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Feed the Future Innovation Lab for Food Security Policy

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Does Sustainable Intensification of Maize Production Enhance Child Nutrition? Evidence from Rural Tanzania

Jongwoo Kim, Nicole M. Mason, and Sieglinde Snapp

Introduction

In many developing countries including Tanzania, food insecurity and child malnutrition remain persistent problems. Globally about 155 million children under age five are stunted, which is the result of chronic malnutrition; more than one third of these children live in sub-Saharan Africa (SSA) (UNICEF, WHO, and World Bank Group 2017). Malnutrition is a leading cause of child mortality, making children more vulnerable to severe diseases. Approximately 45% of global deaths of children under age five are linked to malnutrition and the mortality rate of children in SSA is the highest in the world (Black et al. 2013; Fund UNCS 2014). Tanzania is the third worst affected country in SSA with respect to child malnutrition, exceeded only by Ethiopia and the Democratic Republic of Congo (Muhimbula and Issa-Zacharia 2010).

Agriculture and nutrition are closely linked because the majority of undernourished people still live in rural areas and many of them are smallholder farmers (Sibhatu, Krishna, and Qaim 2015; Pinstrup-Andersen 2007). Agriculture can affect the level of nutrition of smallholder farming households in primarily two ways: (1) through production of food crops in different quantities and qualities, and at different levels of diversity that households then consume directly; and (2) through the sale of agricultural output, which can raise household incomes and, in turn, affect food purchases and consumption (Jones, Shrinivas, and Bezner-Kerr 2014; Hawkes and Ruel 2006). These agriculture-nutrition linkages imply that the adoption of improved agricultural technologies at the farm household level may play a pivotal role in reducing the level of child malnutrition through higher crop yields and returns.

Key Findings:

- For children under age five (0-59 months), their household's adoption of *Intensification* (use of only inorganic fertilizer), *Sustainable* (use of only organic fertilizer, only maize-legume intercropping, or both), and *SI* (joint use of inorganic fertilizer with organic fertilizer and/or maize-legume intercropping) practices for maize production raises children's height-for-age z-score (HAZ). (An HAZ below -2 indicates that a child is stunted.) However, only the adoption of SI practices increases children's weight-for-age z-score (WAZ). (A WAZ below -2 indicates that a child is underweight.)
- For children aged 25-59 months, who are less likely than younger children to be breastfed and may be more directly affected by household diet changes associated with changes in agricultural practices and production, adopting practices in the Sustainable and SI groups increases HAZ by 44% and 38%, respectively, and WAZ by 29% and 52%, respectively. Moreover, the adoption of these practices reduces the probability of stunting and underweight among children aged 25-59 months.
- On the other hand, Intensification (use of inorganic fertilizer only) *increases* the probability of stunting and underweight among this older group of children.
- Overall, use of more sustainable maize production practices such as applying organic fertilizer and intercropping with legumes, alone and in combination with inorganic fertilizer, appears to be more beneficial to child nutritional outcomes than use of inorganic fertilizer alone.

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Although the adoption of conventional agricultural intensification practices such as high-yielding crop varieties and inorganic fertilizer substantially contributed to reductions in food insecurity in SSA for the past several decades (Godfray et al. 2010), such forms of intensification might not be sufficient to sustainably raise agricultural productivity and could have negative environmental consequences (Pingali 2012; Kassie et al. 2015). In this context, agricultural sustainable intensification (SI) has been gaining attention as a possible solution to simultaneously address nutrition/food security and environmental security challenges (Petersen and Snapp 2015). Narrowly defined, SI entails raising agricultural productivity while preserving or improving the natural resource base, but broader definitions of SI require that it also maintain or enhance human well-being, including child nutrition (Zurek, Keenlyside, and Brandt 2015). It is an open question, however, whether adoption of practices that contribute to SI from an environmental standpoint do indeed improve child nutrition. To begin to address this question, this study uses data from Tanzania to analyze the child nutrition effects of rural households' adoption of farming practices that contribute to the SI of maize production, an important staple food that is widely grown by smallholder farmers. To do this, we apply a multinomial endogenous treatment effects model using three-waves of nationally representative household panel survey data (the Tanzania National Panel Surveys of 2008/09, 2010/11, and 2012/13) conducted by the Tanzania National Bureau of Statistics in conjunction with the World Bank.

