Smallholder farmers' motivations for using Conservation Agriculture and the roles of yield, labour and soil fertility in decision making

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Highlights

- Strongest predictor of intention to use CA is the attitude that farmers hold towards CA.
- Key cognitive drivers are increased yield, reduction in labour and improvement in soil quality.
- Farmer Field School members perceive CA as the easiest to use and have the highest intention to use CA.
- The poorest farmers have a higher intention to use CA than better-off farmers.
- Potential barriers to using CA are perceptions of labour shortage and lack of knowledge/skills.

Abstract: Conservation Agriculture (CA) has been widely promoted as an agro-ecological approach to sustainable production intensification. Despite numerous initiatives promoting CA across Sub-Saharan Africa there have been low rates of adoption. Furthermore, there has been strong debate concerning the ability of CA to provide benefits to smallholder farmers regarding yield, labour, soil quality and weeding, particularly where farmers are unable to access external inputs such as herbicides. This research finds evidence that CA, using no external inputs, is most attractive among the very poor and that farmers are driven primarily by strong motivational factors in the key areas of current contention, namely yield, labour, soil quality and weeding time benefits. This study is the first to incorporate a quantitative socio-psychological model to understand factors driving adoption of CA. Using the Theory of Planned Behaviour (TPB), it explores farmers' intention to use CA (within the next 12 months) in Cabo Delgado, Mozambique where CA has been promoted for almost a decade. The study site provides a rich population from which to examine farmers' decision making in using CA. Regression estimates show that the TPB provides a valid model of explaining farmers' intention to use CA accounting for 80% of the variation in intention. Farmers' attitude is found to be the strongest predictor of intention. This is mediated through key cognitive drivers present that influence farmers' attitude such as increased yields, reduction in labour, improvement in soil quality and reduction in weeds. Subjective norm (i.e. social pressure from referents) and perceived behavioural control also significantly influenced farmers' intention. Furthermore, path analysis identifies farmers that are members of a Farmer Field School or participants of other organisations (e.g. savings group, seed multiplication group or a specific crop/livestock association) have a significantly stronger positive attitude towards CA with the poorest the most likely users and the cohort that find it the easiest to use. This study provides improved understanding relevant to many developing countries, of smallholder farmers' adoption

dynamics related to CA, and of how farmers may approach this and other ‘new’ management systems.

Keywords: Conservation Agriculture, Adoption, Theory of planned Behaviour

1. Introduction

The complex interaction of population growth, technological advancement and climate change have impacted heavily on agricultural and environmental sustainability. Modern farming systems that are used throughout the industrialized world have traditionally been characterized by high use of inputs and mechanization of agriculture involving tillage. Notwithstanding the potential to increase food production through conventional intensive agriculture it has been well documented that such agricultural systems are a source of significant environmental harm (Pretty, 2008; Tilman, 1999). In Sub-Saharan Africa, conventional tillage practice usually through hand-hoe or animal traction has resulted in soil erosion and loss of soil organic matter (SOM) which has been further exacerbated by the practice of crop residue removal and burning (Rockström et al., 2009). Consequently a ‘business as usual’ approach to agricultural development is seen as one which will be inadequate to deliver sustainable intensification for future needs (Shaxson et al., 2008). Thus, the discourse on agricultural sustainability now contends that systems high in sustainability are those that make best use of the environment whilst protecting its assets (Pretty, 2008).

Conservation Agriculture (CA) forms part of this alternative paradigm to agricultural production systems approaches. Most recently, authors have questioned the mode in which CA is being used as an ‘across-the board’ recommendation to farmers without proven benefits in terms of boosting yields, labour reduction and carbon sequestration (Giller, 2012). This is compounded by internal debate with those advocating for the use of CA practices with different terms emerging from 'no-tillage' to 'conservation tillage' and 'minimum tillage' over the past decades. Many of these have been ascribed to CA. A wide variety of the differing typologies have also been defined and discussed (Kassam et al., 2009). CA is, however, defined as: (i) *Minimum Soil Disturbance*: Minimum soil disturbance refers to low disturbance no-tillage and direct seeding. The disturbed area must be less than 15 cm wide or less than 25% of the cropped area (whichever is lower). There should be no periodic tillage that disturbs a greater area than the aforementioned limits. (ii) *Organic soil cover*: Three categories are distinguished: 30-60%, >60-90% and >90% ground cover, measured immediately after the direct seeding operation. Area with less than 30% cover is not considered as CA. (iii). *Crop rotation/association*: Rotations/associations should involve at least 3 different crops. (FAO, 2015).

CA, by definition, is now practiced on more than 125 million hectares worldwide across all continents and ecologies (Friedrich et al., 2012). It is also used on various farm sizes from smallholders to large scale farmers and on a wide variety of soils from heavy clay to highly sandy (ibid). There have, however, been mixed experiences with CA particularly in Sub-Saharan Africa (Giller, 2009) where human and animal powered CA systems predominate (given the lack of mechanisation) as opposed to machine powered systems (i.e. involving minimal soil disturbance) that are being used elsewhere in the world. Furthermore, across Sub-Saharan Africa there have been low rates of adoption which have fuelled controversy surrounding the benefits of CA both in terms of the private and social benefits accruing from adoption. Akin to Giller's arguments (Giller, 2009; Giller, 2012), Baudron et al. (2012) found for farmers in the Zambezi Valley (Zimbabwe) that CA required additional weeding and lack of labour availability for this task reduced uptake. Chauhan et al. (2012) have also argued that in general there is a poor understanding of weed dynamics within a CA system which can have a bearing on farmer adoption of CA. Sumberg et al. (2013) also explored the recent debates surrounding CA and questioned the 'universal approaches to policy and practice' which may limit the understanding of different contextual factors and alternative pathways.

Other issues surrounding the CA discourse involve the particular time horizon for benefits to materialise and that farmers are concerned with immediate costs and benefits (such as food security) rather than the future (Giller, 2009). Rusinamhodzi et al. (2011) found that CA does have added benefits but these are largely found in the longterm. Yields under CA may even incur losses compared to conventional agriculture, especially in the short run and in excessively wet years (Thierfelder and Wall, 2010). A recent systematic review conducted by Wall et al. (2013) for CA in Eastern and Southern Africa (maize [*Zea mays*]-based systems) also found that yields were generally equal or higher than conventional agriculture. Wall et al. (2013) further postulate that successful CA systems require adequate soil fertility levels and biomass production. The feasibility of crop residue retention, particularly in strong mixed crop-livestock systems has also been questioned (Giller, 2009).

Nkala (2012) also suggests that CA is not benefiting the poorest farmers and they require incentives in the form of subsidised inputs. Grabowski and Kerr (2013) further argue that without subsidised fertiliser inputs CA adoption will be limited either to only small plots or abandoned altogether. Access to fertiliser and other inputs including herbicides are therefore a contentious issue, with a number of authors arguing that for CA to improve productivity; appropriate fertiliser applications and herbicide applications need to be used (Rusinamhodzi et al., 2011; Thierfelder et al., 2013b). Wall et al. (2013) found in their review that of the studies with improved yields most were fertilised (including animal manure) and had both retained residues as mulch and employed chemical weed control complemented by hand weeding- requiring inputs that in reality are beyond the reach of most smallholders.

