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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.
- Participants in Farmer Field Schools have a significantly higher intention to apply CA as they perceive benefits but also find it easy to use.
- 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.

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

Comment [B1]: Taken this out of the conclusion i.e. the results from the thesis which reviewer 1 said we should take out as it is not published.. shall we take out of abstract?

51 **Keywords:** Conservation Agriculture, Adoption, Theory of planned Behaviour

52

53

54 **1. Introduction**

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

69

70 Conservation Agriculture (CA) forms part of this alternative paradigm to agricultural
71 production systems approaches. Most recently, authors have questioned the mode in which
72 CA is being used as an ‘across-the board’ recommendation to farmers without proven
73 benefits in terms of boosting yields, labour reduction and carbon sequestration (Giller, 2012).
74 This is compounded by internal debate with those advocating for the use of CA practices with
75 different terms emerging from ‘no-tillage’ to ‘conservation tillage’ and ‘minimum tillage’

76 over the past decades. Many of these have been ascribed to CA. A wide variety of the
77 differing typologies have also been defined and discussed (Kassam et al., 2009). CA is,
78 however, defined as: (i) *Minimum Soil Disturbance*: Minimum soil disturbance refers to low
79 disturbance no-tillage and direct seeding. The disturbed area must be less than 15 cm wide or
80 less than 25% of the cropped area (whichever is lower). There should be no periodic tillage
81 that disturbs a greater area than the aforementioned limits. (ii) *Organic soil cover*: Three
82 categories are distinguished: 30-60%, >60-90% and >90% ground cover, measured
83 immediately after the direct seeding operation. Area with less than 30% cover is not
84 considered as CA. (iii). *Crop rotation/association*: Rotations/associations should involve at
85 least 3 different crops. (FAO, 2015).

86
87 CA, by definition, is now practiced on more than 125 million hectares worldwide across all
88 continents and ecologies (Friedrich et al., 2012). It is also used on various farm sizes from
89 smallholders to large scale farmers and on a wide variety of soils from heavy clay to highly
90 sandy (ibid). There have, however, been mixed experiences with CA particularly in Sub-
91 Saharan Africa (Giller, 2009) where human and animal powered CA systems predominate
92 (given the lack of mechanisation) as opposed to machine powered systems (i.e. involving
93 minimal soil disturbance) that are being used elsewhere in the world. Furthermore, across
94 Sub-Saharan Africa there have been low rates of adoption which have fuelled controversy
95 surrounding the benefits of CA both in terms of the private and social benefits accruing from
96 adoption. Akin to Giller's arguments (Giller, 2009; Giller, 2012), Baudron et al. (2012) found
97 for farmers in the Zambezi Valley (Zimbabwe) that CA required additional weeding and lack
98 of labour availability for this task reduced uptake. Chauhan et al. (2012) have also argued that
99 in general there is a poor understanding of weed dynamics within a CA system which can
100 have a bearing on farmer adoption of CA. Sumberg et al. (2013) also explored the recent

101 debates surrounding CA and questioned the ‘universal approaches to policy and practice’
102 which may limit the understanding of different contextual factors and alternative pathways.

103

104 Other issues surrounding the CA discourse involve the particular time horizon for benefits to
105 materialise and that farmers are concerned with immediate costs and benefits (such as food
106 security) rather than the future (Giller, 2009). Rusinamhodzi et al. (2012) found that CA does
107 have added benefits but these are largely found in the second and third year. Most-on-farm
108 trials reflect positively on CA albeit showing that yield benefits are usually in the long-term
109 and that within the short-run, especially within the first few seasons results are variable.
110 Yields under CA may even incur losses compared to conventional agriculture, especially in
111 the short run (Thierfelder and Wall, 2010). A recent systematic review conducted by Wall et
112 al. (2013) for CA in Eastern and Southern Africa (maize-based systems) also found that
113 yields were generally equal or higher than conventional agriculture. Wall et al. (2013) further
114 postulate that successful CA systems require adequate soil fertility levels and biomass
115 production. The feasibility of crop residue retention, particularly in strong mixed crop-
116 livestock systems has also been questioned (Giller, 2009).

