Could agricultural extension services offer protection against climate change? Evidence from smallholder farmers in Kenya, Mozambique, and Nigeria

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Could agricultural extension services offer protection against climate change?

Evidence from smallholder farmers in Kenya, Mozambique, and Nigeria

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Introduction

Agriculture will be impacted by a changing climate

Agriculture worldwide is expected to be affected by climate change (Shukla et al. 2019, Bozzola et al. 2018, Chatzopoulos & Lippert 2015, Seo et al. 2009, Van Passel et al. 2017). Sub-Saharan Africa (SSA)—where over 60% of the population are smallholder farmers (Djoumessi 2022) and the agricultural sector accounts for 23% of GDP (Goedde et al 2019)—is particularly vulnerable to these impacts (Omotoso et al. 2023, Shukla et al. 2019, World Bank 2016).

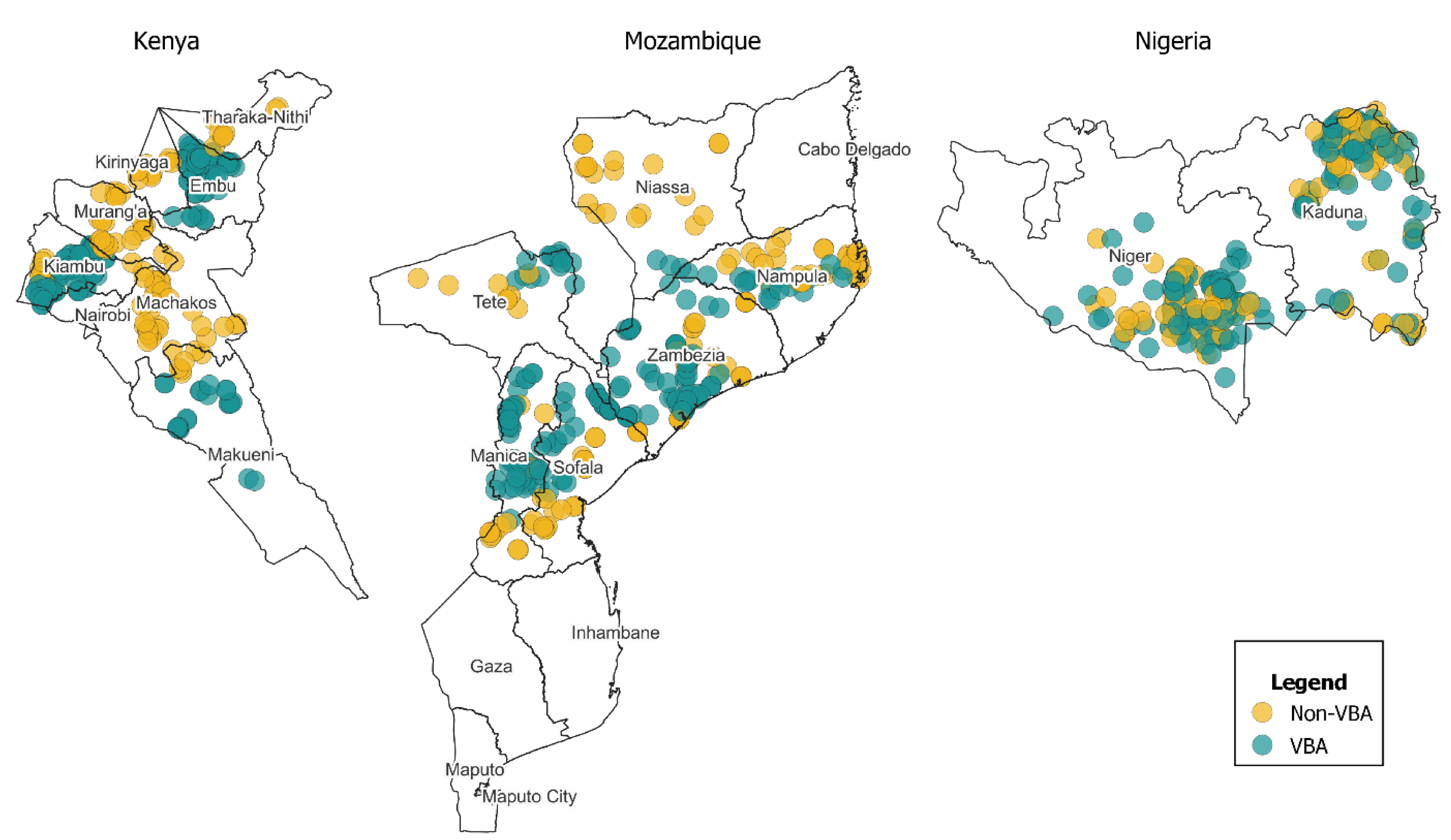
Adaptation is key and <u>institutions</u>, such as the village-based advisor model, may be one way to do this

AGRA, an African-led institution for smallholder agriculture transformation in SSA, implemented the Village-Based Advisors (VBA)—a private sector extension program—in 2017. The program strategically recruits skilled farmers i.e., VBAs, trains them on good agricultural practices, and in turn they train and support fellow farmers in their villages. VBAs also serve as a link to input and output markets, connecting farmers with suppliers of seeds, fertilizers, mechanization services, and potential buyers. These VBAs have the potential to improve farmer performance as the climate changes.

