Extended Abstract
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Paper/Poster Title	Multiple adoption of climate-smart agricultural technologies (CSAT) in the Sahelian region of West Africa: The impact on poverty and vulnerability to poverty

Abstract prepared for presentation at the 98th Annual Conference of The Agricultural Economics Society will be held at The University of Edinburgh, UK, 18th - 20th March 2024.

Abstract	***200 words max***
In recent years, climate-smart agricultural technologies (CSAT) are advocated by experts and stakeholders for climate change adaptation in most developing countries, including Sub-Saharan Africa (SSA). However, CSAT adoption is low in many parts of SSA such as the Sahel. This study utilizes a cross-sectional baseline data of 3,371 smallholder farmers (cultivating maize, millet, sorghum, cowpea and groundnut) in West Africa Sahel (Mali and Niger). A multinomial endogenous treatment effect (METE) model was employed to analyze the poverty and vulnerability to poverty impact of multiple CSAT (improved seed varieties, agrochemicals and sustainable land management practices) adoption among the crop farmers. The results indicate that several sociodemographic, socio-institutional and climatic factors significantly determine farmers' decision to adopt multiple CSAT. The impact estimates revealed that CSAT adoption (regardless of the combinations) positively and significantly influences poverty and vulnerability to poverty. The poverty mechanism analysis reveals that CSAT adopters allocate a smaller proportion of crop income to food consumption but invest more in agricultural productive resources and debt repayment compared to non-adopters. These findings suggest that while promoting CSAT, it's vital to incorporate a subsidized approach to disseminating these technologies and should be targeted towards resource-poor farm households.	

Keywords	Adoption; Climate-smart agricultural technologies; Smallholder farmers; Poverty; West Africa Sahelian region.
JEL Code	C31; O12; O33; Q12; Q16; Q18

Introduction	***100 – 250 words***

Climate change is perceived as a threat to agricultural and socioeconomic development. In large parts of the Sahel in Sub-Saharan Africa (SSA), with Mali and Niger as an example, rising average temperatures, increasing frequencies of droughts, flooding and declining rainfall have led to a decline in domestic crop production and an increase in the poverty rate (United Nations, 2016). Niger and Mali are ranked 183 and 169 of 188 countries in the world based on gross national income (GNI) per capita (World Bank, 2021), indicating the high rate of poverty in these countries. Agriculture is considered as a panacea for achieving sustainable development goals (SDGs) one and two relating to poverty and zero hunger (FAO, 2018).

In recent years, climate-smart agricultural technologies (CSAT) have been promoted by experts and stakeholders to cushion the adverse effect of extreme weather events on crop production (FAO, 2018). The role of CSAT in promoting food security and eradicating poverty underpins our motivation for this study. Moreover, to the best of our knowledge, there is no study on the impact of multiple CSAT adoption on poverty and vulnerability to poverty. In addition, most CSAT studies are crop-specific, we extend the literature by focusing on five major staple crops (millet, sorghum, cowpea, groundnut, and maize) produced by smallholder farmers in the Sahel (including Mali and Niger). We considered three main categories of CSAT in our study, which are agrochemicals, improved seed varieties, and sustainable land management technologies.

Methodology	***100 – 250 words***

We utilized cross-sectional data collected in 2019 by the International Institute of Tropical Agriculture (IITA), Mali. A sample size of 3371 smallholder farm households (2004 in Mali and 1367 in Niger) was used for the analysis. We modelled the impact of farmers' decision to adopt CSAT on the outcome variables using a multinomial endogenous treatment effect (METE) framework. This econometric technique was used for our empirical analysis to account for potential endogeneity that might occur due to self-selection of technology adoption.

The METE equation is specified below.

$$\mathbb{P}_i = \chi_i'\beta + \eta_1\mathbb{C}_1 + \eta_2\mathbb{C}_2 + \lambda_1 \upsilon_{1i} + \lambda_2 \upsilon_{2i} + \xi_i$$

where $\mathbb{P}_i$ denotes outcome variables (poverty and vulnerability to poverty status), χ_i is a vector of exogenous variables with associated parameter β. $\mathbb{C}_1$ and $\mathbb{C}_2$ denotes incomplete (one or two CSAT categories) and complete/package (all three) CSAT adoption. η_j refers to the treatment (adopting either of CSAT combinations) effects relative to the control (non-adopters). υ_{ij} control for potential unobserved factors that influence the selection of farmers who adopt CSAT and outcome variables. λ_j represents parameter estimating whether there is a positive or negative correlation between CSAT adoption status and outcome variables via the unobserved characteristics.
The poverty status of the farm households is measured by comparing their per capita consumption (food and non-food) expenditure (PCE) to the international poverty line of USD 1.90/day. The vulnerability index is measured using a poverty threshold of 0.5, which implies that a farm household with a vulnerability score of 50% or more has a chance of getting poor in the near future.

Results	***100 – 250 words***

The first stage result of the METE model indicates that household size, education, assets (such as household and productive assets, and tropical livestock units), farmland distance, off-farm income, farmer-based organization (FBO), access to credit and extension, location, soil fertility and topography, crop disease and drought shock significantly determines farmers' decision to adopt CSAT. Specifically, household size, farming experience and drought shock negatively influenced combinations of CSAT adoption. Education, assets, FBO, credit access, extension agent contact, crop disease shock, soil fertility and topography were found to have a positive and significant effect on CSAT adoption.

The impact estimates (second stage results) revealed that CSAT adoption (both incomplete and package) has a positive and significant effect on poverty and vulnerability to poverty. Pathway analysis of the poverty mechanism reveals that the proportion of crop income spent on food consumption has a negative significant impact on CSAT adoption. However, CSAT adopters significantly increase their crop income expenditure in agricultural productive resources and debt repayment than non-adopters. Subsequently, a heterogenous analysis of the poverty impact

results indicated that assets, off-farm income, access to credit and extension services has a negative and significant effect on poverty among CSAT adopters	
Discussion and Conclusion	***100 – 250 words***
The findings on the negative significance of household size, farm experience and drought shock on CSAT implies that farmers with large household size, more farming experience and those who were previously affected by drought occurrence are less likely to adopt CSAT in the study area. A plausible explanation on the negative effect of drought shock is that farmers who suffered production loss due to drought in previous crop season might be redundant to invest more in agricultural technologies like CSAT in subsequent crop season. The positive effect of FBO, credit and extension access on CSAT adoption implies that institutional factors play a major role in enhancing CSAT adoption due to its financial and information diffusion features. The impact results indicated that adopters of CSAT tend to be poor and more vulnerable than non-adopters. The poverty mechanism analysis reveals that adopters of CSAT tend to utilize a smaller proportion of crop income on food consumption than non-adopters. On the other hand, CSAT adopters significantly invest more of their crop income in agricultural productive resources and debt repayment than non-adopters. The poverty heterogeneity analysis shows that CSAT farmers with more assets, off-farm income, access to credit and extension services are less likely to be poor. These findings suggest that while promoting CSAT, it's vital to incorporate a subsidized approach to disseminating these technologies and should be targeted towards resource-poor farm households. Engagement in off-farm income could help farmers adopting CSAT to increase their consumption patterns while sustaining their investment in agricultural technologies.	