Recent economic theory contends that the adopter makes a choice based on maximization of expected utility subject to prices, policies, personal characteristics and natural resource assets (Caswell et al., 2001). Similarly, a vast array of studies within the agricultural technology adoption literature have focused on farm characteristics and socio-economic factors that influence adoption. Limited research, however, has been done which has concentrated on cognitive or social- psychological factors that influence farmers' decision making such as social pressure and salient beliefs (Martínez-García et al., 2013).

Thus, in analysing the factors that affect adoption, understanding of the socio-psychological factors that influence farmers' behaviour is an important consideration. With respect to CA research, this notion is supported to some extent by Knowler and Bradshaw (2007) who have shown for an aggregated analysis of the 31 distinct analyses of CA adoption that there are very few significant independent variables (education, farm size etc.) that affect adoption. Just two, 'awareness of environmental threats' and 'high productivity soil' displayed a consistent impact on adoption i.e. the former having a positive and the latter a negative impact on adoption. Wauters and Mathijs (2014) similarly meta-analysed adoption of soil conservation practices in developed countries and also found that many classic adoption variables such as farm characteristics and socio-demographics are mostly insignificant, and if significant, both positive and negative impacts are found. Other authors have also suggested that adoption should not be viewed as a single decision but rather a decision making process over time as farmers continually try, adapt and decide on when to use technologies (Martínez-García et al., 2013). Furthermore, in a recent meta review of CA studies, Stevenson et al. (2014) have suggested a key area for research in Asia and Africa will be understanding the process of adoption.

Research on CA in Cabo Delgado (Northern Mozambique where this study is based) is sparse and/or has not been documented by way of peer-reviewed research. Previous studies on CA systems have been conducted elsewhere in Mozambique (Nkala et al., 2011; Nkala, 2012; Famba et al., 2011; Grabowski and Kerr, 2013; Thierfelder et al., 2015; Nyagumbo et al., 2015; Thierfelder et al., 2016). Most of these studies have focused on on-farm level experiments whilst some have focused on farm-level economics (Grabowski and Kerr, 2013) and determinants of adoption (Nkala et al., 2011). In addition, other studies in Mozambique have explored adoption of chemical fertiliser and new maize varieties using socio-psychological constructs (Cavane and Donovan, 2011) and explored adoption of new crop varieties through social networks (Bandiera and Rasul, 2008) whilst others have used more conventional approaches (i.e. using farm level/household characteristics) to assess agriculture technology adoption (Uaiene et al., 2009; Benson et al., 2012) or further econometric approaches used to examine the impact of adoption of various improved agricultural technologies on household income in Mozambique (Cunguara and Darnhofer, 2011). Leonardo et al. (2015) also recently assessed the potential of maize-based smallholder productivity through different farming typologies. Thus household level studies exploring adoption dynamics with a socio-psychological lens have been lacking both on CA and within the agricultural technology adoption literature in general i.e. not restricted to Mozambique (as outlined earlier).

Socio-psychological theories which are helpful in this regard are The Theory of Planned Behaviour (TPB) and Theory of Reasoned Action (TRA). The TPB and TRA frameworks have been used in several studies to assess farmers' decision making for a range of agricultural technologies (Beedell and Rehman, 2000; Martínez-García et al., 2013; Borges et al., 2014). This has included more specifically studies which have assessed conservation related technologies such as water conservation (Yazdanpanah et al., 2014) including organic agriculture (Läpple and Kelley, 2013), soil conservation practices (Wauters et al., 2010) and more recently payment for ecosystem services related initiatives (Greiner, 2015). In relation to CA practices, previous studies have been conducted by Wauters et al. (2010) relating to for example, reduced tillage, which includes residue retention and the use of cover crops. These studies have focused on Europe and also have dealt with the behaviours as individual practices, e.g. the intention to use cover crops.

To our knowledge, having reviewed the various online search databases (e.g. Web of Science and Scopus etc.), for studies that use TPB in relation to Conservation Agriculture, this study is the first quantitative theory of planned behaviour study assessing farmers' intention to use Conservation Agriculture by definition i.e. the simultaneous application of minimum soil disturbance, organic mulch as soil cover and rotations/intercrops and/or use of associations.

This study makes a contribution to the existing literature by researching farmers' perceptions of CA use and addresses issues surrounding beliefs farmers hold with regards to specific areas of contention i.e. yields, labour, soil quality and weeds. We test the validity of the theory of planned behaviour in explaining farmers' intention to apply CA. Further, we test the added explanatory impact of farmer characteristics. After confirming the usefulness of the TPB to understand farmers' intentions, we proceed by investigating farmers' cognitive foundation, i.e., their beliefs that underpin their attitudes, norms and perceived control.

1.1 Background

1.1.1 Study area

Cabo Delgado is the northernmost province situated on the coastal plain in Mozambique.

Its climate is sub-humid, (or moist Savanna) characterized by a long dry season (May to November) and rainy season (December to April).

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

Though provincial data is sketchy, yields for staple crops in Mozambique are very low compared to neighbouring countries in Southern Africa. Average yields (calculated from FAOSTAT data based on the years 2008-2013), for example, show relatively low yields for maize (1.12 tons/ha), cassava (*Manihot esculenta Crantz*), (10 tons/ha) and rice (*Oryza sativa* L.), (1.2 tons/ha). These are lower than neighbouring Malawi which has much higher cassava (15 tons/ha), maize (2.3 tons/ha) and rice (2.1 tons/ha) yields. Maize and rice yields in

Malawi are virtually double those in Mozambique. Zambia has comparatively higher maize and rice yields but lower overall cassava yields than Mozambique. Maize yields (2.7 tons/ha) in Zambia, on average based on the past five years, are triple those in Mozambique and rice yields in Zambia are virtually double (1.7 tons/ha) (FAOSTAT, 2016).

The majority of inhabitants, within Cabo Delgado province rely on subsistence agriculture, where livestock numbers are very low and market access is often limited due to poor roads and infrastructure. Research has highlighted that the prevalence of stunting (55%) is the highest among all provinces in Mozambique (FAO, 2010). Furthermore, poverty studies also place Cabo Delgado among the poorest in Mozambique (Fox et al., 2005). A more recent study using the human development poverty index ranks Cabo Delgado as the second poorest province in Mozambique (INE, 2012). This is compounded by high population growth in Mozambique which exacerbates the poverty nexus. Current projections show that the population of Pemba-Metuge district will more than double by 2040 (INE, 2013). Though population density is considered very low across Mozambique (Silici et al., 2015) intensification as opposed to extensification of land will be imperative for the future with increased population, climate variability and lack of labour to clear new land (Thierfelder et al., 2015). Similar pressures exist in much of Sub-Saharan Africa and in many countries population pressure is far greater.

1.1.2 Conservation Agriculture in Cabo Delgado

CA adoption has gathered momentum in Cabo Delgado, in recent years, largely stimulated by the institutional presence of the AKF-CRSP (Aga Khan Foundation Coastal Rural Support Programme), which has been promoting CA in the province since 2008. The establishment of a number of Farmer Field Schools, within each of the districts, has also helped to encourage adoption of CA among farming households. As of 2014, there were 266 Farmer Field Schools that focus on CA running in Cabo Delgado with a combined membership of 5000 members.