Research Question

Could agricultural extension help protect farmers against a changing climate?

Using a large multi-country cross-sectional micro-dataset of 7,661 geolocated farmers from Kenya, Mozambique and Nigeria (Siegal et al. 2023; see), we provide evidence that suggests such protection is possible.



Study locations across three countries (Kenya, Mozambique and Nigeria)

Methods

We **combine** an **impact evaluation** of the VBA program **with climate modeling** to **derive climate change impacts** on VBA and non-VBA farmers

Rigorous impact evaluation of institutional adaptation

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Climate impacts modeling using Ricardian analysis

Climate impacts with and without adaptation

(1) Impact evaluation of the VBA extension service using CEM

We used coarsened exact matching, CEM (Iacus et al. 2012, Iacus et al. 2019, King and Nielsen 2019) to identify a group of non-VBA farmers with which to compare VBA farmers, resulting in a well-balanced counterfactual group. Using this built-in evaluation, we were able to compare the impact of climate change on VBA and non-VBA farmers.

(2) Multi-country data enables climate impacts modeling using Ricardian analysis

Our dataset spans a wide variety of climates across the three countries, which enables us to model farmer climate response using a well-established climate impact analysis technique called the Ricardian Analysis (Mendelsohn et al. 1994, Kurukulasuriya & Mendelsohn 2008, Seo & Mendelsohn 2008, Seo et al. 2009, Kurukulasuriya et al. 2011, Abidoye et al. 2017). A typical Ricardian model leverages spatial variation in climates and regresses farmer profit per hectare on local climate along with a comprehensive set of environmental and farmer socio-economic characteristics.

(3) Use model to predict the impact of future climate scenarios.

Future climate scenarios were extracted from the CORDEX Africa model projections for the short term (2021-2040), the medium term (2041-2060) and the long term (2081-2100) and for three Representative Concentration Pathways (RCP), namely RCP 2.6, RCP 4.5, and RCP 8.5 i.e., moderate to severe climate change. By separately modeling climate response and using projected climates, we can derive the response of VBA and non-VBA farmers.

Ricardian analysis

For our analysis, we relate farmer profit to historical climate data, which consisted of 30-year mean monthly temperature and precipitation. Our regression equation has the following form,

$$\pi_i = \alpha + \sum_S\left(\tau_s T_{is} + \tau_s^{sq} T_{is}^2\right) + \sum_S\left(\rho_s P_{is} + \rho_s^{sq} P_{is}^2\right) + \sum_L(\sigma_l S_{il}) + \gamma_E N_i + \boldsymbol{H}\boldsymbol{\Gamma}_{\boldsymbol{H}} + \gamma_D D_i + \sum_C(\theta_c) + \varepsilon_i$$

where π_i is net revenue for farmer i. T_{is} and T_{is}^2 are 30-year mean temperature and temperature squared terms, and P_{is} and P_{is}^2 are 30-year mean precipitation and precipitation squared terms for farmer i during season $s \in S = \{Autumn, Winter, Spring, Summer\}$. The four seasons in this study are defined as in Kurukulasuriya & Mendelsohn (2008) i.e., Autumn is from August through October, Winter is from November through January, Spring is from February through April, and Summer is from May through July (squared terms enable better fit). For each farmer i, S_{il} is the soil type $l \in L = \{Clay, Loam, Silt, Sand\}$ (from ISRIC's world soil information—Africa Soil Profiles Database (AfSP) v1.2 (Hengl et al., 2015)), 30-year mean NDVI, N_i, and $\boldsymbol{H}$, a vector of household socio-economic controls including size of household, cellphone ownership and household head's age, whether they are female and have primary education. Additionally, country dummies θ_c where $c \in C = \{Kenya, Mozambique, Nigeria\}$ are included to capture country specific effects.