117

118 Nkala (2012) also suggests that CA is not benefiting the poorest farmers and they require
119 incentives in the form of subsidised inputs. Grabowski and Kerr (2013) further argue that
120 without subsidised fertiliser inputs CA adoption will be limited either to only small plots or
121 abandoned altogether. Access to fertiliser and other inputs including herbicides are therefore
122 a contentious issue, with a number of authors arguing that for CA to improve productivity;
123 appropriate fertiliser applications and herbicide applications need to be used (Rusinamhodzi
124 et al., 2011; Thierfelder et al., 2013). Wall et al. (2013) found in their review that of the
125 studies with improved yields most were fertilised (including animal manure) and had both

126 retained residues as mulch and employed chemical weed control complemented by hand
127 weeding-requiring inputs that in reality are beyond the reach of most smallholders.

128

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

136

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

151 Stevenson et al. (2014) have suggested a key area for research in Asia and Africa will be
152 understanding the process of adoption.

153

154 Research on CA in Cabo Delgado (Northern Mozambique where this study is based) is
155 sparse and/or has not been documented by way of peer-reviewed research. Previous studies
156 on CA systems have been conducted elsewhere in Mozambique (Nkala et al., 2011; Nkala,
157 2012; Famba et al., 2011; Grabowski and Kerr, 2013; Thierfelder et al., 2015; Nyagumbo et
158 al., 2015; Thierfelder et al., 2016). Most of these studies have focused on on-farm level
159 experiments whilst some have focused on farm-level economics (Grabowski and Kerr, 2013)
160 and determinants of adoption (Nkala et al., 2011). In addition, other studies in Mozambique
161 have explored adoption of chemical fertiliser and new maize varieties using socio-
162 psychological constructs (Cavane and Donovan, 2011) and explored adoption of new crop
163 varieties through social networks (Bandiera and Rasul, 2008) whilst others have used more
164 conventional approaches (i.e. using farm level/household characteristics) to assess agriculture
165 technology adoption (Uaiene et al., 2009; Benson et al., 2012) or further econometric
166 approaches used to examine the impact of adoption of various improved agricultural
167 technologies on household income in Mozambique (Cunguara and Darnhofer, 2011).
168 Leonardo et al. (2015) also recently assessed the potential of maize-based smallholder
169 productivity through different farming typologies. Thus household level studies exploring
170 adoption dynamics with a socio-psychological lens have been lacking both on CA and within
171 the agricultural technology adoption literature in general i.e. not restricted to Mozambique (as
172 outlined earlier).

173

174 Socio-psychological theories which are helpful in this regard are The Theory of Planned
175 Behaviour (TPB) and Theory of Reasoned Action (TRA). The TPB and TRA frameworks

176 have been used in several studies to assess farmers' decision making for a range of
177 agricultural technologies (Beedell and Rehman, 2000; Martínez-García et al., 2013; Borges et
178 al., 2014). This has included more specifically studies which have assessed conservation
179 related technologies such as water conservation (Yazdanpanah et al., 2014) including organic
180 agriculture (Läpple and Kelley, 2013), soil conservation practices (Wauters et al., 2010) and
181 more recently payment for ecosystem services related initiatives (Greiner, 2015). In relation
182 to CA practices, previous studies have been conducted by Wauters et al. (2010) relating to for
183 example, reduced tillage, which includes residue retention and the use of cover crops. These
184 studies have focused on Europe and also have dealt with the behaviours as individual
185 practices, e.g. the intention to use cover crops.

186

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

192

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

200

201 **1.1 Background**

202 *1.1.1 Study area*

203

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

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

207

208 There are ten different agro-ecological regions which have been grouped into three different
209 categories based in large part on mean annual rainfall and evapotranspiration (ETP).

210 Highland areas typified by high rainfall (>1000mm, mean annual rainfall) and low

211 evapotranspiration correspond to zones R3, R9 and R10. Medium altitude zones (R7, R4)

212 represent zones with mean annual rainfall ranging between 900-1500mm and medium level

213 of ETP. Low altitude zones (R1, R2, R3, R5, R6, R7, R8) which are hot with comparatively

214 low rainfall (<1000mm mean annual rainfall) and high ETP (INIA, 1980; Silici et al., 2015).