Unlike other NGOs in parts of Mozambique and Sub-Saharan Africa, AKF have not provided inputs such as herbicides and chemical fertilisers in order to stimulate adoption. Given the lack of draft and mechanical power in Cabo Delgado, manual systems of CA have been promoted. AKF's approach has aimed to improve soil fertility through the use of legumes as green manure, annual (cover also as crops) and perennials, developing mulch cover with residues and vegetation biomass (produced on-farm or brought in from the surroundings i.e. bush areas) and compost.

2. Materials and Methods

2.1. Theoretical framework

The TPB is a social-psychological model which seeks to understand the dynamics of human behaviour (Ajzen, 1991). The model predicts the intention to perform a particular behaviour based on three factors. These are: (i) attitudes towards the behaviour which can be either positive or negative, (ii) subjective norms (i.e. social pressures to adhere to the certain behaviour) and (iii) perceived behavioural control (i.e. to what extent the individual perceives to have control over engaging in the behaviour). These three factors together either form a positive or negative intention to perform the behaviour under study (See Figure 1). In addition, if there is adequate actual behavioural control e.g. presence of sufficient knowledge, skills and capital then the individual will act on their intention. Ajzen (2005) has suggested that it is possible to substitute actual behavioural control for perceived behavioural control. For this study perceived behavioural control is taken as a proxy for actual behavioural control. The TPB is the successor of the Theory of Reasoned Action (TRA). Theory of Reasoned Action was developed first, by Fishbein and Ajzen (1975) and posited that people's behaviour was explained by two considerations. The first was attitude, or the degree to which people evaluated the behaviour as positive or negative. The second was subjective norm, the perceived social pressure from others to perform the behaviour or not. Empirical evidence showed that this theory was successful in explaining people's behaviour as long as they have full volitional control over performance of the behaviour, i.e. all necessary conditions in terms of presence of necessary requirements and absence of any inhibiting factors were met. As this is only the case in a limited number of contexts and behaviours, the TPB was developed. In this theory, the concept of perceived behavioural control was added, which reflect the perceived degree of control a person has regarding his/her own capacity to perform the behaviour. This perceived degree of control has to do with the degree to which all the necessary prerequisites in order to perform the behaviour are met. As a general rule of thumb, the stronger the attitude, subjective norm and perceived behavioural control the stronger the intention is likely to be to perform the behaviour (Davis et al., 2002).

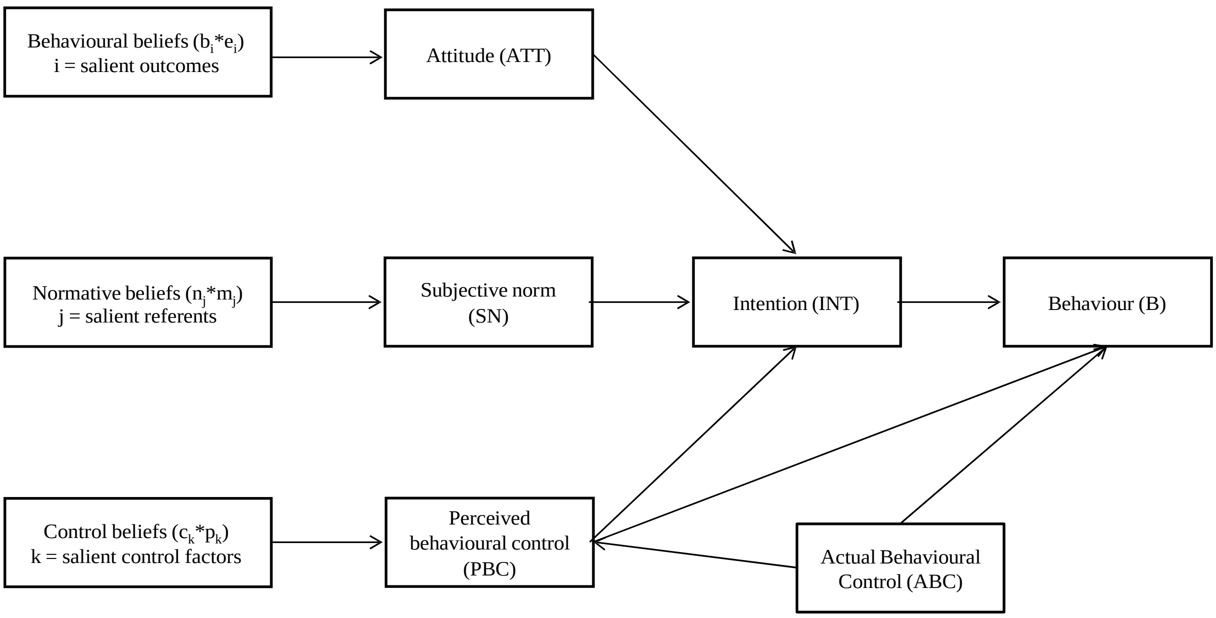

Figure 1. Theory of planned behaviour (Adapted from Azjen, 1991)

Attitudes, subjective norms and perceived behavioural control are the results of behavioural, normative and control beliefs respectively. These beliefs are the cognitive foundations that determine the socio-psychological constructs. The belief based measures are calculated using the expectancy-value model (Fishbein and Ajzen, 1975). Behavioural belief or the expectation that the belief will lead to an outcome (b) is multiplied by the outcome evaluations of those beliefs(e). Each of the beliefs are subsequently multiplied by their respective outcome evaluation. These are then aggregated to give an overall attitude weight. Similarly, for subjective norm, each normative belief i.e. the expectations of others also termed referents (n) is multiplied by the motivation to comply with their opinions(m). These are then summed to create an overall weight for subjective norm. Finally, control beliefs, (c) are multiplied by the perceived power of the control belief (p) that either inhibit or help to facilitate the behaviour. These are also aggregated to create a weight for perceived behavioural control (Wauters et al., 2010; Borges et al., 2014). The relationship between the cognitive foundations (beliefs) and their respective constructs is shown in the following equations:

$$A = \sum_{i=1}^{x} b_i e_i$$

$$SN = \sum_{j=1}^{y} n_j m_j$$

$$PBC = \sum_{\kappa=1}^{z} c_k p_k$$

Similar notation is used to that of Wauters et al.(2010) and Borges et al., (2014) where i is the ith behavioural belief, χ the total number of behavioural beliefs, j the jth referent, Y the total number of referents, κ the κth control factor and z the total number of possible control factors. While we will not quantitatively calculate attitude, subjective norm and perceived behavioural control using the expectancy-value theory, this theory offers us a framework we can use to investigate the cognitive foundations that determine attitude, subjective norm and perceived behavioural control.

2.2. Survey procedure

We adopted a sequential mixed-method research approach, in which qualitative data collection preceded the quantitative data collection stage. Sequential mixed-methods are widely used in agricultural research to shed light on often complex phenomena, such as farmers' behaviour (e.g. Arriagada et al., 2009). The results of the first stage were used to design the data collection instrument used in the second stage. According to the TPB conceptual framework, outlined above, key themes exploring the advantages and disadvantages of the behaviour in this case CA use were explored. Moreover, these interviews were used to elicit information on social norms and social referents and existing factors affecting adoption of CA. Knowledge of these factors is necessary to construct the survey instrument intended to quantitatively assess farmers beliefs related to the outcomes, referents and control factors. In this qualitative stage, 14 key informant interviews and 2 focus groups discussions (FGD) were carried out in three different villages over the period of a month from February to March, 2014.

