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POLICY BRIEF No.2

EPIC | Economics and Policy Innovations for Climate-Smart Agriculture


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Smallholder productivity under climatic variability:

Adoption and impact of widely promoted agricultural practices in Tanzania

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Executive summary

This brief summarizes the results of a novel analysis that examines the determinants of adoption of agricultural practices to improve food security and their productivity implications in Tanzania. Conducted by the FAO Economics and Policy Innovations for Climate-Smart Agriculture Programme (EPIC), the approach integrates historical climate data with a rich set of socio-economic data in a rigorous empirical analysis. The analysis creates evidence to support the efficient targeting of agricultural policies to improve food security under climate change.

Introduction

Food security in Tanzania is projected to deteriorate in the next 30 years as a consequence of climate change relative to a baseline with no climate change and considering domestic agricultural production as the principal channel of impact. [1]

Maize is Tanzania's most widely cultivated crop, produced by 4.5 million households, representing about 82 percent of all farmers whose average productivity of 1.5 tonnes/ha is one of the lowest on the continent (Figure 1). Maize productivity is expected to decrease by 33 percent countrywide as a result of climate change. [2]

The impacts of climate change on agriculture also have implications for the economy as a whole, since agriculture is the nation's largest sector, contributing almost 25 percent of overall GDP, providing 85 percent of export revenues, and employing about 80 percent of the work force (World Bank, 2013). Agricultural growth has largely been driven by the expansion of cultivable land rather than by increasing productivity. Major constraints facing the agriculture sector are low and decreasing productivity due to poor technology, as well as dependence on rainfed production, which increases vulnerability to the unpredictable

1 Arndt, C., Farmer, W., Strzepek, K., and Thurlow, J. (2012). Climate change, agriculture and food security in Tanzania. Review of Development Economics, 16(3):378–393.
2 NAPA (2007). National Adaptation Programme of Action. Technical report, Vice President's Office, Division of Environment, Dar es Salaam, Tanzania.

HIGHLIGHTS – KEY RESULTS

- Many Tanzanian farmers try sustainable land management practices but then drop them for a variety of reasons.
- Rainfall variability and excessively high temperatures, both of which are expected worsen under climate change, have significant negative impacts on maize yields.
- Land tenure security is associated with higher likelihood of adoption of practices with long pay-back periods.
- Farmers that have soil and water conservation measures are also more likely to intercrop maize with legumes, resulting in significantly higher maize yields.
- If farmers who used improved seed varieties also used inorganic fertilizers they would get much higher returns.

weather conditions that are expected to worsen under climate change.

Since the 1980s, Tanzania's agricultural policy has focused on increasing output and the efficiency of agricultural production. In 1997, the policy was revised to widen its focus on enhancing environmental awareness through extension education. It also determined to undertake further research on the promotion of agricultural practices to improve food security and smallholder productivity while avoiding negative environmental externalities, nutrient depletion, soil degradation and erosion.

In particular, training and promotion of soil conservation and water-harvesting technologies, as well as regulatory and technical services ranging from quality control and certification of improved seeds to sustainable land use planning, have been deployed. Like other countries in sub-Saharan Africa, Tanzania has a large fertilizer subsidy programme. In 2009/10, 1.5 million beneficiaries received 4.5 million input vouchers to increase yields of maize and other crops.

Despite the government's efforts to promote agricultural practices that improve productivity and food security, adoption rates of the main options remain low. If these are to be improved, two key issues need to be addressed: first, developing a thorough understanding of the determinants of adoption and second, updating and revising our understanding of the impacts of these technologies under the site-specific effects of climate change.

