Agricultural Water Management 204 (2018) 11–16

Contents lists available at ScienceDirect

Agricultural Water Management

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

Soil water management practices (terraces) helped to mitigate the 2015 drought in Ethiopia

Frédéric Kosmowski

CGIAR Standing Panel on Impact Assessment, ILRI, P.O. Box 5689, Gurd Sholla Area, Addis Ababa, Ethiopia

ARTICLE INFO

Keywords:
Soil water management practices
Climate-smart agriculture
Terraces
Contour bunds
Drought
Propensity score matching
Ethiopia

ABSTRACT

While the benefits of soil water management practices relative to soil erosion have been extensively documented, evidence regarding their effect on yields is inconclusive. Following a strong El-Niño, some regions of Ethiopia experienced major droughts during the 2015/16 agricultural season. Using the propensity scores method on a nationally representative survey in Ethiopia, this study investigates the effect of two widely adopted soil water management practices – terraces and contour bunds – on yields and assesses their potential to mitigate the effects of climate change. It is shown that at the national level, terraced plots have slightly lower yields than non-terraced plots. However, data support the hypothesis that terraced plots acted as a buffer against the 2015 Ethiopian drought, while contour bunds did not. This study provides evidence that terraces have the potential to help farmer deal with current climate risks. These results can inform the design of climate change adaptation policies and improve targeting of soil water management practices in Ethiopia.

1. Introduction

Research suggests that conventional agriculture creates unsustainable erosion rates that can result in decreased agricultural potential (Montgomery, 2007). In Ethiopia, soil erosion is considered a severe constraint for land resource productivity. Since the 1980s, massive soil conservation programs have been carried out by governmental and non-governmental organizations. Following a top-down approach, soil water management practices have been promoted according to the land's physical limitations and erosion risks. These interventions, often implemented at the water catchment level, are designed to foster community labor mobilization (Desta et al., 2005).

Climate change is an additional burden to these already prevalent environmental challenges. Expected changes in the frequency and occurrence of precipitation patterns in Ethiopia (Souverijns et al., 2016) are likely to threaten agricultural productivity (Sultan, 2012). In recent years, climate-smart agriculture has emerged as an approach whose objective is to integrate climate change into the planning and implementation of sustainable agricultural strategies (Lipper et al., 2014). Three pillars define this approach: sustainable production; adapting and building resilience to climate change; and developing opportunities to reduce greenhouse gas emissions from agriculture. Consequently, soil water management practices that sustainably increase productivity and resilience, while reducing greenhouse gas emissions certainly qualify as climate-smart practices (Zougmoré et al., 2014). Although there is considerable interest in understanding farmer's resilience to climate change among different soil water management practices, surprisingly little empirical evidence exists. The question of whether soil water management practices can increase resilience in the context of climate change can best be assessed through crop yield response to extreme events.

This article explores two soil water management practices that have been widely adopted in Ethiopia: terraces and contour bunds. Farmers implement these practices as an adaptive strategy for agricultural land use in mountainous areas prone to erosion. They differ regarding the scale of intervention needed, the amount of labor involved and the potential benefits for yields (WOCAT, 2003). On the one hand, terraces consist of building horizontal human-made plots and are thus labor intensive. By reducing plot steepness, terraces affect soil composition, hydrology and thus plant growth. A meta-analysis found that terracing was on average 11.5 times more efficient at controlling erosion than non-terraced plots (Wei et al., 2016). The authors also observe an effect on runoff reduction, soil water recharge and nutrient enhancement. In Ethiopia, terraces have been mostly implemented in the form of level ditches – where the soil is thrown uphill to form an embankment (*Fanja yuu* terraces) – but stone bunds are also common (Kato et al., 2011). On the other hand, contour bunds are a simple agronomic measure that consists of ploughing and planting across the field slope so that it matches contour lines. The practice does not lead to changes in the slope profile and can be repeated each cropping season. Gebreegziabher et al. (2009) provide evidence of a positive effect of contour bunds on water utilization and soil conservation. As noted by the authors,

E-mail address: f.kosmowski@cgiar.org.

https://doi.org/10.1016/j.agwat.2018.02.025
Received 27 February 2017; Accepted 22 February 2018