Sustainable Intensification of Maize Production in Tanzania

SI of maize production is particularly important in Tanzania because maize is the main staple food and the most common complementary or weaning foods for children in the country are maize-based (Kimanya et al. 2010). This study focuses on three soil fertility management (SFM) practices (alone and in combination) that have the potential to contribute to SI in maize-based systems: (1) inorganic fertilizer, (2) organic fertilizer, and (3) maize-legume intercropping. We group households into four categories based on their use of these practices on their maize plots: *Non-adoption*; *Intensification* (use of only inorganic fertilizer); *Sustainable* (use of only organic fertilizer, only maize-legume intercropping, or both); and *SI* (joint use of inorganic fertilizer with organic fertilizer and/or maize-legume intercropping on the same plot) (see Table 1). We then estimate how households' adoption of each SI category affects nutritional outcomes of children within the household. Out of 4,269 maize growing households across the three rounds of survey data used in the study, about 41% fall in the Sustainable category. The Intensification and SI categories are much less prevalent, at 6% and 9% of maize-producing households, respectively (Table 1).

Table 1. SI of Maize Production Categories and Prevalence among Maize-Growing Households in Tanzania

Case	Inorganic fertilizer	Organic fertilizer	Maize-legume intercropping	SI category	% of maize-growing HHs in this category
1				Non-adoption	44.3
2	√			Intensification	6.1
3		√		Sustainable	40.8
4			√		
5		√	√		
6	√	√		SI	8.8
7	√		√		
8	√	√	√		

Source: Author's calculations based on Tanzania National Panel Survey (TNPS 2008/09, 2010/11, 2012/13).

Child Malnutrition in Tanzania

In studies on child malnutrition, nutritional status is usually measured with two indicators: weight-for-age z-score (WAZ), and height-for-age z-score (HAZ). These measures reflect long-term factors such as deficiencies in nutrition, frequent infections, and inappropriate feeding practices. WAZ and HAZ measure nutritional status in the form of z-scores derived by comparing children's weight-for-age or height-for-age with these outcomes for children in a well-nourished reference group. For example, WAZ is the difference in standard deviations of a child's weight-for-age from the median weight of children of the same age and gender in the reference group. A child is considered underweight if his/her WAZ is below -2, and stunted if his/her HAZ is below -2. The national prevalence of underweight children under age five in Tanzania steadily decreased from 16% in 2008/09 to 13% in 2012/13. Stunting also declined from 43% in 2008/09 to 37% in 2012/13 (Table 2). However, child malnutrition rates in rural areas continue to be substantially higher than in urban areas (See Table 2).

Findings and Policy Implications

The full regression results from the multinomial endogenous treatment effects model are reported and discussed in the working paper associated with this policy brief. For simplicity, this policy brief focuses on the key factors explaining the adoption of SI categories and the average treatment effects of adoption of the various categories on child nutritional outcomes. Consistent with previous studies, we found that an increase in the education level of the household head, access to off-farm income, more secure land tenure, and greater farm assets and livestock owned are key factors explaining the adoption of SI categories. In addition, the results suggest that the producer price of maize plays an important role in the adoption decisions: increases in this price positively affect adoption of Intensification but negatively affect adoption of Sustainable maize production practices in Tanzania. The results further suggest that access to extension advice and subsidized fertilizer, and the presence of farmers' cooperatives in the community are important determinants of the adoption of the various SI categories.