As with most qualitative data analysis the transcriptions were coded and categorised into groups using deductive content analysis (Patton, 2002). These were done first by colour i.e. highlighting aspects which related to the theory of planned behaviour. Sub-themes were then explored which related to specific aspects of the theory of planned behaviour such as behavioural beliefs and social referents. Links within categories and across categories were also looked for. The final result of this stage was a complete list of all salient outcomes, all salient referents and all salient control factors. This list was subsequently used to design part of the survey, as explained in the next section. For the complete lists of all salient outcomes, referents and control factors, we refer to tables 5, 6 and 7 respectively. The term 'all accessible' is used in these table captions which refer to the complete lists of salient outcomes, referents and control factors gathered in the first stage.

A translator was used that was conversant in the different dialects used in the district. Access to the village and district was granted through discussion with the village elders through the Aga Khan Foundation district facilitator.

The study presents results from a survey of 197 farmers in the Metuge district, of Cabo Delgado Province Mozambique**.** A multi-stage sampling procedure was used to select the households from a list of local farmers provided by key informants in each of the villages. The total clusters (i.e. in this case villages were chosen based on whether the Aga Khan Foundation had a presence there and started on CA awareness work). This list came to 13 villages. Six communities were chosen randomly from this list and households were selected randomly from the lists in these villages using population proportional to population size. In the initial sample, 250 farmers were surveyed. Due to non-response of 53 farmers, our final effective sample size was 197. The survey was translated into Portuguese and trained enumerators were used that were conversant in both Portuguese and the dialects used in the different villages.

2.3. Variables and measurement

The survey consisted of several sections. The first 4 sections contained questions about household and farm characteristics, about agricultural production practices, about plot level characteristics and about the previous use of conservation agriculture. The next two sections dealt with household assets and food and nutrition security. The seventh section assessed farmers' current CA adoption. The remaining sections contained questions dealing with the

TPB. Since the survey was performed in the course of a larger research project, in the remainder of this section, we only explain the measurement of those variables that were used in the analyses reported in this study.

Age (AGE) was measured as a continuous variable, village (VILLAGE_ID), and education (EDUC) were measured using codes for the villages i.e. 1-6 and levels of educational attainment in the case of education. Membership of a CA Farmer Field School (MEMBER_FFS), membership of other organisations (MEMBER_OTHER), sex (SEX) were measured using dichotomous variables. Principal component analysis (PCA) was conducted in order to establish a wealth index (i.e. POVERTY_INDEX). As is common in a number of poverty studies the first principal component (PC1) which explained the majority of variance in the data was used as the index (Edirisinghe, 2015). Households were then ranked into terciles with respect to the level of wealth, taking three values referring to lower, middle and upper tercile (POVERTY_GROUP).

The TPB variables were measured using Likert-type items or items from the semantic differential, i.e., questions to which the respondent has to answer on a scale with opposite endpoints. Intention (INT) was assessed by asking the farmer how strong his intention was to apply CA on his/her farm over the next year, on a scale from 1 (very strong) to 5 (very weak). Attitude (ATT) was assessed using two items. The first asked the farmer to rate the importance of using CA on the farm in the course of the next year, on a scale from 1 (very important) to 5 (very unimportant). The second item asked the farmer to indicate how useful it would be to apply CA on the farm in the next year, on a scale from 1 (very useful) to 5 (very useless). The
3 final score for attitude was calculated as the mean score of these two items.

Subjective norm (SN) was assessed by asking the farmer how likely it is that identified important others (salient referents) would think he/she should apply CA in the next year, on a scale from 1 (very likely) to 5 (very unlikely). Finally, perceived behavioural control (PBC) was assessed through a question about the difficulty of applying CA in the next year, on a scale from 1 (very easy) to 5 (very difficult). When inserting the data in a database, all these items were recoded from -2 to +2, with low values being unfavorable and high values being favorable towards CA.

Behavioural beliefs are farmers' beliefs about the salient outcomes of CA. During the qualitative stage, we identified a list of salient outcomes. For each of these outcomes, two questions were included in the survey, one for belief strength and one for outcome evaluation. Strength of the behavioural belief was measured by asking the respondent to indicate his/her agreement with the statement that application of CA resulted in the particular outcome, on a scale with endpoints 1 (strongly agree) and 5 (strongly disagree). Outcome evaluation was measured by asking the farmer the importance of that outcome, on a scale from 1 (very important) to 5 (very unimportant). Both items were recoded into a bipolar scale from -2 to +2, with -2 values meaning that the outcome was very unlikely and very unimportant to the farmer and +2 indicating the opposite.

Normative beliefs are beliefs about important referents. During the qualitative stage, we identified a list of salient referents, and for each of these, two questions were included in the survey. Strength of normative belief was measured with the question "how strongly would the following encourage you to use conservation agriculture on your farm?" on a scale with endpoints 1 (strongly encourage) to 5 (strongly discourage). Motivation to comply was also measured on a unipolar scale from 1 (very motivated) to 5 (not at all motivated) with the question: "How motivated would you be to follow the advice of the following regarding using conservation agriculture on your farm?" Both items were recoded into bipolar scales from -2 to +2, with -2 indicating that the referent would strongly discourage CA and that the farmer was not at all motivated to comply with advice from this referent, and +2 meaning the opposite.

Control beliefs are beliefs of the farmers about control factors (barriers or motivators). Control belief strength assessed the degree to which the control factor is relevant for the specific respondent. For example, "Do you have enough labour to use CA in the next 12 months?" scaled from 1 (strongly agree) to 5 (strongly disagree). Power of control factor measures the degree to which the control factor can make it easy or difficult to apply CA. This was measured by asking the farmer whether they agreed with the statement that the presence of this control factor was important to be able to apply CA, on a scale from 1 (strongly agree) to 5 (strongly disagree). The first item was recoded into a scale from -2 to +2; with -2 meaning that the control factor was not present.

2.4. Data analysis

Data was analysed in SPSS version 21. First, the data was cleaned by checking for cases with too many missing values, outliers and irregularities. As the survey was performed using personal enumeration, no cases had to be excluded because of too many missing values. Further, no outliers or other irregularities were found. All scale questions exhibited an acceptable degree of variation, meaning that not too many scores were in just one scale category. Second, we calculated descriptive statistics of the sample, including farm and farmer characteristics, adoption rate and TPB variables. Third, we performed a series of mean comparison analyses to compare the mean level of the TPB variables between different groups, using analysis of variance (ANOVA). When there were more than two groups, we performed post-hoc tests, which were evaluated using Tukey HSD in case of equal variances and Dunnett's T3 in case of unequal variances. The equality of variance assumption was evaluated using the Levene's test. We compared mean scores of the TPB between a number of variables that have been hypothesized to influence adoption of conservation practices, these being highest education level of the household head (EDUC), sex of the household head (SEX), membership in a CA Farmer Field School (MEMBER_FFS), membership in other organisations (MEMBER_OTHER), between the different villages (VILLAGE_ID), and between three groups on the poverty index (POVERTY_GROUP). We also computed correlations between TPB variables, and age of the household head (AGE) and the continuous poverty index (POVERTY_INDEX). Fourth, we tested the ability of the theory of planned behaviour to explain farmers' intention to apply CA, and investigated the role of the aforementioned farm and farmer characteristics. This was done using a hierarchical regression analysis with intention as dependent variable, in which attitude (ATT), subjective norm (SN) and perceived behavioural control (PBC) were added in the first step and the farmer characteristics in the second. Regression analysis was done using simple ordinary least squares (OLS) and assumptions were checked. As this analysis suggested that, in line with Ajzen (2011), the impact of these factors was fully mediated through the TPB predictors, we performed a path analysis in AMOS. First, we included all paths between these farmer characteristics and the three TPB variables, and gradually eliminated insignificant paths. As an additional check of the model, we dichotomized intention into a new variable, HIGH_INT, being 1 when intention was higher than 0, on a scale from -2 (very negative intention) to 2 (very positive intention) and 0 otherwise. The mean scores for attitude (ATT), subjective norm (SN) and perceived behavioural control (PBC) were compared between these two groups of those with low intention and high intention, using ANOVA analysis. Fifth, we examined the belief structure, by means of a Mann-Whitney U test, which assesses whether significant differences exist in the beliefs held by those with low intention and high intention.