215 The Cabo Delgado province falls within three agro-ecological zones R7, R8, and R9. The

216 district under study (Pemba-Metuge) falls under R8; distribution of rainfall is often variable

217 with many dry spells and frequent heavy downpours. The predominant soil type is Alfisols

218 (Maria and Yost, 2006). These are red clay soils which are deficient in nitrogen and

219 phosphorous (USDA, 2010).

220

221 Though provincial data is sketchy, yields for staple crops in Mozambique are very low

222 compared to neighbouring countries in Southern Africa. Average yields (calculated from

223 FAOSTAT data based on the years 2008-2013), for example, show relatively low yields for

224 maize (1.12 tons/ha), cassava (10 tons/ha) and rice (1.2 tons/ha). These are lower than

225 neighbouring Malawi which has much higher cassava (15 tons/ha), maize (2.3 tons/ha) and

226 rice yields (2.1 tons/ha). Maize and rice yields in Malawi are virtually double those in
227 Mozambique. Zambia, also in Southern Africa, has comparatively higher maize and rice
228 yields but lower overall cassava yields than Mozambique. Maize yields (2.7 tons/ha) in
229 Zambia, on average based on the past five years, are triple those in Mozambique and rice
230 yields in Zambia are virtually double (1.7 tons/ha) (FAOSTAT, 2016).

231

232 The majority of inhabitants, within Cabo Delgado province rely on subsistence agriculture,
233 where market access is often bleak due to poor roads and infrastructure. Research has
234 highlighted that the prevalence of stunting (55%) is the highest among all provinces in
235 Mozambique (FAO, 2010). Furthermore, poverty studies also place Cabo Delgado among the
236 poorest in Mozambique (Fox et al., 2005; INE, 2011). A more recent study using the human
237 development poverty index ranks Cabo Delgado as the second poorest province in
238 Mozambique (INE, 2012). This is compounded by high population growth in Mozambique
239 which exacerbates the poverty nexus. Current projections show that the population of Pemba-
240 Metuge district will more than double by 2040 (INE, 2016). Though population density is
241 considered very low across Mozambique (Silici et al., 2015) intensification as opposed to
242 extensification of land will be imperative for the future. Thierfelder et al. (2015) has argued
243 that increased population pressure in Mozambique coupled with the negative impacts of
244 future climate variability and lack of labour to clear new lands will force farmers to have
245 more intensive farming systems which are permanent in nature rather than the current slash
246 and burn or shifting cultivation methods that are common place.

247

248 ***1.2. Conservation Agriculture in Cabo Delgado***

249 CA adoption has gathered momentum in Cabo Delgado, in recent years, largely stimulated by
250 the institutional presence of the AKF-CRSP (Aga Khan Foundation Coastal Rural Support

251 Programme), which has been promoting CA in the province since 2008. The establishment of
252 a number of Farmer Field Schools, within each of the districts, has also helped to encourage
253 adoption of CA among farming households. As of 2014, there were 266 Farmer Field Schools
254 that focus on CA running in Cabo Delgado with a combined membership of 5000 members.

255
256 Unlike other NGOs in parts of Mozambique and Sub-Saharan Africa, AKF have not provided
257 inputs such as herbicides and chemical fertilisers in order to stimulate adoption. Given the
258 lack of draft and mechanical power in Cabo Delgado, manual systems of CA have been
259 promoted. AKF's approach has aimed to improve soil fertility through the use of legumes as
260 green manure, annual (cover also as crops) and perennials, developing mulch cover with
261 residues and vegetation biomass (produced on-farm or brought in from the surroundings i.e.
262 bush areas) and compost.