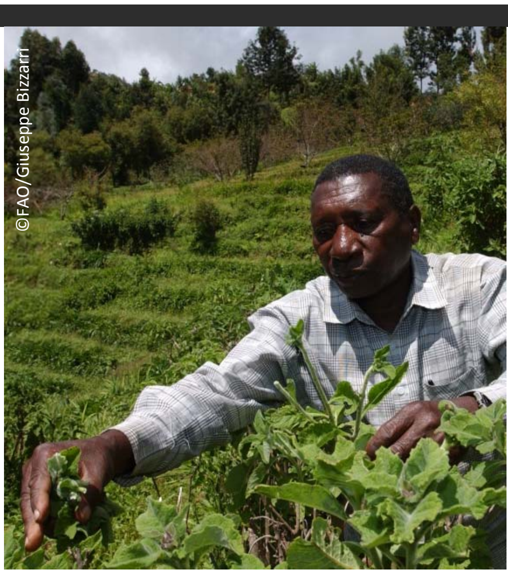
This brief summarizes the findings from innovative research conducted at FAO-EPIC to fill this gap by using a novel data set that combines information from two large-scale household surveys covering the cropping years of 2008/09 and 2010/11. The socio-economic data is combined with geo-referenced historical rainfall and temperature data in order to understand what determines adoption of sustainable and productivity-improving practices and their impacts on maize productivity in Tanzania.

The specific practices analysed are: maize-legume intercropping, soil and water conservation (SWC) practices, organic fertilizer, inorganic fertilizer and high yielding maize varieties.

Maize-legume intercropping, SWC and inorganic fertilizers

Our analysis of the impact of adoption on maize productivity addressed the two most common challenges faced by empirical impact analyses. First, the potential endogeneity of adoption decisions makes it difficult to establish causal relationships. Second, unobserved household heterogeneity can affect adoption but is not captured in this type of analysis.

We found that the adoption of maize-legume intercropping, SWC and inorganic fertilizers all have positive and statistically significant effects on maize yields, suggesting that these practices could enhance food security through increasing agricultural output and incomes. Surprisingly, the effect of adopting improved seeds was not found to be statistically significant, probably because three quarters of farmers who use improved varieties do not use inorganic fertilizers, which are required in order to reap the benefits of improved seeds.



Weather conditions

We also found that current weather conditions strongly affect maize productivity. Farmers located in enumeration areas where the cropping season's rainfall has been highly variable showed 15 percent lower maize yields. Similarly, farmers located in areas with very high maximum temperatures (above 30°C) during the cropping season experienced approximately 25 percent lower maize yields. Both rainfall variability and higher temperatures are expected to increase under climate change, underlining the importance of policies to buffer food security from the estimated effects of climatic conditions (see Figures 7 and 8 for the distribution of these shocks by district). It is important to understand how combinations of practices affect the impacts. In many cases adoption of one practice alone will not have any effect, but adoption with a complementary practice will have a significant impact. An analysis of farmers' adoption of five practices that captured the complementarity or substitutability among different practices showed evidence that improved seeds are complementary to inorganic fertilizers and SWC measures, and that inorganic fertilizers are complementary to the use of organic fertilizers, as well as maize-legume intercropping. These findings suggest that the promotion of sustainable and productivity increasing agricultural practices may exploit these complementarities to enhance their effectiveness.

Determinants of technology adoption and productivity impacts

Figures 2–6 show the distribution of the adoption of agricultural technologies by agro-ecological zone. Exploiting the panel structure of our data through transition matrices we found that the most stable technology adoption is inorganic fertilizer: 83 percent of adopters in 2008 still used it in 2010, though less than 20 percent used it in both years (Table 1c). The highest disadoption rate is observed among SWC practices (72 percent, Table 1d). Moreover, we found that among improved seed adopters (18 percent of the sample) about 75 percent had not used any fertilizer, suggesting that most farmers were not able to exploit the potential benefits of their joint usage.

Table 1: Transition matrices of agricultural technology adoption (2008/09-2010/11 seasons)

a) Maize-Legume Intercropping

		2010/2011	
		No	Yes
2008/2009	No	508	151
		77%	22%
	Yes	152	166
		48%	52%

b) Organic Fertilizer

		2010/2011	
		No	Yes
2008/2009	No	744	67
		92%	8%
	Yes	70	96
		42%	58%

c) Inorganic Fertilizer

		2010/2011	
		No	Yes
2008/2009	No	720	73
		91%	9%
	Yes	32	152
		17%	83%

Figure 1: Maize productivity by district, 2010/11 (kg/ha)