3. Results

3.1. Summary statistics

Table 1 shows the summary statistics of the sample. Off-farm income is generally very low signifying the importance of agriculture in this region. Household sizes are quite high on average with low levels of educational attainment. Very low use of external inputs were found with only one farmer from the sample using a pesticide or compost and no farmers were using fertilisers, herbicides or animal manure (Lalani, 2016). Application of mulch refers to those farmers covering the soil with at least 30% of the cultivated soil surface covered.

Table 1. Summary statistics of the sample (n = 197)

Variable	Mean value or Percentage (Standard deviation in parenthesis)
SEX of Household Head	(Male 65%; Female 35%)
AGE of Household Head	62(27.9)
Marital status	(69 %= married, 2%= Divorced, 4%=Separated, 9%= Widowed and 16%=Single)
EDUC (Based on educational attainment i.e. grades completed 1-12)	2.4(2.8)
Household size	5.2(2.4)
Off-farm income (1 =yes, 2=no)	1.8(0.3)

Number of plots owned	1.4(0.5)
Mean Total Land size (hectares)	1.7(7.0)
Current adoption	
Micro-pits with mulch and rotation/intercrop using at least 3 different crops	51%
No-tillage with mulch and rotation/intercrop using at least 3 different crops	12%
Partial adoption/adaptation (mostly using two crops with mulch and either no till/micro-pits)	10%
No CA (no mulch)	24%
No CA (with mulch)	3%

Table 2 presents summary statistics of the TPB variables. It shows that the farmers in the sample have on average a positive intention to apply CA in the next 12 months. Likewise, they have a positive attitude towards CA, they are influenced by social norms to apply CA and they perceive CA as easy to use.

Table 2. Summary statistics and mean comparison of the theory of planned behaviour variables (n = 197)

	INT[h]	ATT[h]	SN[h]	PBC[h]
All	0.888 (0.713)	0.876 (0.496)	1.061 (0.667)	0.741 (0.699)
Villages				
Saul (n = 33)	1.061 (1.116)	1.046 [a] (0.642)	1.152 (0.755)	0.727 (0.911)
Nangua (n = 57)	0.947 (0.692)	0.886 (0.500)	1.070 (0.728)	0.772 (0.756)

Tatara (n = 38)	0.658 (0.582)	0.684[a] (0.512)	0.974 (0.716)	0.605 (0.679)
25 Juni (n = 24)	0.958 (0.550)	0.958 (0.327)	1.125 (0.537)	0.875 (0.448)
Nancarmaro (n = 11)	1.000 (0.000)	1.000 (0.000)	1.182 (0.405)	1.000 (0.000)
Ngalane (n = 34)	0.794 (0.538)	0.809 (0.427)	0.971 (0.577)	0.677 (0.638
Sex				
Male (n= 129)	0.861 (0.798)	0.857 (0.546)	1.054 (0.711)	0.690 (0.789)
Female (n = 68)	0.941 (0.515)	0.912 (0.386)	1.074 (0.581)	0.838 (0.477)
Education				
No education (n = 93)	0.893 (0.598)	0.844 (0.478)	1.054 (0.632)	0.817 (0.551)
Education (n = 104)	0.885 (0.804)	0.904 (0.512)	1.067 (0.700)	0.673 (0.806)
Membership in CA Farmer Field School				
Member (n = 122)	1.148[b] (0.400)	1.090 [b] (0.249)	1.262 [b] (0.442)	0.992 [b] (0.375)
No member (n = 75)	0.467 [b] (0.890)	0.527 [b] (0.592)	0.733 [b] (0.827)	0.333 [b] (0.890)
Membership in other organisations				
Member (n = 40)	1.100[c] (0.672)	1.063 [c] (0.282)	1.300 [c] (0.564)	0.950 [c] (0.639)
No member (n = 157)	0.834 [c] (0.715)	0.828 [c] (0.527)	1.000 [c] (0.679)	0.688 [c] (0.706)
Poverty group				
Low (n = 64)	1.078[d] (0.762)	0.992[e] (0.441)	1.359[f] (0.675)	0.938[g] (0.560)
Middle (n = 65)	0.800 [d] (0.712)	0.846 [e] (0.537)	0.969 [f] (0.612)	0.631 [g] (0.782)
High (n = 64)	0.813 [d] (0.639)	0.813 [e] (0.484)	0.875 [f] (0.630)	0.688 [g] (0.687)

a significant difference between Tatara and Saul ($p < 0.05$)
b significantly different between members and non-members ($p < 0.001$)
c significantly different between members and non-members ($p < 0.05$)
d significantly different between low and middle and between low and high ($p < 0.10$)
e significantly different between low and high ($p < 0.10$)
f significantly different between low and middle and between low and high ($p < 0.05$)

g significantly different between low and middle and between low and high ($p < 0.10$)
h Means scores and standard deviation on a scale from -2(unfavourable towards CA) and +2 (favourable towards CA)

3.2. Relationship between TPB variables and farmer characteristics

Table 2 presents the results of a series of ANOVA analyses comparing TPB variables between groups with different characteristics. There is no significant difference in any of the variables between villages, with the exception of attitude, being significantly higher in Saul compared to Tatara. Furthermore, the TPB variables do not differ between male and female farmers, or between educated and non-educated farmers. There is a significant difference between farmers who belong to other organisations (e.g. savings group, seed multiplication group or specific crop/livestock association) and those who do not. Farmers who are members of the CA Farmer Field Schools have more favourable values of all TPB variables, as do farmers who belong to any other group. The difference is much more pronounced for membership of the CA Farmer Field Schools. Lastly, there is a statistically significant difference according to the poverty group, a wealth classification based on the poverty index, described above. Farmers from the low wealth group have significantly more favourable values towards CA than farmers from the middle or high group. This is confirmed by computing the Spearman's correlation between the TPB variables and the POVERTY_INDEX, which is always negative and significant (INT: -0.211; ATT: -0.199; SN: -0.311; PBC: -0.201; $p < 0.01$). AGE, finally, had no significant correlations with any of the TPB variables.

3.3. The theory of planned behaviour model

The TPB suggests that intention is explained by attitude, subjective norm and perceived behavioural control. In addition, the analysis reported in table 2 suggests that there are some farmer characteristics that influence farmers' TPB variables. According to Ajzen (2011), the impact of such variables on intention is usually mediated through attitude, subjective norm and perceived behavioural control.

