The effect of invasive pests on food security: An understudied effect of climate change

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Motivation

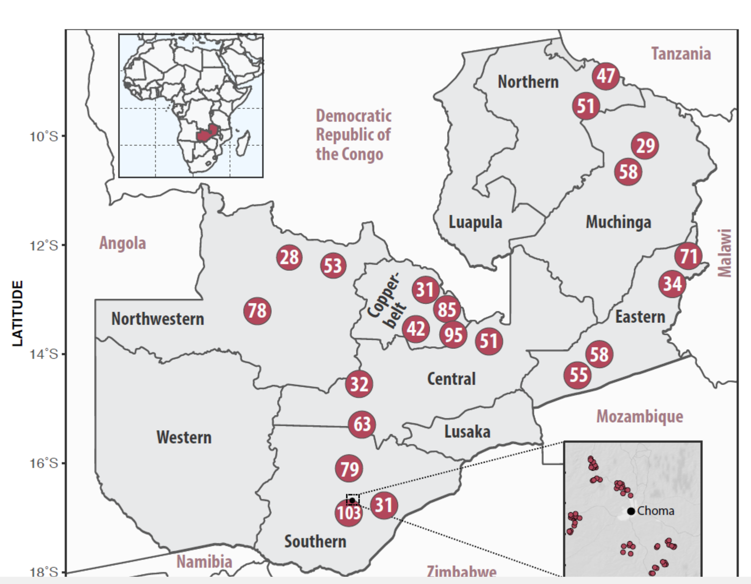
- Global agricultural production and food security are threatened by insect pests.
- Pest invasions have been exacerbated by climate change, as temperatures increase both the range and the appetite of the insects.
- Previous literature that estimates the effects of Fall armyworms (FAW) on Food Security rely on self-reported estimates and cross-sectional data (Tambo et al., 2021c; Bannor et al., 2022; Abro et al., 2021) which in turn bias the estimates, but little is known about the impact FAW on maize yields and they affect household welfare while controlling for mis-measurement error.
- Further, the direct effect of climate change on agricultural production has received a lot of attention in the literature, less work estimates the effect of insect pests on food production and food security, and how their spread is exacerbated by climate change.

Research question

1. Does a pest shock exacerbate agricultural production and eventually food security?
2. What are the mitigation strategies that farmers are employing against FAW?
3. How does the impact of a pest shock on food security compare to the effect of a 50-year drought on food security?
4. How does the effect of climate change on crop yield losses and compare with the effect of climate change on crop yields through increasing the intensity of FAW?

Why do we care?

- FAWs/insects pests are likely to be a problem in the unforeseen future due to climate change which has made more regions in the world conducive for multiplication.
- Policy has focused more on the effect of the direct effect of climate change (droughts) on crop yields but the bigger effect could be through the indirect effect of climate change on crop yields and food security through insect pests (FAW).
- In Sub-Saharan Africa (SSA) where the FAWs invasions are relatively new, it is unclear if the mitigation strategies are effective.



- The map shows the sample sizes across the districts we sampled. **Source: Author's work**
- The numbers in the map are the households sampled in the respective district.

Data

The data are from a large panel household survey of smallholder farmers across Zambia conducted in June and July of 2016, 2017, 2018, and 2019 covering 2015/16, 2016/17, 2017/18 and 2018/19 agricultural seasons called Household, Income, Consumption, and Production Survey (HICPS). The survey sample includes about 1,200 smallholder households in 12 districts of Zambia with data on socioeconomic, and demographic characteristics, production activities, income sources and insect pest infestation, household consumption, and weekly dietary questions.

Our study site includes 12 districts in Zambia which were randomly selected to cover the three primary rainfall zones in the country.

Empirical Strategy

In this paper, we follow the approach by Musaba and Bwacha, 2014 to estimate the production function of maize but include a shifter to capture the effect of FAW. To estimate the effects of FAW on Maize yields, we employ a difference-in-differences model with fixed effects as described in 1:

$$Y_{it} = \sigma_t + \beta FAW_{it} + \gamma \mathbf{X}_{it} + \alpha_i + \theta_t + \zeta_{it} + \varepsilon_{it} \quad (1)$$

The dependent variable is the natural log of maize yields (kg/ha) and in separate specifications Food security outcomes. Our main variables of interest are βFAW_{it}.