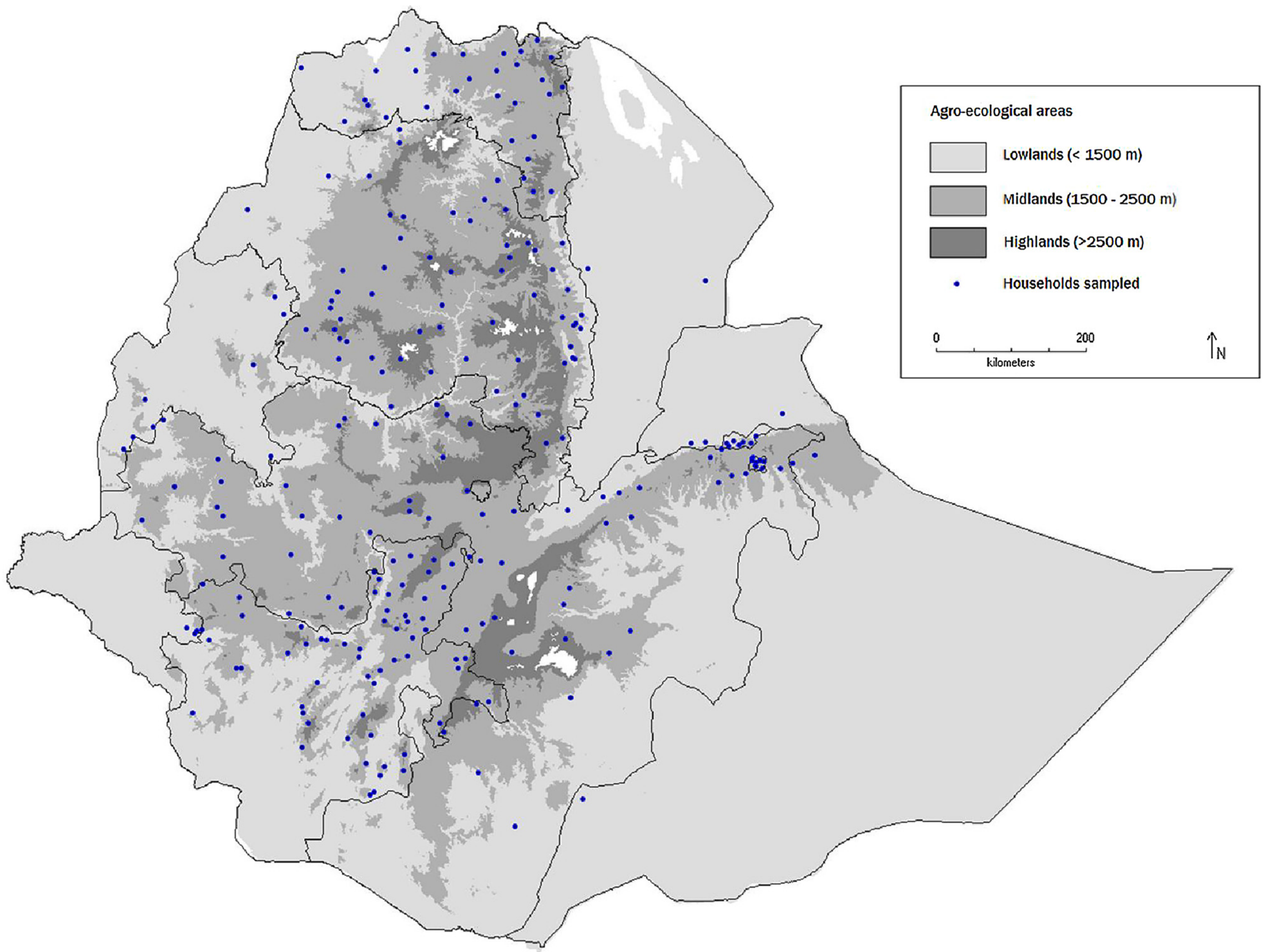

Fig. 1. Map of Ethiopia showing agro-ecological areas and sampled households.

contour bunds are most efficient when used in combination with other soil water management practices.

Previous studies in sub-Saharan Africa have shown mixed evidence regarding the effect of terraces and contour bunds on yields, with most, but not all studies reporting a positive effect (Gebremedhin et al., 1999; Vancampenhout et al., 2006; Adgo et al., 2013). In Tanzania, Raes et al. (2007) found that contour bunds appreciably increased the production of rain-fed lowland rice. One limitation of these studies is that they are conducted on relatively homogenous areas while also relying on small sample sizes, raising questions about inferences that can be made. Another interesting contribution is Kato et al. (2011) who found that soil water management practices perform differently in the different rainfall regimes of Ethiopia. While the authors acknowledged a risk-reducing effect of stone bunds in low-rainfall areas, soil bunds were only effective when used in combination with other technologies. At present, the relationship between soil water management and yield response to extreme events has seldom been examined and no empirical evidence exist for how yields would respond to extreme events. In 2015, some regions of Ethiopia faced one of the worst drought in decades. The zones of Tigray and Amhara were hit particularly hard (see Fig. A.1 in supplementary material). According to UN estimates, about 10.2 million farmers were in need of food assistance at the end of the 2015/16 meher season (WFPE, 2016).

The pathway through which soil water management practices may offer a buffering effect when a drought occurs is complex. Studies have demonstrated that at the global level, climate variability accounts for one third of observed cereal yields variability (Lobell and Field, 2007; Ray et al., 2015). However, due to the predominantly rainfed system of cultivation in sub-Saharan Africa, as high as 60% of cereal yield variability could be explained by climate variability (Ray et al., 2015). When rainfall events occur, part of the surface water runs-off while the rest infiltrates the soil at different levels. On mountainous plots, water infiltration in the soil is typically limited: most of surface water runs-off. Terracing decreases connectivity of overland flow, allows enhancing water infiltration and leading to an increase in soil moisture. The micro-watersheds created by terracing can increase water concentration as well as soil nutrient, which in turns provides better water conservation (Vancampenhout et al., 2006). The altered soil structure, richer in nutrients, can reduce evaporation and consequently have a shock minimizing effect when a drought occur. Thus, it is hypothesized that, compared to sites without terraces, terracing leads to a yield increase in drought-affected areas due to deeper water infiltration, soil water availability, soil nutrient supply and reduced evaporation. This effect is hypothesized to be more important on terraced plots, that rely on a structural transformation, than on plots where contour bunding was practiced. While contour bunds also decrease run-off volume, the effect on soil nutrient levels is likely more limited (Gebreegziabher et al., 2009) and thus the effect on yields may not be as pronounced as for terracing. Yields are influenced by several other factors, including biophysical factors, crop genetics, biotic and abiotic stress as well as farm management practices at different phenological stages of plant growth. Ideally, these factors should be accounted for when estimating the effect of soil water management practices on yields.

This article thus investigates the effect of terraces and contour bunds on yields during the 2015 drought in Ethiopia. Using the propensity matching method, the treatment effect of these practices is first