To investigate the validity of the theory of planed behaviour, we first ran a hierarchical regression analysis with intention as dependent, entering attitude, subjective norm and perceived behavioural control in the first step, and adding the farmer characteristics in the second step. The results are presented in table 5. It shows that attitude has the highest influence on intention, followed by perceived behavioural control. Subjective norm has the lowest influence. All three TPB-variables have a significant influence on intention. The model R^2 was 0.795, indicating that attitude, subjective norm and perceived behavioural control combined, explain 80% of the variation in intention to apply CA in the next 12 months. Adding the farmer characteristics increase R^2 only marginally and none of the additional variables are significantly different from 0. This is in line with the mediation hypothesis.

The Durbin-Watson test statistic of this hierarchical regression was 1.857, indicating no violation of the homoscedasticity assumption. Upon analysis of the residuals, however, we did find minor violations of the normality assumption. Therefore, as an additional test of the validity of the model, we dichotomized intention, as described above, and compared mean attitude, subjective norm and perceived behavioural control between those with low and high intention. The results are shown in table 3. Furthermore, we notice that attitude, subjective norm and perceived behavioural control have significant and positive correlations with intention, thereby further confirming the empirical validity of the model.

Table 3. Results of the ANOVA mean comparison of TPB variables between farmers with low and high intention to use CA (n = 197)

	ATT[b]	SN[b]	PBC[b]
Low intention (n = 41)	0.037[a]	0.098 [a]	-0.390 [a]
High intention (n = 156)	1.096 [a]	1.314 [a]	1.039 [a]

[a] significantly different between those with low and high intention, $p < 0.001$
[b] mean value on a score from -2 (very unfavourable) to +2 (very favourable)

Table 4. Results of the hierarchical regression analysis on intention to adopt CA, with basic TPB variables only in the first step, and farmer characteristics added in the second step (n=197)

	Standardized coefficient	R^2
ATT	0.529***	
SN	0.137 **	
PBC	0.303 ***	
		0.795
ATT	0.563 ***	
SN	0.139***	
PBC	0.298***	
POVERTY_INDEX	0.022	
SEX	-0.013	
AGE	-0.037	
EDUC	-0.049	
MEMBER_FFS	0.038	
MEMBER_OTHER	0.007	

		0.796

** p < 0.01
*** p < 0.001

In the final analysis, we further investigate the mediation hypothesis, suggesting that the association of farmers' characteristics with intention (reported in table 2) is mediated through the TPB-variables. We estimated a path model, using AMOS, first including all possible paths from each of the farmer characteristics to attitude, subjective norm and perceived behavioural control. After elimination of all insignificant paths, the final model is as presented in figure 2.

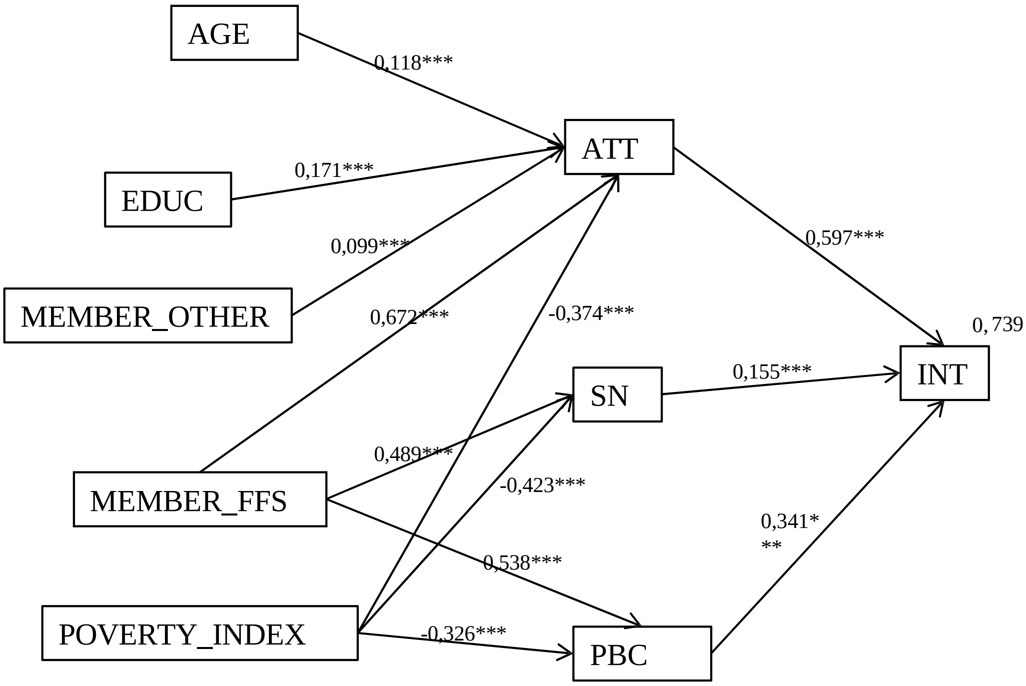

Figure 2. Path analysis of the impact of TPB variables and farmer characteristics on intention to apply CA (n = 197; standardized regression coefficient above arrows; *** p < 0.001; squared multiple correlations above rectangles)

This path model confirms the impact of attitude, subjective norm and perceived behavioural control on intention. Furthermore, it shows that age, education and membership of other organisations have a small but significant positive influence on the attitude towards CA. Older farmers have a more positive attitude towards CA. The more educated a farmer, the more positive his/her attitude towards CA. Farmers who are members of other organisations have a more positive attitude towards CA. More importantly, there are two other farmers' characteristics with a far greater impact. Farmers who are members of a CA Farmer Field School have a substantially more positive attitude towards CA, they perceive higher social norms, and they find it substantially easier to use. Finally, the poorer a farmer is on the poverty index, the more positive his/her attitude, the more favourable his/her perceived social norms and the easier he/she finds it to apply CA.

3.4. Analysis of the belief structure.

Table 5 highlights that farmers with a high intention to use CA have favourable perceptions of the benefits associated with using CA. Positive behavioural beliefs are seen as a cognitive driver to use of a technology (Garforth et al., 2006). Thus, there are clearly eight overall cognitive drivers. The three strongest are: (i) increased yield, (ii) reduction in labour, and (iii) CA improves soil quality. Other cognitive drivers which scored particularly highly are CA performs better in a drought year, CA reduces weeds and CA provides benefits in the first year of use. Those with high intention also feel CA is able to be used on all soil types and does not increase the amount of pests signified by the negative value for those beliefs.