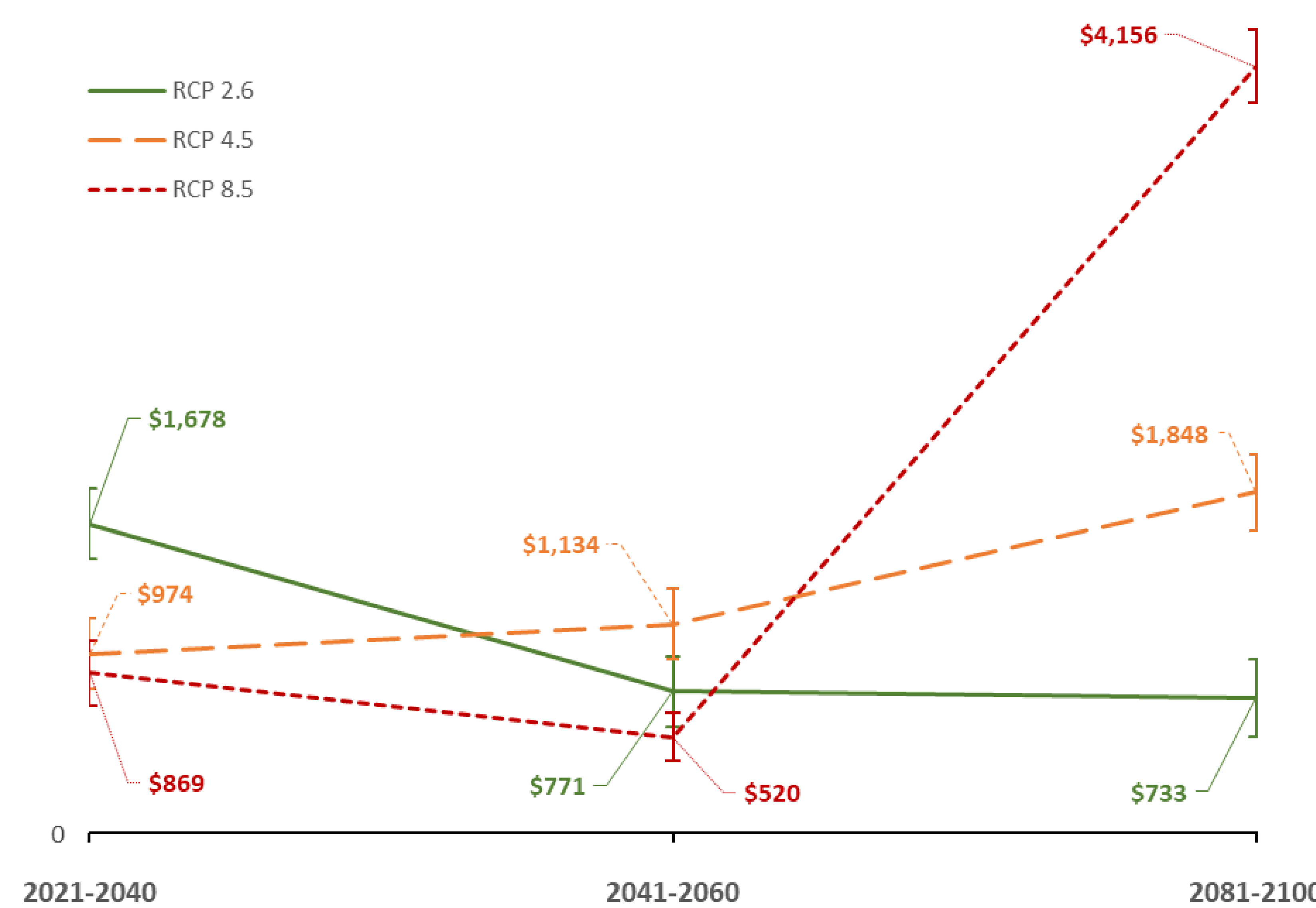
Results

Climate change will damage agriculture…

Our analysis suggests that climate change will damage farmer profits: moderate warming (RCP2.6) may not be as damaging as more extreme climate change (RCP4.5 and RCP8.5), especially in the medium- and long-term (not shown here).

… but farmers in locations exposed to the VBA program will outperform non-VBA farmers.

The graph below shows the performance of VBA farmers relative to non-VBA farmers. The outcome is the estimated difference in farmer profit/hectare between VBA and non-VBA farmers (non-VBA are represented by the horizontal line marked $0). In all climate change scenarios and across time, farmers in locations with a VBA are projected to experience less damage than farmers in locations without a VBA. It is worth noting that in the more extreme scenarios (RCP4.5 and RCP8.5), the damage to agriculture is catastrophic in the long-term, particularly for farmers without VBA support.



Estimated profit/ha difference between VBA and non-VBA

Conclusion

Agric. institutions can be a form of climate change adaptation.

Our results demonstrate the potential of agricultural extension institutions to ameliorate the damaging impact of a changing climate on agriculture. There is little literature on agricultural adaptation to climate change, especially in the developing world (Baninla et al 2022), and the evidence on what types of adaptations will work is limited, especially institutional adaptations. The VBA-program likely better integrates farmers into the value chain by offering not only access to relevant technologies and inputs, but also access to output markets through the VBA. Though not a certainty, this deeper integration might be partly why VBA farmers endure less damage than their non-VBA counterparts.