Table 3 summarizes the effects of adoption of the various SI categories on child nutritional outcomes among maize-growing households in Tanzania. The upper panel in Table 3 shows the results for the full sample of children under age 5 (0-59 months). These findings suggest that adopting SI categories in general can enhance child nutrition relative to not adopting any of them but the estimated effects differ across child nutrition indicators. All of the SI categories (i.e., Intensification, Sustainable, and SI) increase HAZ, while only the SI category is positively associated with higher WAZ. However, because the estimated effect of the Sustainable category on children's HAZ is implausibly large (100% increase) and because children aged 0-24 months who are largely breastfed may not be as responsive to food intake, we re-estimate the models using the sub-sample of children aged 25-59 months. The sub-sample results (shown in the lower panel of Table 3) suggest that adopting practices in the Sustainable and SI categories increases HAZ by 44% and 38%, respectively, and WAZ by 29% and 52%, respectively, on average.

Table 2. Trends in the Malnutrition Status of Children under Age 5 in Tanzania

	Underweight (%) (WAZ < -2)			Stunting (%) (HAZ < -2)		
	2008/09	2010/11	2012/13	2008/09	2010/11	2012/13
Tanzania	15.9	13.6	12.5	43.0	34.8	37.4
Urban	9.8	9.2	9.3	30.2	24.1	29.5
Rural	17.1	14.6	13.3	45.6	37.2	39.3

Source: Tanzania National Bureau of Statistics 2014.

Table 3. Estimated Effects of the Adoption of Each SI Category on Child Nutritional Outcomes

Full sample: 0-59 months (n=3,449)		
	HAZ	WAZ
Intensification	+39.8%	No effect
Sustainable	+99.9%	No effect
SI	+33.7%	+63.1%
Sub-sample: 25-59 months (n=2,072)		
	HAZ	WAZ
Intensification	No effect	No effect
Sustainable	+44.1%	+28.9%
SI	+38.4%	+52.3%
	Probability of:	
	Stunting	Underweight
Intensification	+22.1% pts	+25.3% pts
Sustainable	-16.4% pts	No effect
SI	-17.4% pts	-6.5% pts

Notes: Base category is Non-adoption. No effect indicates that the result is not statistically different from zero. All other results reported in the table are statistically significant at the 10% level or lower.

Moreover, adoption of Sustainable and SI practices reduces the probability of stunting and/or underweight among children in the sub-sample. However, adoption of Intensification (use of inorganic fertilizer without organic fertilizer and/or maize-legume intercropping) is found to actually increase the probabilities of stunting and underweight in this sub-sample. This may be because both the Sustainable and SI categories include maize-legume intercropping, and this may increase the intake of nutritious legumes by children in adopting households. On the other hand, while Intensification may raise maize yields, increased maize production alone appears to be insufficient to enhance the nutritional outcomes of children beyond breastfeeding age.

Overall, the results suggest that the adoption of maize-legume intercropping, organic fertilizer, or their use in conjunction with inorganic fertilizer on maize plots can substantially enhance child nutrition in rural Tanzania. Our results have several implications for agricultural policy. First, it is important for policy makers to find effective ways to increase adoption of these practices by Tanzanian maize farmers. At present, Tanzania has much lower adoption rates of inorganic fertilizer, organic fertilizer, and maize-legume intercropping than other countries in eastern and southern Africa such as Kenya, Malawi, and Ethiopia (Kassie et al. 2015). Second, our findings suggest that agricultural extension through both governmental and non-governmental organizations (e.g., farmers' cooperatives) and fertilizer subsidies may be effective strategies to promote and disseminate information about SI practices for maize. Finally, the important effect of household heads' education levels on SI adoption decisions suggests that promoting education may be one mechanism to increase SI in maize-based systems and to reduce child malnutrition in Tanzania.

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Kim is a PhD student and Mason is Assistant Professor, in the Department of Agricultural, Food, and Resource Economics (AFRE) and Snapp is Professor of Soils and Cropping Systems Ecology in the Department of Plant, Soil, and Microbial Sciences at Michigan State University.

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