263

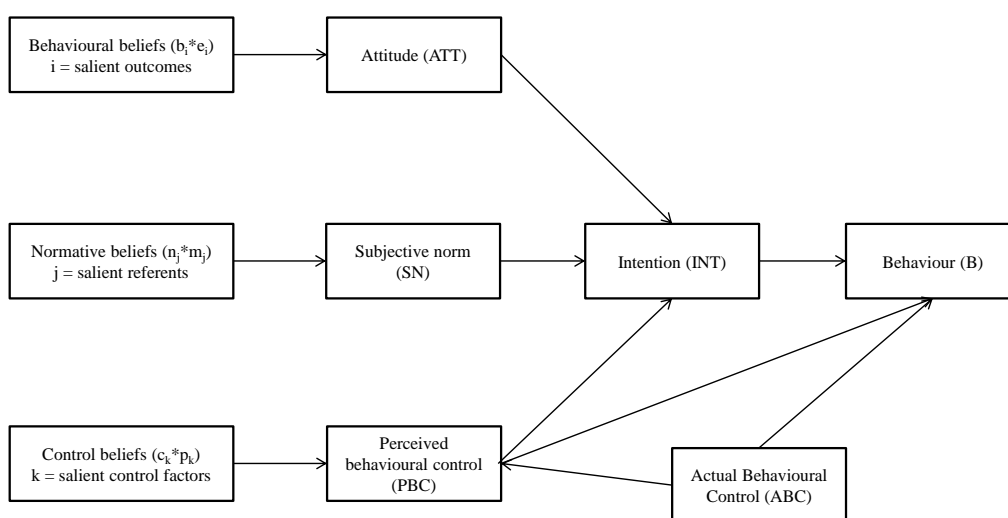
264 **2. Materials and Methods**

265

266 ***2.1. Theoretical framework***

267 The TPB is a social-psychological model which seeks to understand the dynamics of human
268 behaviour (Ajzen, 1991). The model predicts the intention to perform a particular behaviour
269 is based on three factors. These are: (i) attitudes towards the behaviour which can be either
270 positive or negative, (ii) subjective norms (i.e. social pressures to adhere to the certain
271 behaviour) and (iii) perceived behavioural control (i.e. to what extent the individual perceives
272 to have control over engaging in the behaviour). These three factors together either form a
273 positive or negative intention to perform the behaviour under study (See Figure 1). In
274 addition, if there is adequate actual behavioural control e.g. presence of sufficient knowledge,
275 skills and capital then the individual will act on their intention. Ajzen (2005) has suggested

276 that it is possible to substitute actual behavioural control for perceived behavioural control.
 277 For this study perceived behavioural control is taken as a proxy for actual behavioural
 278 control. The TPB is the successor of the Theory of Reasoned Action (TRA). Theory of
 279 Reasoned Action was developed first, by Fishbein and Ajzen (1975). It **posited that people's**
 280 **behaviour** was explained by two considerations. The first was attitude, or the degree to which
 281 people evaluated the behaviour as positive or negative. The second was subjective norm, the
 282 perceived social pressure from others to perform the behaviour or not. Empirical evidence
 283 showed that this theory was successful in explaining people's behaviour as long as they have
 284 full volitional control over performance of the behaviour, i.e. all necessary conditions in
 285 terms of presence of necessary requirements and absence of any inhibiting factors were met.
 286 As this is only the case in a limited number of contexts and behaviours, the TPB was
 287 developed. In this theory, the concept of perceived behavioural control was added, which
 288 reflect the perceived degree of control a person has regarding his/her own capacity to perform
 289 the behaviour. This perceived degree of control has to do with the degree to which all the
 290 necessary prerequisites in order to perform the behaviour are met. As a general rule of thumb,
 291 the stronger the attitude, subjective norm and perceived behavioural control the stronger the
 292 intention is likely to be to perform the behaviour (Davis et al., 2002).



293

294 **Figure 1. Theory of planned behaviour (Adapted from Ajzen, 1991)**

295

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

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

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

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

311 Similar notation is used to that of Wauters et al.(2010) and Borges et al., (2014) where i is the
312 i th behavioural belief, x the total number of behavioural beliefs, j the j th referent, y the total

313 number of referents, k the k th control factor and z the total number of possible control
314 factors (Wauters et al., 2010; Borges et al., 2014). While we will not quantitatively calculate
315 attitude, subjective norm and perceived behavioural control using the expectancy-value
316 theory, this theory offers us a framework we can use to investigate the cognitive foundations
317 that determine attitude, subjective norm and perceived behavioural control.