Table 5. Mean comparison of belief strength and outcome evaluation of all accessible outcomes, between farmers with high intention and low intention to use CA(n=197)

Salient Outcome	Behavioural belief strength			Outcome evaluation		
	High intention (n = 156)	Low intention (n = 41)	U test	High intention (n = 156)	Low intention (n = 41)	U test
CA increases yield	1.50 (0.54)	0.02 (0.27)	**	0.99 (0.33)	0.02 (0.42)	**

CA reduces labour	1.48 (0.54)	0.05 (0.38)	**	0.99 (0.33)	-0.02 (0.61)	**
CA improves soil quality	1.47 (0.57)	0.20 (0.46)	**	0.98 (0.37)	0.10 (0.54)	**
CA reduces weeds	1.41 (0.63)	0.07 (0.41)	**	0.94 (0.42)	-0.10 (0.58)	**
CA increases pests	-0.30 (1.24)	0.22 (0.53)	**	-0.69 (1.10)	-0.05 (0.55)	**
CA can't be used on soil types	-0.78 (0.71)	0.29 (0.68)	**	-1.07 (0.73)	0.05 (0.63)	**
CA leads to benefits i.e. yield in the first year of use	1.39 (0.74)	0.07 (0.41)	**	0.82 (0.61)	-0.07 (0.52)	**
CA performs better than conventional in a drought year	1.42 (0.60)	0.02(0.42)	**	1.01 (0.36)	0.00 (0.50)	**

**denotes significance 0.001 level, standard deviation in parenthesis

Table 6 shows that farmers with a high intention to use CA are more likely to feel encouraged to use CA through social referents such as the AKF village facilitator, Farmer Field School and the government. Nevertheless, those with weak intention highlighted the potential of certain social referents to play a more important role in influencing adoption. Overall, those with a weak intention have a lower motivation to comply with the opinion of others, but a motivation to comply that is still positive, especially with regards to the AKF village facilitator, government and other experienced farmers. Those with a high intention to use CA also scored a significantly higher score than those with low intention for the role of a spouse in influencing likely adoption and radio and television. Interestingly, overall those with high intention to use CA also place more importance on self-observation and self-initiative and more of an importance of group work i.e. associations/groups

Table 6. Mean comparison of strength of normative belief and motivation to comply regarding all accessible referents between farmers with high intention and weak intention to use CA (n=197)

Referents	Normative belief strength			Motivation to comply		
	High intention (n = 156)	Low intention (n = 41)	U test	High intention (n = 156)	Low intention (n = 41)	U test
Government	1.07 (0.26)	0.78 (0.42)	**	1.06 (0.23)	0.83 (0.44)	**
NGO	1.02 (0.14)	0.81 (0.40)	**	1.02 (0.14)	0.76 (0.43)	**
Radio	0.82 (0.45)	0.37 (0.54)	**	0.82 (0.40)	0.46 (0.55)	**
TV	0.81 (0.43)	0.29 (0.41)	**	0.79 (0.43)	0.32 (0.53)	**
Village Facilitator AKF	1.28 (0.45)	0.83 (0.38)	**	1.14 (0.35)	0.85 (0.36)	**
Association/group	1.02 (0.14)	0.73 (0.50)	**	1.00 (0.00)	0.78 (0.42)	**
Farmer Field School	1.10 (0.34)	0.59 (0.50)	**	1.08 (0.29)	0.66 (0.53)	**

Sibling	0.76 (0.49)	0.27 (0.59)	**	0.78 (0.44)	0.24 (0.68)	**
Spouse	0.96 (0.22)	0.63 (0.49)	**	0.97 (0.20)	0.61 (0.54)	**
Self-observation	0.59 (0.89)	-0.05 (0.86)	**	0.62 (0.89)	-0.10 (0.89)	**
Self-initiative	0.56 (0.85)	-0.15 (0.88)	**	0.58 (0.82)	-0.10 (0.86)	**
Grandfather	0.56 (0.85)	-0.10 (0.86)	**	0.55 (0.84)	-0.10 (0.83)	**
Other experienced farmers	1.01 (0.08)	0.83 (0.44)	**	1.00 (0.00)	0.78 (0.42)	**

**denotes significance 0.001 level, standard deviation in parenthesis

Table 7 shows that farmers with a high intention to use CA perceive that they have enough labour and knowledge and skills to use CA. It is interesting to note that those with high intention to use CA do feel that CA does require adequate knowledge and skills which signals a potential barrier to using CA. However, farmers with high and low intention do not feel that group work is a pre-requisite to using CA. Pests and soil type which have been cited as potential barriers to adoption for CA in other farming contexts do not seem to affect usage in this farming system. For example, farmers with high intention to use CA feel they are able to adequately control pests and that pests do not limit the success of using CA. Furthermore, farmers with high intention also believe that mechanisation is not needed to perform CA thus supporting the notion that this manual form of CA as opposed to tractor or animal powered is perceived to be a favourable option for farmers in this region. For farmers with larger land holdings that would like to increase the scale of CA, other forms of CA, animal or tractor powered direct seeding systems may be attractive.

Table 7. Mean comparison of strength of control belief and power of control regarding all accessible control factors, between farmers with high intention and weak intention to use CA (n = 197)

Control factors	Strength of control belief			Power of control		
	High intention (n = 156)	Low intention (n = 41)	U test	High intention (n = 156)	Low intention (n = 41)	U test
Enough labour to do CA	1.09 (0.29)	0.17 (0.50)	**	-0.99 (0.16)	0.39 (0.63)	**
Enough knowledge/skills to do CA	1.39 (0.60)	0.05 (0.22)	**	1.49 (0.56)	0.51 (0.60)	**
Expect to be part of a group	0.19 (1.03)	0.02 (0.27)	Ns	0.21 (1.46)	0.42 (0.63)	Ns
I can practice CA with the soil I have	1.35 (0.69)	0.10 (0.37)	**	-0.96 (0.28)	0.34 (0.62)	**
Can deal with the pests I have	1.35 (0.63)	0.07 (0.41)	**	-0.97 (0.20)	0.34 (0.62)	**
I will have enough mechanisation to do CA	-0.99 (0.08)	0.29 (0.60)	**	-0.99 (-0.08)	0.34 (0.62)	**

**denotes significance at 0.001 level, Ns denotes non-significance, standard deviation in parenthesis

4. Discussion and conclusions

This study investigated, using a socio-psychological model, farmers' intention to apply CA in the next 12 months. The results show that the model explains a high proportion of variation in intention. In addition, farmers' attitude is found to be the strongest predictor of intention followed by perceived behavioural control and subjective norm. These findings thus take on broader significance within the literature as they identify key drivers behind the use of CA (all three pillars) that may be relevant for similar farming systems - against a backdrop of debate around yield, labour, soil quality, and weeds. Farmers with a high intention invariably found these as strong cognitive drivers. Most striking is that yield is the strongest driver followed by labour and soil quality. In addition, farmers' with a high intention to use CA also perceived benefits (i.e. increase in yield) in the first year of use which has also been a focus of debate within the research community, namely the degree to which CA leads to short-term yield gains (Rusinamhodzi et al., 2011). Thierfelder et al. (2013a), however, have found for some crop mixes that CA can provide gains in the first year of use relative to conventional agriculture. Furthermore, the study found the poorest are those with the highest intention to use CA which is also contrary to other authors that have suggested the poor are unlikely to find CA beneficial without subsidised inputs such as fertilisers and herbicides (Nkala, 2012). This is a noteworthy result, and is in contrast to commonly held opinions that it is the more affluent farmer who is the most likely to be interested in or able to apply conservation practices (e.g. Saltiel et al., 1994; Somda et al., 2002). Okoye (1998), however, found similar findings to this study with poorer farmers more likely to adopt soil erosion control practices. The results from this study also showed for those with a weak intention to use CA, perceptions of CA requiring a high-level of knowledge/skills and labour predominate.

