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Analysis

Farm-level Economic Analysis - Is Conservation Agriculture Helping the Poor?

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ABSTRACT

Conservation Agriculture (CA) has been widely promoted as an agro-ecological approach to sustainable production intensification. Across Sub-Saharan Africa, however, there have been low rates of adoption with fierce debate over its attractiveness for resource-poor farmers. Farm-level economics has been a key component of this debate with several authors questioning whether short-term benefits can occur with CA and advocating the need for more sophisticated economic analysis when comparing CA and conventional agriculture. This has included the importance placed upon more detailed farm-level data gathering as opposed to on-farm/on-station research. This study uses farm-level budget data gathered from a cross-sectional survey of 197 farmers, for the 2013/2014 season, within a district situated in Cabo Delgado Mozambique, to compare the underlying economics of CA and conventional agriculture. The study is enriched by having observations reflecting each year of CA use i.e. first, second and third year. Probabilistic cash flow analysis is used to compare the net present value of CA compared to conventional cropping over the short and longer term for differing crop mixes. Benefits are found in the short-term under CA but these are largely dependent on crop mix and the opportunity cost of labour assumed. We further employ Monte-Carlo simulations to compare the poorest farmers' net returns under different crop mixes and risk tolerance levels. Contrary to previous research, which has mostly suggested that better-off farmers are more likely to find CA useful, we find evidence that for the cohort of farmers under study the poorest are likely to find CA beneficial for a variety of crop mixes and risk-levels including under extreme risk aversion with the full opportunity cost of labour and mulch accounted for. These findings suggest that CA can be an attractive option for a wide variety of resource levels and crop mixes including those of the very poor in similar farming systems elsewhere in Sub-Saharan Africa.

1. Introduction

Conservation Agriculture (CA) is now practiced worldwide across all continents and ecologies including on various farm sizes from smallholders to large scale farmers (Friedrich et al., 2012). It is defined as the simultaneous application of three principles, namely minimal soil disturbance, permanent organic soil cover (covering at least 30% of the cultivated area) and the use of rotations and/or associations involving at least three different crops (FAO, 2015). In Sub Saharan Africa, conventional tillage practice which is primarily practiced through the application of hand-hoe or plough has resulted in severe soil erosion and loss of soil organic matter (SOM) which has been further exacerbated through the practice of slash and burn cultivation (Rockström et al., 2009; Thierfelder et al., 2012). Despite enthusiasm from proponents the adoption of CA has, however, remained fragmented throughout the region (Giller et al., 2009; Rockström et al., 2009).

There still exists a polarised debate, particularly in Sub-Saharan Africa, surrounding the merits of CA as an alternative to conventional tillage based farming. The debate has largely centred around the farm level costs/benefits, including the time horizon of benefits actually accruing, labour requirements and in particular whether CA requires the additional need of high inputs such as fertilisers and herbicides to be profitable (Giller et al., 2009; Rusinamhodzi et al., 2012). Significant yield benefits and/or improvements to gross margins due to higher labour productivity have been found in a number of circumstances relative to conventional agriculture (Mazvimavi and Twomlow, 2009; Ndlovu et al., 2014; Thierfelder et al., 2014a; Mupangwa et al., 2016) though fertilisers (organic/inorganic) are used in these comparisons and seen as an important addition. Likewise, Thierfelder et al. (2014b) showed that there can be benefits in the first few seasons under CA including significant yield benefits, however, these are site specific which may also require 'appropriate fertilisation' in order 'to become significant'. Vanlauwe et al. (2014) argued that a fourth principle should be

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used to define CA (i.e. the appropriate use of fertiliser) due to low yields and the competing needs for crop residues thereby resulting in sub-optimal application for soil cover. Thus, it is argued that adequate fertiliser application would simultaneously enhance crop productivity and organic residue availability. Sommer et al. (2014a) in contrast argue that fertiliser application should not be an additional principle but rather an additional practice as they argue that the application of (inorganic or organic) fertiliser is crucial to making CA work. However, this may not be the case for all soils and agro-ecosystems as improvements to productivity have been found under CA relative to conventional agriculture with very small amounts of residues applied (e.g. Sommer et al., 2014b). Moreover, sound nutrient management in any production system is a 'good practice' but should not be considered as a principle of CA (Sommer et al., 2014a) given there are also instances where mineral fertiliser applications have not resulted in higher yields and where soils are unresponsive (Tittonell and Giller, 2013).

Others have argued that CA has not benefited the poorest farmers (Nkala et al., 2011). Giller et al. (2015) more recently argued that CA is likely to 'remain beyond the grasp of smallholders' that lack adequate mechanisation, animal traction or herbicides. Considering maximisation of all production factors (including labour and land) and reducing the risk to the whole-farm is considered important for farmers (Giller et al., 2015). In addition, there has been scant research in the Sub-Saharan African region on smallholder farms that delves into farm-level economic analysis of CA with appropriate sophistication (Pannell et al., 2014).

A wide ranging review of previous farm-level economic studies has been discussed in depth by other authors (Pannell et al., 2014). They conclude that there are key deficiencies in much of the economic analysis, to date, including a lack of consideration of the time lags, discount rates, appropriate opportunity costs for labour (particularly as farm labour is monetised) and crop residues. Moreover, omission of the role of risk and uncertainty in farm level economic analysis is widespread (Ngwira et al., 2013; Pannell et al., 2014; Thierfelder et al., 2016).