318

319 **2.2. Survey procedure**

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

333

334 As with most qualitative data analysis the transcriptions were coded and categorised into
335 groups using deductive content analysis (Patton, 2002). These were done first by colour i.e.
336 highlighting aspects which related to the theory of planned behaviour. Sub-themes were then
337 explored which related to specific aspects of the theory of planned behaviour such as

338 behavioural beliefs and social referents. Links within categories and across categories were
339 also looked for. The final result of this stage was a complete list of all salient outcomes, all
340 salient referents and all salient control factors. This list was subsequently used to design part
341 of the survey, as explained in the next section. For the complete lists of all salient outcomes,
342 referents and control factors, we refer to table 6, 7 and 8 respectively. The term ‘all
343 accessible’ is used in these table captions which refer to the complete lists of salient
344 outcomes, referents and control factors gathered in the first stage.

345

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

349

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

361

362 ***2.3. Variables and measurement***

363 The survey consisted of several sections. The first 4 sections contained questions about
364 household and farm characteristics, about agricultural production practices, about plot level
365 characteristics and about the previous use of conservation agriculture. The next two sections
366 dealt with household assets and food and nutrition security. The seventh section assessed
367 farmers' current CA adoption. The remaining sections contained questions dealing with the
368 TPB. Since the survey was performed in the course of a larger research project, in the
369 remainder of this section, we only explain the measurement of those variables that were used
370 in the analyses reported in this study.

371

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

382

383 The TPB variables were measured using Likert-type items or items from the semantic
384 differential, i.e., questions to which the respondent has to answer on a scale with opposite
385 endpoints. Intention (INT) was assessed by asking the farmer how strong his intention was to
386 apply CA on his/her farm over the next year, on a scale from 1 (very strong) to 5 (very weak).
387 Attitude (ATT) was assessed using two items. The first asked the farmer to rate the

388 importance of using CA on the farm in the course of the next year, on a scale from 1 (very
389 important) to 5 (very unimportant). The second item asked the farmer to indicate how useful
390 it would be to apply CA on the farm in the next year, on a scale from 1 (very useful) to 5
391 (very useless). The final score for attitude was calculated as the mean score of these two
392 items.

393

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

401

402 Behavioural beliefs are farmers' beliefs about the salient outcomes of CA. During the
403 qualitative stage, we identified a list of salient outcomes. For each of these outcomes, two
404 questions were included in the survey, one for belief strength and one for outcome evaluation.
405 Strength of the behavioural belief was measured by asking the respondent to indicate his/her
406 agreement with the statement that application of CA resulted in the particular outcome, on a
407 scale with endpoints 1 (strongly agree) and 5 (strongly disagree). Outcome evaluation was
408 measured by asking the farmer the importance of that outcome, on a scale from 1 (very
409 important) to 5 (very unimportant). Both items were recoded into a bipolar scale from -2 to
410 +2, with -2 values meaning that the outcome was very unlikely and very unimportant to the
411 farmer and +2 indicating the opposite.

412

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

424

425 Control beliefs are beliefs of the farmers about control factors (barriers or motivators).
426 Control belief strength assessed the degree to which the control factor is relevant for the
427 specific respondent. For example, “Do you have enough labour to use CA in the next 12
428 months?” scaled from 1 (strongly agree) to 5 (strongly disagree). Power of control factor
429 measures the degree to which the control factor can make it easy or difficult to apply CA.
430 This was measured by asking the farmer whether they agreed with the statement that the
431 presence of this control factor was important to be able to apply CA, on a scale from 1
432 (strongly agree) to 5 (strongly disagree). The first item was recoded into a scale from -2 to
433 +2, with -2 meaning that the control factor was not present.

434

435 **2.4. Data analysis**

436 Data was analysed in SPSS version 21. First, the data was cleaned by checking for cases with
437 too many missing values, outliers and irregularities. As the survey was performed using