Recent research on sustainable intensification opportunities, in another province of Mozambique, identified significant 'knowledge gaps' among the poorest farmers. Results from a participatory modelling exercise suggested that a 'first stepping stone' for poorer farmers would be the introduction of basic agronomic practices such as suitable plant populations, adequate row-spacing and adjustment in sowing dates that would substantially improve productivity (e.g. 120% increase in maize yields) before costly inputs such as fertilisers and herbicides are used. (Roxburgh and Rodriguez, 2016). Furthermore, the returns from investment in fertiliser application were greatest for the medium and high-performing farmers (Roxburgh and Rodriguez, 2016). This may explain the attraction of manual systems of CA in this study (highest intention to use CA among the poorest and yield increase the strongest overall cognitive driver among farmers in this study) that do not require costly external inputs and could be the focus for similar groups of farmers and related research elsewhere in Sub-Saharan Africa. Manual systems of CA have been productive in other parts of Mozambique benefiting from a number of attributes relative to conventional-tillage based agriculture including timely planting and precise seed placement (Thierfelder et al., 2016). Moreover, direct seeded CA systems (similar to those used in this region) have provided yield benefits over time due in large part because of better planting arrangements, increased soil quality over time, improved soil moisture conditions for crop growth/development and less soil disturbance (Thierfelder and Wall, 2010). Use of manual systems of CA e.g. direct seeding have also led to labour savings and higher returns to labour (Thierfelder et al., 2016) which is important for the poor (the second strongest cognitive driver in this study i.e. reduction in labour).

Thus one of the major constraints to adoption is the perception of CA requiring a high level of knowledge and skills which is most likely the case for smallholders in other parts of Sub-Saharan Africa (Wall et al., 2013). Reducing risk (i.e. production risk and price risk) and 'uncertainty' (i.e. absence of perfect knowledge or the decision maker having incomplete information) is paramount in the adoption process. The study highlights that observation and self-initiative were considered significant motivating factors for farmers with a high intention to use CA thus signalling that farmers have likely observed other farmers using CA (or as a result of their own observations from their own farms) and have formed the perception of CA being performed manually with success. Garforth et al. (2004) also found that local and personal contacts played an important role in adoption of a technology and Martínez-García et al. (2013) showed self-observation and self-initiative to be strong social referents as farmers invariably would decide to use an innovation based upon observations made or upon taking the initiative through testing. This has an effect of reducing the uncertainty in taking up a 'new' management system such as CA.

Central to this (reduction in uncertainty) are the social learning mechanisms that are formed through locally constructed innovation systems. Wall et al. (2013) also note the need for local innovation systems that involve farmer to farmer exchange and participatory methods which help to adapt CA to local conditions. One such component is the use of the Farmer Field School approach found in this study region. The study found, for example, that FFS participants have a significantly higher intention to apply CA in the near future (Table 2 and 4). Secondly, path analysis (Figure 2) shows that this effect is not just due to the fact that farmers perceive benefits from CA use (effect through attitude), but also through influencing subjective norms (i.e. participants have higher motivation to comply with social referents regarding CA), and by the perceived ease of use of this technique (i.e. they perceive CA as the easiest to use). Waddington and White (2014) have also suggested that for the FFS methodology to be effective it should follow a 'discovery- based approach' where farmers are able to learn through observation and experimentation with new practices. They also assert that 'observability' is important in influencing non-FFS farmers to adopt FFS practices.

Risk in much of Sub-Saharan Africa, such as this region of Mozambique, is associated with primarily rainfall. Seasonal distribution of rainfall is likely to increase in variability coupled with a reduction in rainfall throughout the region as a result of climate change (Lobell et al., 2008). This will undoubtedly exacerbate the risks to production facing farmers. Interestingly, farmers' perception of those with a high intention to use CA indicated that CA performs better in a drought year. Thus, the perception of farmers, in this context, signal that CA reduces the risk associated with drought such as crop failure which may also help to stimulate adoption (particularly for risk-averse farmers). These perceptions may be a result of observation and/or experience on the part of the farmer but also a personal/collective bias built up by shared perceptions in the communities that CA has certain benefits. Thus, it should be noted that it is possible that farmers' perceptions may be different from research results in on-station/on-farm experiments or when actual measurement takes place. Research has suggested in the case of rainfall, for instance, that farmers' perceptions of rainfall reduction over time did not always match historical measurements (Osbahr et al., 2011; Sutcliffe et al., 2015). Nguyen et al., (2016) postulate that farmers are better at observing features that are 'touchable' and are 'felt personally' i.e. based on sensory experiences rather than other those such as rainfall amount which are not easily observed or perceived by human senses without the use of appropriate instruments. Yield, labour (e.g. time used for weeding) and weed reduction it can be argued are 'touchable' and 'personally felt' attributes that farmers incorporate into their formulations of perception and decision making. Furthermore, although soil quality is hard to measure, in the absence of laboratory testing, the visual soil assessment methodology used in FFS training in this context may explain some of the sensory observations that farmers use when formulating perceptions and thereby decision making. Notwithstanding the potential for bias or misrepresentation by farmers the social learning mechanisms described by Nguyen et al. (2016) that are suggested to enable farmers to effectively adapt to climate change are similar to ones found in this study in that they focus on both dimensions of learning (i.e. 'perceiving to learn' and 'learning to perceive'). For example, as one farmer in this study region remarked: *"Before I started CA I had noticed that when I would clear straw from my land and put it at the side of my field (i.e. to clear the main part of the plot for burning and re-planting the year after) the area with straw would still produce a crop and the soil was good. Therefore, I thought that putting straw down was a good idea so when I heard this was part of CA I thought it was a good idea"*. This provides an example of how observation/perception (perceiving to learn) played a role in garnering interest in CA. Two other farmers remarked: *"I learnt about CA from the goat association then I decided to attend a field trip to a demonstration plot as part of a group" ..... "I decided to try and divided my plot with CA and without CA and after seeing the difference I now use CA on all of my land".* Thus participating in the demonstration plot/field trip and experimenting may constitute as 'learning to perceive'.

In sum, farmers' perceptions provide a valuable insight into the adoption process and it is ultimately the 'balance of benefits' that farmers perceive which will determine adoption (Wall et al., 2013). This study has identified that contrary to much of the literature surrounding CA in recent years (in Sub-Saharan Africa) farmers are motivated to use CA (within this farming system) primarily because of their attitude which is strongly influenced by their perceptions towards the benefits of CA vis-à-vis a locally constructed innovation system that has created opportunities for social learning and thereby reduced the risk and uncertainty associated with a ‘new’ management system such as CA. The results of this study may help to formulate similar research elsewhere in the region which includes socio-psychological factors/models in exploring adoption dynamics. More broadly, it may also encourage further investigation on CA use which relates to what farmers consider important in their contexts (e.g. agro-ecological/socio-economic) and of particular relevance to the poorest. Farmers’ expectations and experiences with CA and those of researchers, agricultural scientists and others could also be more closely aligned with further emphasis on the co-construction of knowledge. A need for enhanced ‘farmer participatory adaptive research’ which accounts for ‘farmer preferences’ has been one proposal (Wall et al., 2013). Sewell et al. (2014) also provides an example of an approach to innovation and learning whereby a community of farmers, social scientists and agricultural scientists were co-inquirers and through strong ties and trust being forged the co-construction of new knowledge formed. This collaborative approach to learning will likely improve understanding of how to adapt CA and other innovations to different conditions.

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