Results: Effects of FAW on maize yields

Effects of FAW on maize yields and results interpretations

VARIABLES	(1) lyield FE	(2) lyield ITT	(3) lyield IV
FAW	-0.0426**	-0.147***	-0.448***
	(0.0204)	(0.0512)	(0.016)
Labor (Household size)	0.0667	0.0713	0.037
	(0.078)	(0.0795)	(0.0842)
Landholding size (total cultivated land) (ha)	-0.418***	-0.411***	-0.426***
	(0.0598)	(0.0654)	(0.0694)
Fertilizer Application rate (kg)	0.114***	0.112***	0.122***
	(0.0158)	(0.0166)	(0.0177)
Quantity of seed (kg)	0.221***	0.234***	0.240***
	(0.0507)	(0.0549)	(0.0582)
Capital	0.0654***	0.0645**	0.0507*
	(0.0238)	(0.0252)	(0.0274)
Weather controls	Yes	Yes	Yes
HH FE	Yes	Yes	Yes
Year FE	Yes	Yes	Yes
Camp*Year FE	Yes	Yes	Yes
Observations	2,725	2,570	2,570
R-squared	0.632	0.639	0.225

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Figure 2. Effects of FAW on maize yields

VARIABLES	(1) lyield	(2) lyield
FAW	-0.303***	-0.585***
	(0.111)	(0.204)
Planting date (Weeks)		-0.0512**
		(0.0213)
FAW *Planting date		0.0528**
		(0.0238)
Hybrid	0.139*	
	(0.0801)	
FAW*hybrid	-0.0614	
	(0.0915)	
Labor (Household Size)	-0.0501	-0.0300
	(0.0634)	(0.0621)
Landholding size (Cultivated land) (ha)	-0.426***	-0.487***
	(0.0684)	(0.0651)
Fertilizer Application (kg)	0.114***	0.120***
	(0.0176)	(0.0173)
Quantity of seed (kg)	0.264***	0.349***
	(0.0531)	(0.0436)
Capital	0.0498*	0.0492*
	(0.0273)	(0.0270)
Weather controls	Yes	Yes
HH FE	Yes	Yes
Year FE	Yes	Yes
Camp*year FE	Yes	Yes
Observations	2,529	2,489
R-squared	0.281	0.297

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Figure 3. Panting date and hybrid use

Results: FAW on Food Security and Heterogeneous effects

VARIABLES	(1) FCS OLS	(2) FCS ITT	(3) FCS IV	(4) HDD OLS	(5) HDD ITT	(6) HDD IV	(7) rCSI OLS	(8) rCSI ITT	(9) rCSI IV
FAW	-0.00317	-0.0576***	-0.0843***	-0.0193***	-0.0922***	-0.135***	0.195***	0.452***	0.662***
	(0.00688)	(0.0106)	(0.0196)	(0.00687)	(0.0104)	(0.0219)	(0.0102	(0.014)	(0.0538)
Weather controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
HH FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	2,922	2,756	2,756	2,922	2,756	2,756	2,922	2,756	2,756

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Figure 4. Effects of FAW on Food security outcomes

VARIABLES	(1) FCS	(2) HDD	(3) rCSI	(4) FCS	(5) HDD	(6) rCSI	(7) FCS	(8) HDD	(9) rCSI
FAW	-0.0243	-0.00641	0.110***	-0.00313	-0.0193***	0.00998	-0.00354	-0.0199***	0.243***
	(0.0233)	(0.0207)	(0.03)	0.00688)	(0.00689)	0.00976)	(0.00689)	(0.00689)	(0.0141)
Income	0.0159***	0.0234***	-0.00621						
	(0.0036)	(0.00313)	(0.00455)						
FAW*Income	0.00267	0.00367*	-0.0124***						
	(0.00275)	(0.00239)	(0.00348)						
Capital				0.0286***	0.0210**	-0.0294***			
				(0.0083)	(0.0038)	(0.0105)			
FAW*Capital				0.00399*	0.00568	-0.0260***			
				(0.00366)	0.00343)	(0.00459)			
Land							0.00268	0.00227	-0.0018
							(0.00163)	(0.00163)	(0.00334)
FAW*Land							1.86e-05	-2.32e-06	-2.62e-06
							(1.18e-05)	(1.45e-06)	(2.42e-05)
Weather controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
HH FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	2,922	2,922	2,922	2,904	2,904	2,904	2,920	2,920	2,920

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Figure 5. Farmer heterogeneous effects

Results

- After controlling for mis-measurement error we find a negative and significant effect of FAW on food security and agricultural productivity.
- We find that increased temperatures are related to higher FAW incidence.
- We find the effects of FAW on maize yields and food security are greater than the effects of a 50-year drought on maize yields and food security.

Conclusions

- We show that the effect of severe FAW outbreaks, such that as experienced by 74 percent of farmers in our geographically diverse sample in Zambia, have an effect on households' food security that is 1.5 times larger than that of a 50-year drought.
- Our results also point to a few strategies that can mitigate the effects of FAW.
- Crop failure caused by insect pests must be addressed by understanding the factors that can mitigate the effect of the pests before crop failure occurs.

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