438 personal enumeration, no cases had to be excluded because of too many missing values.
439 Further, no outliers or other irregularities were found. All scale questions exhibited an
440 acceptable degree of variation, meaning that not too many scores were in just one scale
441 category. Second, we calculated descriptive statistics of the sample, including farm and
442 farmer characteristics, adoption rate and TPB variables. Third, we performed a series of mean
443 comparison analyses to compare the mean level of the TPB variables between different
444 groups, using analysis of variance (ANOVA). When there were more than two groups, we
445 performed post-hoc tests, which were evaluated using Tukey HSD in case of equal variances
446 and Dunnett's T3 in case of unequal variances. The equality of variance assumption was
447 evaluated using the Levene's test. We compared mean scores of the TPB between a number
448 of variables that have been hypothesized to influence adoption of conservation practices,
449 these being highest education level of the household head (EDUC), sex of the household head
450 (SEX), membership in a CA Farmer Field School (MEMBER_FFS), membership in other
451 organisations (MEMBER_OTHER), between the different villages (VILLAGE_ID), and
452 between three groups on the poverty index (POVERTY_GROUP). We also computed
453 correlations between TPB variables, and age of the household head (AGE) and the
454 continuous poverty index (POVERTY_INDEX). Fourth, we tested the ability of the theory of
455 planned behaviour to explain farmers' intention to apply CA, and investigated the role of the
456 aforementioned farm and farmer characteristics. This was done using a hierarchical
457 regression analysis with intention as dependent variable, in which attitude (ATT), subjective
458 norm (SN) and perceived behavioural control (PBC) were added in the first step and the
459 farmer characteristics in the second. Regression analysis was done using simple ordinary
460 least squares (OLS) and assumptions were checked. As this analysis suggested that, in line
461 with Ajzen (2011), the impact of these factors was fully mediated through the TPB
462 predictors, we performed a path analysis in AMOS. First, we included all paths between these

463 farmer characteristics and the three TPB variables, and gradually eliminated insignificant
 464 paths. As an additional check of the model, we dichotomized intention into a new variable,
 465 HIGH_INT, being 1 when intention was higher than 0, on a scale from -2 (very negative
 466 intention) to 2 (very positive intention) and 0 otherwise. The mean scores for attitude (ATT),
 467 subjective norm (SN) and perceived behavioural control (PBC) were compared between these
 468 two groups of those with low intention and high intention, using ANOVA analysis. Fifth, we
 469 examined the belief structure, by means of a Mann-Whitney U test, which assesses whether
 470 there exist significant differences in the beliefs held by those with low intention and high
 471 intention.

472

473 **3. Results**

474

475 *3.1. Summary statistics*

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

483

484 **Table 1. Summary statistics of our 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%

485

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

490

491 **Table 2. Summary statistics and mean comparison of the theory of planned behaviour**
 492 **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 ^c (0.537)	0.969 ^f (0.612)	0.631 ^g (0.782)
High (n = 64)	0.813 ^d (0.639)	0.813 ^c (0.484)	0.875 ^f (0.630)	0.688 ^g (0.687)

493 a significant difference between Tatara and Saul ($p < 0.05$)

494 b significantly different between members and non-members ($p < 0.001$)

495 c significantly different between members and non-members ($p < 0.05$)

496 d significantly different between low and middle and between low and high ($p < 0.10$)

497 e significantly different between low and high ($p < 0.10$)

498 f significantly different between low and middle and between low and high ($p < 0.05$)

499 g significantly different between low and middle and between low and high ($p < 0.10$)

500 h Means scores and standard deviation on a scale from -2(unfavourable towards CA) and +2 (favourable
501 towards CA)

502

503 **3.2. Relationship between TPB variables and farmer characteristics**

504 Table 2 presents the results of a series of ANOVA analyses comparing TPB variables
505 between groups with different characteristics. There is no significant difference in any of the
506 variables between village, with the exception of attitude, being significantly higher in Saul
507 compared to Tatara. Furthermore, the TPB variables do not differ between male and female
508 farmers, or between educated and non-educated farmers. There is a significant difference
509 between farmers who belong to a other organisations_(e.g. savings group, seed multiplication
510 group or specific crop/livestock association) and those who do not. Farmers who are
511 members of the CA Farmer Field Schools have more favourable values of all TPB variables,
512 as do farmers who belong to any other group. The difference is much more pronounced for
513 membership of the CA Farmer Field Schools. Lastly, there is a statistically significant
514 difference according to the poverty group, a wealth classification based on the poverty index,
515 described above. Farmers from the low wealth group have significantly more favourable
516 values towards CA than farmers from the middle or high group. This is confirmed by

517 computing the Spearman's correlation between the TPB variables and the
518 POVERTY_INDEX, which is always negative and significant (INT: -0.211; ATT: -0.199;
519 SN: -0.311; PBC: -0.201; $p < 0.01$). AGE, finally, had no significant correlations with any of
520 the TPB variables.