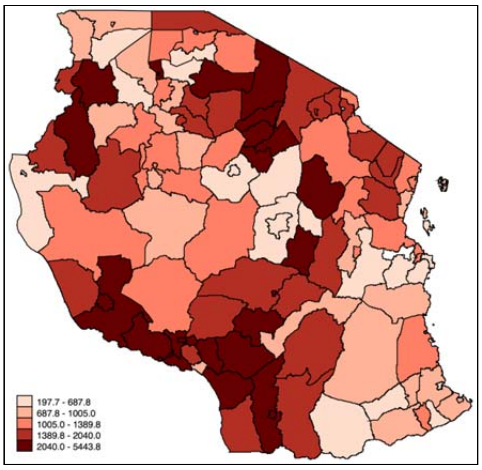


Figure 2: Maize-legume intercropping adoption by AEZ, 2010/2011 (%)

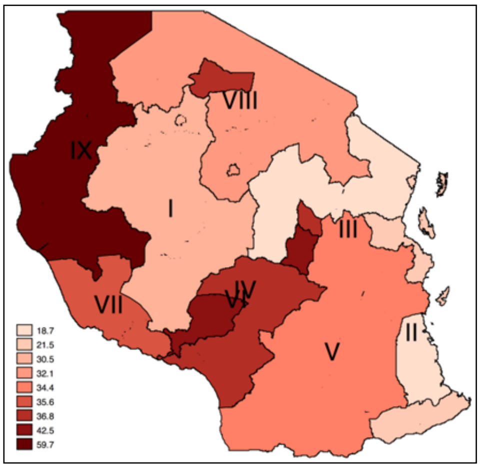


Figure 3: Organic fertilizer adoption by AEZ, 2010/11 (%)

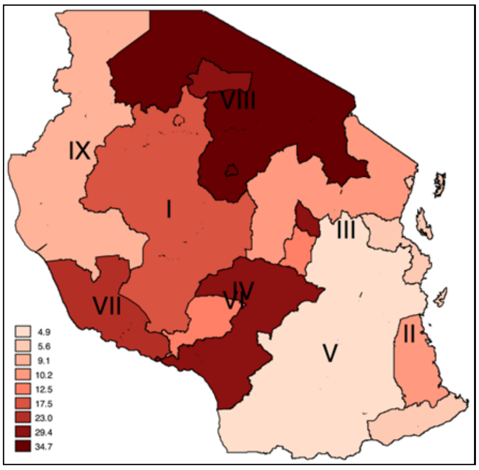


Figure 4: SWC adoption by AEZ, 2010/11 (%)

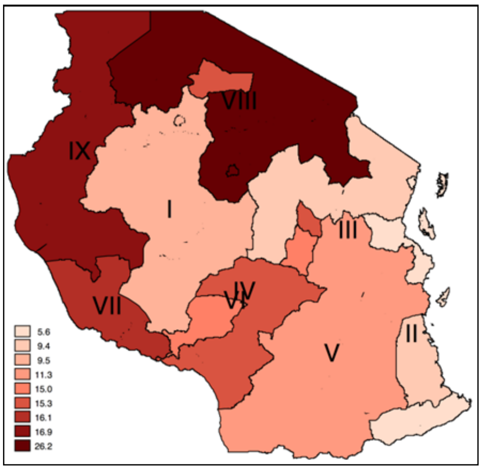


Figure 5: Inorganic fertilizer adoption by AEZ, 2010/11 (%)

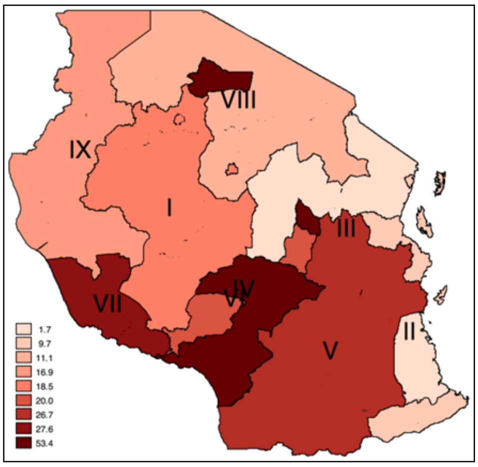
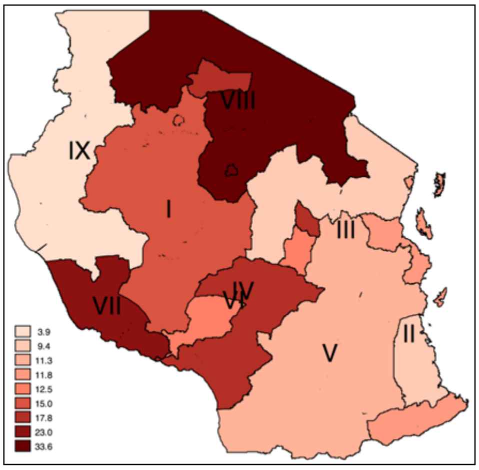


