World Development 108 (2018) 28–46

Contents lists available at ScienceDirect

World Development

journal homepage: www.elsevier.com/locate/worlddev

Who benefits from which agricultural research-for-development technologies? Evidence from farm household poverty analysis in Central Africa

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ARTICLE INFO

Article history:
Accepted 13 March 2018

Keywords:
AR4D
Poverty
Impact evaluation
Central Africa

ABSTRACT

It remains a challenge for agricultural research-for-development (AR4D) institutions to demonstrate to donors which technologies contribute significantly to poverty reduction due to a multitude of impact pathways. We attempt to overcome this challenge by utilizing the potential outcomes framework and quantile treatment effects analytical approaches applied on panel household data collected from Central Africa. Our findings show that adoption of AR4D technologies reduced the probability of being poor by 13 percentage points. A large share of this poverty reduction is causally attributable to adoption of improved crop varieties (32%) followed by adoption of post-harvest technologies (28%) and crop and natural resource management (26%), with the rest 14% attributable to unidentified and/or unmeasured intermediate outcomes or factors. The findings further indicate that relatively poor farm households benefit from adopting improved crop varieties more than the relatively better-off households. Correspondingly, the relatively better off households benefit from adopting post-harvest technologies enhancing crop commercialization much more than the relatively poor households. The findings reveal interesting policy implications for successful targeting of agricultural interventions aimed at reducing rural poverty.

1. Introduction

Over the years, researchers have had to answer the question of not only if agricultural research for development (AR4D) is good value for money but also whether AR4D interventions lead to poverty reduction. A number of studies have demonstrated that investments in the development of AR4D technologies, in both low and middle income countries, reduce rural poverty much more than investments in public infrastructure and education (Fan, Hazell, & Thorat, 2000; Fan, Zhang, & Zhang, 2004; Thorat & Fan, 2007; Fan & Zhang, 2008). There is growing evidence to support continued investment in AR4D technologies in agrarian economies to alleviate rural poverty (Eicher, 1990; Datt & Ravallion, 1998; World Bank, 2007; Renkow & Byerlee, 2010). A large number of studies continue to emphasize the positive impact of individual AR4D technologies on food and nutrition security (Kassie, Jaleta, & Mattei, 2014; Shiferaw, Menale, Jaleta, & Yirga, 2014; Khonje, Manda, Alene, & Kassie, 2015; Wossen et al., 2017; Zeng et al., 2017; Jaleta, Kassie, Marenya, Yirga, & Erenstein, 2018) and poverty reduction (Alene et al., 2009; Becerril & Abdulai, 2010; Asfaw, Kassie, Simtowe, & Lipper, 2012; Bezu, Kassie,

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https://doi.org/10.1016/j.worlddev.2018.03.013
0305-750X/

Shiferaw, & Ricker-Gilbert, 2014; Kassie et al., 2014; Coromaldi, Pallante, & Savastano, 2015; Khonje et al., 2015; Zeng et al., 2015; Manda, Alene, Gardebroek, Kassie, & Tembo, 2016; Wossen et al., 2017). The analysis in these studies focused on the causal relationships between the different social welfare outcomes and single/multiple technological components based on direct (through increased production, reduced costs, and higher incomes) and indirect (through employment generation, food prices, and growth linkage effects) impact pathways. More precisely, some studies solely looked into the average impacts of crop genetic improvement of groundnut, pigeon pea, chickpea and maize, wheat, and cassava varieties (Kassie, Shiferaw, & Muricho, 2011; Asfaw et al., 2012; Bezu et al., 2014; Kassie et al., 2014; Shiferaw et al., 2014; Khonje et al., 2015; Zeng et al., 2015; Feleke, Manyong, Abdoulaye, & Alene, 2016; Verkaart, Munyua, Mausch, & Michler, 2017; Wossen et al., 2017); conservation and management of natural resources such as soil and water conservation technologies (Abdulai & Huffman, 2014; Abdulai, 2016; Manda et al., 2016; De los Santos-Montero & Bravo-Ureta, 2017); cropping system diversification and sustainable intensification (Teklewold, Kassie, Shiferaw, & Köhlin, 2013; Abdulai & Abdulai, 2017; Arslan, Belotti, & Lipper, 2017; Kotu, Alene, Manyong, Hoeschle-Zeledon, & Larbi, 2017); and postharvest technologies (Bokusheva et al. 2012; Mmbando, Wale, & Baiyegunhi, 2015).