521

522 ***3.3. The theory of planned behaviour model***

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

528

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

540

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

549

550 **Table 3. Results of the ANOVA mean comparison of TPB variables between farmers**
 551 **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

552 ^a significantly different between those with low and high intention, p < 0.001

553 ^b mean value on a score from -2 (very unfavourable) to +2 (very favourable)

554

555

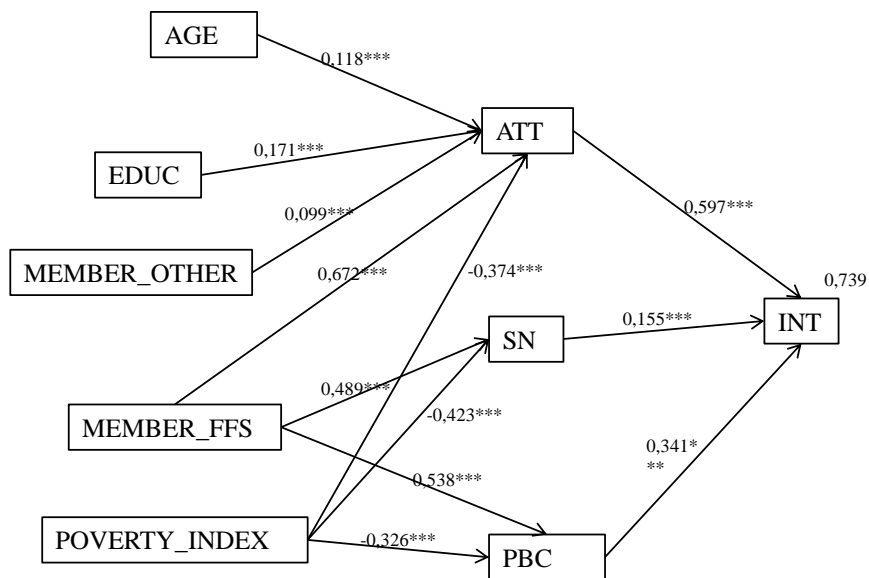
556 **Table 4. Results of the hierarchical regression analysis on intention to adopt CA, with**
 557 **basic TPB variables only in the first step, and farmer characteristics added in the**
 558 **second step (n=197)**

	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

559 ** p < 0.01
560 *** p < 0.001
561

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



568

569 **Figure 2. Path analysis of the impact of TPB variables and farmer characteristics on**
 570 **intention to apply CA (n = 197; standardized regression coefficient above arrows; *** p**
 571 **< 0.001; squared multiple correlations above rectangles)**

572

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

584

585 **3.4. Analysis of the belief structure.**

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

594

595 **Table 5. Mean comparison of belief strength and outcome evaluation of all accessible**
 596 **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	-0.78 (0.71)	0.29 (0.68)	**	-1.07	0.05 (0.63)	**

soil types				(0.73)		
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)	**

597 **denotes significance 0.001 level, standard deviation in parenthesis

598

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

610

611 **Table 6. Mean comparison of strength of normative belief and motivation to comply**
612 **regarding all accessible referents between farmers with high intention and weak**
613 **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)	**

614 **denotes significance 0.001 level, standard deviation in parenthesis

615

616

617 Table 7 shows that for farmers with a high intention to use CA they perceive that they have
618 enough labour and knowledge and skills to use CA. It is interesting to note that those with
619 high intention to use CA do feel that CA does require adequate knowledge and skills which
620 signals a potential barrier to using CA. However, farmers with high and low intention do not

621 feel that group work is a pre-requisite to using CA. Pests and soil type which have been cited
 622 as potential barriers to adoption for CA in other farming contexts do not seem to affect usage
 623 in this farming system. For example, farmers with high intention to use CA feel they are able
 624 to adequately control pests and that pests do not limit the success of using CA. Furthermore,
 625 farmers with high intention also believe that mechanisation is not needed to perform CA thus
 626 supporting the notion that this manual form of CA as opposed to tractor or animal powered is
 627 perceived to be a favourable option for farmers in this region. For farmers with larger land
 628 holdings that would like to increase the scale of CA, other forms of CA, animal or tractor
 629 powered direct –seeding systems may be attractive.

