



# Is agricultural adaptation to global change in lower-income countries on track to meet the future food production challenge?



Philip K Thornton<sup>a,\*</sup>, Patricia Kristjanson<sup>b</sup>, Wiebke Förch<sup>c</sup>, Carlos Barahona<sup>d</sup>, Laura Cramer<sup>e</sup>, Sonali Pradhan<sup>d,f</sup>

<sup>a</sup> CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS), International Livestock Research Institute (ILRI), PO Box 30709, Nairobi, 00100, Kenya

<sup>b</sup> World Agroforestry Centre, PO Box 30677, Nairobi, 00100, Kenya

<sup>c</sup> Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH, SADC Adaptation to Climate Change in Rural Areas in Southern Africa Programme, Private Bag X12 (Village), Gaborone, Botswana

<sup>d</sup> Statistics For Sustainable Development, 6 Southern Court, South Street, Reading, RG1 4QS, UK

<sup>e</sup> CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS), International Centre for Tropical Agriculture (CIAT), AA, 6713, Cali, Colombia

<sup>f</sup> School of Agriculture, Policy & Development, University of Reading, Reading RG6 6AR, UK

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## ABSTRACT

Agriculture is critical to sustainable development, and agricultural production by smallholders in lower-income countries contributes substantially to the food security of both rural and urban populations. Smallholders face many challenges related to urbanisation, sustainable use of natural resources and climate change. While there will be different ways of achieving sustainable agricultural systems, all will involve adaptation on a massive scale to meet the future food production challenge at greatly reduced carbon cost. Here we evaluate recent progress in agricultural adaptation using surveys in five regions, 21 countries and 45 sites, covering 315 villages and approximately 6300 households. These surveys include information about the changes made to farming systems in the last decade. We synthesise this information by grouping households into types: food insecure, hanging in, stepping up and stepping out. We then profile each site in terms of its proportion of households of these four types. While farmers have made some changes in their farming practices over the last decade, most changes have been incremental and piecemeal. We find little evidence in the study sites in any region of farming changes at the scale needed to enhance food security of significant proportions of the population. Searching for commonalities in the enabling environment among sites with similar proportions of household types, we found collective action at the community level coupled with appropriate climate information provision and the active participation of local organisations to be associated with higher levels of food security. To foster the changes needed in agricultural and food systems, a much stronger focus will be required on the enabling environment if food security goals are to be attainable. Without more nuanced and effective targeting of technological as well as institutional interventions, agricultural adaptation to meet the food production challenge in the coming decades is unlikely to occur.

## 1. Introduction

Smallholder agriculture is key to sustainable development and achieving several of the Sustainable Development Goals (SDGs; UN, 2015; Herrero et al., 2017). Smallholders face enormous challenges, as do the many national, regional and international research and implementing organisations mandated to address them, given the amount of food that will need to be produced over the next 50 years (Steffen et al., 2015). This has to be done in the face of climate change, while reducing the carbon cost of farming. However, it cannot be achieved

simply by farming at lower intensity and taking more land, because there is not enough for which the economic and environmental costs of conversion would be acceptable (Lambin et al., 2013; Keating et al., 2014; Searchinger et al., 2015).

Calls for sustainable agricultural intensification (Garnett and Godfray, 2012) and climate-smart agriculture (CSA) (Lipper et al., 2014) aim to address the challenge of increasing agricultural productivity and improving rural livelihoods, while at the same time minimising negative environmental impacts and building adaptive capacity. Sustainable agricultural intensification does not imply a

\* Corresponding author.

E-mail address: [p.thornton@cgiar.org](mailto:p.thornton@cgiar.org) (P.K. Thornton).

**Table 1**  
Mean values of household characteristics for four household types in 45 sites in five regions.

Household characteristic	Food insecure	Hanging in	Stepping up	Stepping out
Average number of months with food shortages	7.8	1.4	1.1	1.6
% of households that had increased productivity in the last 10 years	64%	82%	100%	6%
% of households that made changes in practices because of market considerations	73%	89%	100%	35%
% of households that had increased input use to at least some degree	46%	33%	100%	4%
Average number of agricultural products produced on-farm and sold	1.1	1.3	1.6	0.6
% of households that bought at least one agricultural input (seed, fertiliser, insurance)	78%	93%	100%	44%
% of households that receive cash from other sources	42%	53%	53%	53%

All the values of the household characteristics are significantly different between types of household ( $p < 0.001$ ) with the exception of “% of households that receive cash from other sources”, where there are no significant differences between households classified as “Hanging in”, “Stepping up” and “Stepping out”, but these are significantly different from households classified as “Food insecure”.

particular set of practices, but rather a conceptual framework for guiding discussions, actions and investment on achieving balanced outcomes of intensification (Garnett and Godfray, 2012). The same holds for CSA (Neufeldt et al., 2013). This means that there will be different ways of achieving sustainable agricultural systems in the future, depending on agro-ecological zone, farming system, cultural preferences, institutions and policies, among other factors (Nelson and Coe, 2014; Descheemaeker et al., 2016).

