indicate that conscious awareness of weather variability consequences, middle men (as a channel for market participation and monthly market participation increase the chances of using climate change adaptation strategies. Results also indicate that farmers who have financial assets to use more fertilizer and labour are more likely to consciously use climate change adaptation strategies.

Table 4: Determinants of use of adaptation strategies Pooled sample (Osun and Oyo)

First-stage regressions	Model for expected yield			Model for market participation		
	Coefficient	Std. Err	P-value	Coefficient	Std. Err.	P -value
Awareness of strategies	0.702	0.034	0.000	0.702	0.034	0.000
Land	-0.001	0.012	0.894	-0.001	0.012	0.916
Seed	0.0064	0.017	0.709	0.0062	0.017	0.718
Labour	0.044	0.013	0.001	0.044	0.013	0.001
Fertilizer	0.029	0.013	0.022	0.029	0.013	0.022
Pesticide	-0.054	0.016	0.001	-0.054	0.016	0.001
Age	-0.010	0.0062	0.108	-0.010	0.0062	0.108
Age2	0.00009	0.000064	0.138	0.00009	0.000064	0.136
Sex	0.0104	0.026	0.680	0.0104	0.026	0.689
Formal education	0.044	0.0301	0.148	0.044	0.0301	0.147
Household size	0.007	0.0059	0.234	0.007	0.0059	0.238
Farming experience	-0.0008	0.0015	0.595	-0.0008	0.0015	0.562
Farm size	0.028	0.026	0.275	0.028	0.026	0.276
Credit access	0.013	0.034	0.707	0.0122	0.034	0.721
Agric. Practices (mixed cropping)	-0.043	0.026	0.098	-0.043	0.026	0.100
Farming as main occupation	-0.0019	0.0079	0.807	-0.0020	0.0079	0.799
Distance to market	0.00064	0.0054	0.907	0.00048	0.0054	0.930
Participation in weekly market (1,0)	0.0048	0.0336	0.887	0.0045	0.0335	0.893
Participation in monthly market (1,0)	0.048	0.0294	0.100	0.0485	0.0293	0.099
Participation in fortnight market (1,0)	-0.024	0.0275	0.379	-0.024	0.0275	0.388
Poor transportation (1,0)	0.0044	0.046	0.923	0.0037	0.046	0.935
Glut in the market (1,0)	0.0373	0.029	0.195	0.0377	0.029	0.189
Patronizing middlemen (1,0)	0.099	0.043	0.023	0.099	0.043	0.021
Bad pricing (1,0)	-0.069	0.043	0.112	-0.070	0.043	0.102
All about market is bad (1,0)	0.0011	0.047	0.981	0.00009	0.046	0.998
Access to market information (1,0)	0.0187	0.031	0.550	0.01911	0.031	0.541
Information on market prior to sale (1,0)	0.0117	0.036	0.743	0.0117	0.036	0.743
Y (index of adaptive strategy)/intensity	-0.0722	0.055	0.192	-0.0722	0.055	0.194
Constant	0.0168	0.363	0.963	0.0344	0.359	0.924
Number of observations	623			623		
F (28, 594)	31.46			32.67		
Prob. > F	0.0000			0.0000		
R - Squared	0.5972			0.5972		
Adj. R - Squared	0.5782			0.5789		
Root MSE	0.3042			0.3040		

We note that use of climate change adaptation strategies significantly increase expected yield by up ₦ 83.57/tonne Table 5. However, use of pesticide and unexpectedly, farming as main occupation reduce the chances of using climate change adaptation strategies among the

respondents. Awareness of climate change adaptation strategies, land and fertilizer have negative relationship with expected yields.

For market participation model, awareness of climate change adaptation strategies, fertilizer, labour, monthly market participation and middle men increase the likelihood of using climate change adaptation strategies. The more pesticide use, the less the likelihood of using the climate change adaptation strategies among the respondents. The use of climate change adaptation strategies will increase the value of crops sold in the market.