Figure 6: Improved maize adoption by AEZ, 2010/11 (%)



d) SWC Measures

		2010/2011	
		No	Yes
2008/2009	No	707	74
		91%	9%
	Yes	141	55
		72%	28%

e) Improved Seeds

		2010/2011	
		No	Yes
2008/2009	No	717	87
		89%	11%
	Yes	122	51
		71%	29%

Historical rainfall variability

We found a very strong negative relationship between historical climatic variability and the adoption of some practices. The higher the historical variability of rainfall, the lower the probability of organic and inorganic fertilizer adoption. Moreover, we found that the likelihood of inorganic fertilizer adoption was higher in wetter areas. On the other hand, the likelihood of adopting improved seeds was higher in areas where historical rainfall variability was high, suggesting that farmers perceive improved seeds as a strategy for mitigating the effects of highly variable rainfall that is expected to get worse according to climate projections.

Extension services and information

Access to government extension services significantly increases the likelihood of adopting all practices, with the exception of intercropping. We also found that access to information on input prices increases the probability of adopting inorganic fertilizer, SWC and improved seeds. These results clearly highlight the key role played by rural institutions in influencing famers' adoption decisions, suggesting that improvements in extension services, both in terms of coverage and efficiency, are essential in helping farmers gain access to information and adapt to climate change.

Access to credit

We found that farmers with access to credit were more likely to adopt inorganic fertilizer and improved seeds. On the other hand, the adoption of maize-legume intercropping was less likely if farmers had access to credit, suggesting that intercropping may be perceived as a way to cope with the lack of modern inputs. Overall, this evidence suggests that improving access to credit is likely to increase the adoption of modern inputs but decrease maize-legume intercropping, which has greater benefits in the long run for soil health and adaptation. This finding underlines the importance of providing information on both short-run and long-run benefits of all practices to farmers to improve productivity and adaptive capacity at the same time.

Conclusions and recommendations

1. **Disadoption** of the agricultural practices analysed here is widespread. Polices that promote these practices can improve adoption (and its stability), if targeting is based on the determinants of adoption and its impacts, as analysed here.
2. **Site-specific analyses of climatic variables** need to be integrated into policy targeting to foster adoption of appropriate practices that improve food security under climate change. Two important climatic shocks that are expected to become more frequent under climate change – variable rainfall and excessively high temperatures during the growing season – have significant negative impacts on maize yields.
3. **Improved land tenure** is associated with higher adoption of practices that take a long time to deliver full benefits, such as organic fertilizer and SWC. Land tenure should be considered as part of the activities to promote such practices, if stable adoption is to be achieved.
4. **Maize-legume intercropping and SWC**, which are practices with soil quality and climate adaptation benefits, have significantly positive impacts on productivity. They are also complementary in adoption decisions. Efforts to promote these practices can exploit the understanding of the determinants of and the complementarities between the adoption decisions generated in this paper.
5. **Synergies between improved seeds and fertilizers** are not exploited by the majority of farmers. The same applies to other synergies documented here. Agricultural and food security policies can become more effective by exploiting the synergies between different practices based on rigorous analyses, as in this research.

ACKNOWLEDGEMENTS

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EUROPEAN UNION

ABOUT EPIC

EPIC is a programme of the Food and Agriculture Organization of the United Nations (FAO). It supports countries in their transition to Climate-Smart Agriculture through sound socio-economic research and policy analysis on the interactions between agriculture, climate change and food security.

CONTACTS

Economics and Policy Innovations for Climate-Smart Agriculture (EPIC)
Agricultural Development Economics Division (ESA)
Food And Agriculture Organization of the United Nations (FAO)
Viale delle Terme di Caracalla
00153 Rome, Italy
Aslihan.Arslan@fao.org

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