Much of the impact assessment literature on poverty reduction in rural farming communities has focused on the overall average impacts of agricultural programs (Mendola, 2007; Christiaensen, Demery, & Kuhl, 2011; Herdt, 2011) rather than the differential impacts attributable to the different constituents of the program interventions. Consequently, there has not been much evidence on the comparative impacts of different components of AR4D technologies in a way that makes them useful for research investment decisions and priority setting (Alston, Chan-Kang, Marra, Pardey, & Wyatt, 2000; Raitzer & Kelley, 2008; Barrett, Agrawal, Coomes, & Platteau, 2009). Furthermore, since the AR4D technologies are often evaluated without reference to the different groups of people, there has not been much evidence on the distributional impacts of the technologies. To fill in this knowledge gap, we evaluated the degree to which different AR4D technologies—improved crop varieties, crop and natural resource management technologies, and postharvest technologies—contributed to poverty reduction among adopting farm households in Burundi, Eastern DR Congo, and Rwanda. Then, based on the poverty level, we identified the households that benefit most or least from adopting certain components of AR4D technologies. Finally, we investigated the impacts of the intensity of adoption of AR4D technology components on farm-household poverty distribution. Our findings provide useful information for prioritizing research investment decisions for effective poverty reduction and contribute to literature on agricultural impact evaluation in three ways.

First, the paper applies impact decomposition methods and measures differential impacts of adoption of AR4D technologies on poverty reduction by evaluating the share of total impact attributable to a particular AR4D technology component.[1] The voluminous literature in agricultural economics focusing on the impact evaluation of agricultural technologies on poverty reduction (Barrett et al., 2009; de Janvry et al., 2011) has utilized analytical approaches limited to estimating program average impacts (Imbens and Wooldridge, 2009), and very little of this literature has decomposed average impacts into different program components (Flores & Flores-Lagunes, 2009) apart from a few emerging studies in environmental and forest economics (Ferraro & Hanauer, 2014; Cisneros, Zhou, & Börner, 2015).

Second, the paper applies quantile treatment effects and measures the distributional impacts of AR4D technologies. Understanding the distributional impacts not only guides targeting of intervention placements suitable to specific sub-groups of farm households along their income distribution, but also reveals capacity needs relevant to each sub-group. Existing empirical evidences on distributional impacts on poverty arising from adoption of agricultural technologies remain scanty, with available literature reporting mixed effects of reduced poverty but increased inequality (Freebairn, 1995; Rahman, 1999; Athukorala & Wilson, 2017). This literature falls short of identifying which agricultural technologies have poverty-reducing effects and for which farm households based on their income distribution. This paper attempts to address this shortfall.

Third, the paper applies both the discrete treatment variable (incidence of adoption) and continuous treatment variable (intensity of adoption) in its assessment of AR4D technology components on farm-household poverty distribution. The rest of this paper is organized as follows. Section 2 gives an overview of the project through which the three different components of AR4D technologies (improved crop varieties, resource management technologies, and postharvest technologies) were introduced into Central Africa. Section 3 presents the impact mechanisms in which AR4D technologies lead to poverty reduction. Section 4 presents the analytical approach. The data sources are described in Section 5, defining treatment and outcome variables. Section 6 reports and discusses both descriptive and econometric results. Section 7 concludes and highlights research gaps for future work.

2. Project intervention with AR4D technologies in Central Africa

We use the Consortium for Improving Agriculture-based Livelihoods in Central Africa (CIALCA) project to demonstrate how different AR4D technologies contributed to poverty reduction. The CIALCA project was established towards the end of 2005 in Burundi, Eastern DR Congo, and Rwanda. The consortium comprised of three CGIAR centers: the International Institute of Tropical Agriculture (IITA), Bioversity International, and the International Center for Tropical Agriculture (CIAT). CIALCA's main goal was to overcome the effects of the conflict that had disrupted food production and exacerbated rural poverty in selected communities through improving agricultural productivity. The selection of intervention communities was purposive and based on having similar characteristics, namely: reasonably high poverty levels with low food and nutrition security, highly degradable soils but with high agricultural productivity potential, relatively good access to local markets, and the presence of development organizations (Ouma et al., 2011). CIALCA developed and disseminated over 30 AR4D technologies in different selected communities in the three Central African countries (Macharia et al., 2012). The AR4D technologies included: improved crop varieties (IV); crop and natural resource management (CNRM) technologies; and postharvest (PH) technologies including processing, storage, and marketing. More information about these technologies is provided in Section 5.2. In subsequent sections, the terms CIALCA technologies and AR4D technologies are used interchangeably.

3. CIALCA impact mechanisms

To better understand the mechanisms through which technology adoption impacts on household poverty, Fig. 1 provides a framework demonstrating the impact pathways through which

[1] Donors are also interested in the answer to the question: What part of the impact of AR4D on poverty reduction is attributable to individual research institutions responsible for developing improved agricultural technologies? We, however, do not address this question in the current study and leave it for future research.