Table 5: Determinants of yield and market participation

Instrumental variables (2sls) regression	Model for expected yield			Model for market participation		
	Coefficient.	Std. Err.	P -value	Coefficient.	Std. Err.	P -value
With_without	83.57	35.29	0.018	3.65	1.29	0.005
Adclimat	-63.88	26.47	0.016	-2.87	0.97	0.003
Land	-13.48	2.47	0.000	0.00301	0.091	0.973
Seed	2.13	3.53	0.547	-0.0376	0.129	0.771
Labour	4.198	3.33	0.208	-0.1076	0.1217	0.408
Fertilizer	-5.196	2.74	0.058	-0.0780	0.1001	0.436
Pesticide	0.735	4.22	0.862	-0.2902	0.154	0.060
Constant	146.816	63.89	0.022	14.35	2.335	0.000
Number of observations	623			623		
Wald chi2 (7)	46.33			95.90		
Prob. > chi2	0.0000			0.0000		
R - Squared	.			.		
Root MSE	65.527			2.3945		
Tests of endogeneity						
Ho: Variables are exogenous						
Durbin (score) chi2 (1)	7.59347		0.0059	9.5151		0.0020
Wu-Hausman (1, 614)	7.57612		0.0061	9.52308		0.0021

In addition to the first-stage and the instrumental variables regressions which show the determinants of both the use of climate change adaptation strategies and those of the expected yields and market participation, the second-stage (Table 6) also indicate the impact coefficients of the use of climate change adaptation strategies on expected yields and market participation. For the model on expected yield, there are positive and significant impacts of the use of climate

change adaptation strategies for the overall sample. For the market participation, there are positive and significant impacts for the overall sample and for the sample of the respondents who used climate change mitigation strategies.

Table 6: Summary of impacts of the use of climate adaptation strategies on expected yield and market participation

	Expected yield		Market participation	
	Coefficient	P-value	Coefficient	P-value
All (Osun and Oyo)	83.57	0.018	3.65	0.005
Osun	284.19	0.155	-2.82	0.692
Oyo	8.347	0.495	-0.11	0.816
Use of preventive strategy (sample)	73.38	0.133	-1.43	0.142
Use of mitigation strategy (sample)	16.21	0.641	7.17	0.000
Use of coping strategy (sample)	22.90	0.505	-0.66	0.657

## Conclusion

We notice three important scenarios. One, that for both expected yields and market participation, there are positive and significant impacts of the use of climate change adaptation strategies on the overall (pooled) sample of Osun and Oyo states. Two, that for each of the separate Osun and Oyo state samples, no significant impact of the use of climate change adaptation strategies was evident. Three, that only on the sample of the respondents using basically bundles of climate change mitigation strategies as risk management measures has impacted (market participation) the use of climate change adaptation strategies. We classified the climate risk management strategies into 1. Prevention (irrigation, fertilizer, training, organic manure, mulching, cover crop, crop rotation and fallowing); 2. Mitigation (diversification and cooperative), 3. Coping (sell assets, obtaining loan, micro credit, personal saving). If the use of climate change adaptation strategies resulted in positive impact on the value of crop sold, this implies that diversification and cooperative, which the farmers use to mitigate the effects of climate change need to be critically looked into. This is necessarily the task for extension if the use of climate change adaptation strategies for the objective of managing climate change risk

adequately is to be addressed to the benefit of the small rural and small scale African farmers who combine to produce most of the food and cash crops consumed and sold for cash and export. There is need for proper education on the part of all the stakeholders, particularly the various levels of governmental and non-governmental organizations to foster appropriate synergies which will strengthen the various bids to increase food and fibre production. This will result into the needed cooperation among countries and continents of the world. Poverty and hunger will ultimately be eradicated and this can effectively create a win-win situation from the synergy between African and European agriculture.



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