A further criticism of much of the literature on CA has also been directed to the multitude of on-farm/on-station experiments which may not appropriately reflect farmers' realities (Soane et al., 2012). Though there are benefits from conducting rigorous studies through either on-farm or on-station experiments; a number of authors have suggested that farm-level data (i.e. from large scale household surveys) is needed to better analyse the impact of CA in different contexts (Ngwira et al., 2013; Pannell et al., 2014; Dalton et al., 2014; Carmona et al., 2015; Mafongoya et al., 2016). This criticism applies to much of SSA, including Mozambique where considerable attention has been given to research on CA systems in recent years (Nkala et al., 2011; Nkala, 2012; Famba et al., 2011; Grabowski and Kerr, 2014; Thierfelder et al., 2015; Nyagumbo et al., 2015; Thierfelder et al., 2016). Most of these studies have focused on-farm level experiments whilst some have focused on farm-level economics (Grabowski and Kerr, 2014). These have not addressed risk analysis or on-farm level economic analysis through large scale household surveys. Moreover, specific research relating to CA in Cabo Delgado (Northern Mozambique where this study is based) on farm-level economics is limited and/or has not been documented through peer-reviewed research to date.

In this study we use elements of the economic model framework presented by Pannell et al. (2014) to address some of the key concerns raised in the literature. Similar research has also been reported in this journal which also explored the economics of Conservation Agriculture, including using certainty equivalents and considering risk, but did not consider different wealth categories (Tessema et al., 2015). The aim of this study is to better help understand whether CA provides an attractive option for the farmers within this case-study region when all known economic considerations are addressed. Given research, extension and development efforts in general are also focused throughout the region on reaching the poorest, we also use this cohort to explore farmers' net returns under various risk levels and crop mixes used. The description of the model and approach is presented in Section 2 and the model and results in Section 3. A discussion is provided in Section 4 and conclusions to the paper are presented in Section 5.

1.1. Background of Study Area

Cabo Delgado is the northernmost province situated among the coastal plain in Mozambique. The majority of inhabitants, within the province rely on subsistence agriculture (mainly rainfed agriculture). Conventional agriculture practices (including slash and burn) are still pervasive and mainly done through ploughing by hand-hoe or animal traction.

Mozambique consists of ten different agro-ecological regions (R1-10). These have been grouped into three different categories which are based in large part on mean annual rainfall and evapotranspiration (ETP). First, the highland category represents high rainfall regions (>1000 mm, mean annual rainfall) with low evapotranspiration and correspond to R3, R9 and R10. The medium altitude category in contrast (R7, R4) corresponds to areas with mean annual rainfall ranging between 900 and 1500 mm and medium level of ETP. Finally, the low altitude category (R1, R2, R3, R5, R6, R7, R8) are hot with comparatively low rainfall (<1000 mm mean annual rainfall) and high ETP (INIA, 1980; Silici et al., 2015). The Cabo Delgado province falls within R7, R8, and R9. The particular district under study (Pemba-Metuge) is situated within R8; distribution of rainfall is often variable with many dry spells and frequent heavy downpours. The predominant soil type in R8 is Alfisols (Maria and Yost, 2006). These consist of soils with predominantly red clay texture which are deficient in nitrogen and phosphorous (Soil Survey Staff, 2010).

A recent study using the human development poverty index ranks Cabo Delgado as the second poorest province in Mozambique (INE, 2012). The province also has one of the highest rates of stunting in the country (Fox et al., 2005). Other issues such as the high population growth rate in Mozambique further exacerbate the poverty nexus. Within the study district (Pemba-Metuge), current projections show that the population will more than double by 2040 (INE, 2013).

1.1.1. Conservation Agriculture in Cabo Delgado

CA adoption in recent years has been stimulated in the province largely with the support of the AKF-CRSP (Aga Khan Foundation Coastal Rural Support Programme), which has been promoting CA in the province since 2008. AKF's approach has differed to other NGOs in the region as provision of incentives such as vouchers/subsidies or inputs such as herbicides, chemical fertilisers and seeds in order to stimulate adoption have not been provided. Farmer Field Schools have been established within each of the districts and helped to encourage adoption of CA among farming households. Given the lack of draft and mechanical power in Cabo Delgado, manual systems of CA have been promoted such as the use of a dibble stick which is a pointed stick used to open small holes in crop residues for planting seed. Micro-pits are often also used in the early years of CA to break soil compaction and are the most commonly used system in the region. These are similar to basins used elsewhere in Sub-Saharan Africa and originate from the Zai pit system used in the Sahel (e.g. Thierfelder et al., 2016). These AKF-CRSP have promoted the use of micro pits (35 cm long × 15 cm wide × 15 cm deep). It should be noted that these differ to some forms of conservation farming systems used in Zambia and Zimbabwe that require regular soil-tillage inside the basins i.e. minimum tillage systems where tilling is done inside the basins using discs or tines in order to create a seedbed (e.g. Kassam and Brammer, 2016). Finally, the use of jab planters has also recently been promoted in the region.

2. Materials and Methods

2.1. Survey Procedure

This study is based on results from a survey of 197 farmers in the Metuge district, of Cabo Delgado Province Mozambique administered in the summer of 2014. A multi-stage sampling frame was employed to select the households from a list of local farmers provided by key informants