Climate change is already having impacts on smallholder farming systems, particularly in lower-income countries (IPCC, 2014). Negative impacts will increase in severity in many places, at least temporarily, regardless of what happens to global greenhouse gas (GHG) emissions, given the lags in the climate system (Rogelj et al., 2016). This raises the question, how much do we know about how well smallholders in lower-income countries are adapting to the many challenges they face, including climate change? Additionally, what kinds of changes in farming practices and livelihood strategies are they making, and are these leading to more productive, sustainable agricultural systems? In this paper we attempt to evaluate current progress with respect to changing agricultural practices using surveys from five regions, 21 countries and 45 sites, covering 315 villages and approximately 6300 households. The purpose of the surveys was to form the baseline for monitoring and evaluation for the CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS), a large agricultural research for development (AR4D) program that started in 2010 and is due to run until 2022 (Förch et al., 2014). The surveys were carried out between 2011 and 2014, and are in planning to be repeated in 2019 to track changes in key development outcome indicators at the sites relating to the food security of households and communities.

Earlier publications using subsets of these data focused on designing and implementing such an extensive, multi-country baseline survey effort at multiple levels (household, community and organisation) (Förch et al., 2014), and an analysis of the relationship between uptake of climate-smart practices and household food security in East Africa (Kristjanson et al., 2012). Here we use the entire dataset (all sites, all regions, all levels) for the first time, to explore the factors that help explain the relative lack of uptake of new agricultural practices. We first group the surveyed households into different types, on the basis of degree of food security and recent changes in farming practices. We then categorise the sites where these households are located into a set of site types with different proportions of household types. We do this in order to identify commonalities in the supporting policies, institutions and interventions that apply among sites of the same type (i.e., similar proportions of household types). From an understanding of these commonalities, we discuss strategies for better targeting of support to address this household and community diversity, and illustrate these with some examples that hold promise for facilitating the uptake of new agricultural practices at scale.

## 2. Methods

### 2.1. Overview

When the CCAFS baseline survey activities were initiated in 2010, many of the research hypotheses that guided them were technology- and practice-based, focusing on the farm-level behavioural changes that would be needed for smallholder farming systems to be better able to adapt to climate change along with other drivers of change such as population growth, a dwindling natural resource base and increased urbanisation. The surveys were designed to track a wide range of practices related to crop, livestock, land, soil and water management, as well as to capture non-agricultural components of the livelihood system such as off-farm income (Förch et al., 2014). CCAFS's theories of change have evolved in the meantime, as a result of several years' experience and an increased focus on achieving development outcomes through the massive upscaling of appropriate CSA interventions (Thornton et al., 2017). Monitoring a wide range of improved agricultural technologies and management practices at farm level is still greatly needed, but equally important is appropriate integration with collective, institutional, investment and policy efforts that are flexibly targeted to specific environments (CCAFS, 2016). The survey data and related documentation are archived on-line and freely available on Dataverse ([dataverse.harvard.edu/dataverse/CCAFSbaseline](http://dataverse.harvard.edu/dataverse/CCAFSbaseline)) (CCAFS, 2011, 2012, 2015; Garlick, 2015).

The CCAFS study sites were purposively selected to cover a wide variety of agricultural practices and biophysical conditions, as well as different cultural, political and institutional environments. Survey households and villages were randomly selected in each site (the sampling strategy is shown in Table 1 in Förch et al., 2014). Questions were asked at three levels: at the household level, about the changes being made to farming practices over the last 10 years; at the village level, about the changes seen in natural resources over the past 10 years; and at the institutional level, on the shift in focus of organisations working in their communities (Förch et al., 2014). The survey work was undertaken at the sites in Africa and South Asia in 2010, and at the sites in Latin America and South-East Asia in 2012, when these regions were added to CCAFS's portfolio. Here we synthesize results from these multi-level, multi-regional surveys to take stock of the changes that have been made in these farming systems over the last decade.

As a frame for the analysis, we started with the livelihoods aspirations framework of Dorward et al. (2009). This framework considers three different household types: “hanging in” strategies are concerned with maintaining and protecting current levels of wealth and welfare in the face of threats of stresses and shocks; “stepping up” strategies involve investments in agricultural assets to expand the scale or productivity of existing assets and activities; and “stepping out” strategies involve the accumulation of assets that allow investments or switches into new activities and assets (Dorward et al., 2009). This framework is based on the premise that most households have aspirations and a desire to work their way from the first to the second or third trajectory

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