630

631

632 **Table 7. Mean comparison of strength of control belief and power of control regarding**
 633 **all accessible control factors, between farmers with high intention and weak intention to**
 634 **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)	**

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

636 parenthesis

637

638

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642

643

644 **4. Discussion and conclusions**

645

646 This study investigated, using a socio-psychological model, farmers' intention to apply CA in
647 the next 12 months. The results show that the model explains a high proportion of variation in
648 intention. In addition, farmers' attitude is found to be the strongest predictor of intention
649 followed by perceived behavioural control and subjective norm. These findings thus take on
650 broader significance within the literature as they identify key drivers behind the use of CA
651 (all three pillars) that may be relevant for similar farming systems- against a backdrop of
652 debate around yield, labour, soil quality, and weeds. Farmers with a high intention invariably
653 found these as strong cognitive drivers. Most striking is that yield is the strongest driver

654 followed by labour and soil quality. In addition, farmers' with a high intention to use CA also
655 perceived benefits (i.e. increase in yield) in the first year of use which has also been a focus
656 of debate within the research community, namely the degree to which CA leads to short-term
657 yield gains (Rusinamhodzi et al., 2012). Thierfelder et al. (2013), however, have found for
658 some crop mixes that CA can provide gains in the first year of use relative to conventional
659 agriculture. Furthermore, the study found the poorest are those with the highest intention to
660 use CA which is also contrary to other authors that have suggested the poor are unlikely to
661 find CA beneficial without subsidised inputs such as fertilisers and herbicides (Nkala, 2012).
662 This is a noteworthy result, and is in contrast to commonly held opinions that it is the more
663 affluent farmer who is the most likely to be interested in or able to apply conservation
664 practices (e.g. Salatiel et al., 1994; Somda et al., 2014) Okoye et al. (1998), however, found
665 similar findings to this study with poorer farmers more likely to adopt soil erosion control
666 practices. The results from this study also showed for those with a weak intention to use CA,
667 perceptions of CA requiring a high-level of knowledge/skills and labour predominate.

668

669 Recent research on sustainable intensification opportunities, in another province of
670 Mozambique, identified significant 'knowledge gaps' among the poorest farmers. Results
671 suggested that a 'first stepping stone' for poorer farmers would be the introduction of basic
672 agronomic practices such as suitable plant populations, adequate row-spacing and adjustment
673 in sowing dates that would substantially improve productivity (e.g. 120% increase in maize
674 yields) before costly inputs such as fertilisers and herbicides are used. (Roxburgh and
675 Rodriguez,, 2016). Furthermore, the returns from investment in N fertilisation were greatest
676 for the medium and high-performing farmers (Roxburgh and Rodriguez, 2016). Likewise,
677 this may explain the attraction of manual systems of CA in this study (highest intention to use
678 CA among the poorest and yield increase the strongest cognitive driver) that do not require

679 costly inputs and could be the focus for similar groups of farmers and related research
680 elsewhere in Sub-Saharan Africa.

681

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

696

697 Central to this (reduction in uncertainty) are the social learning mechanisms that are formed
698 through locally constructed innovation systems. Wall et al. (2013) also note the need for local
699 innovation systems that involve farmer to farmer exchange and participatory methods which
700 help to adapt CA to local conditions. One such component is the use of the Farmer Field
701 School approach found in this study region. The study found, for example, that FFS
702 participants have a significantly higher intention to apply CA in the near future (Table 2 and
703 4). Secondly, path analysis (Figure 2) shows that this effect is not just due to the fact that

704 farmers perceive benefits from CA use (effect through attitude), but also through influencing
705 subjective norms (i.e. participants have higher motivation to comply with social referents
706 regarding CA), and by the perceived ease of use of this technique (i.e. they perceive CA as
707 the easiest to use). Waddington and White (2014) have also suggested that for the FFS
708 methodology to be effective it should follow a ‘discovery- based approach’ where farmers are
709 able to learn through observation and experimentation with new practices. They also assert
710 that ‘observability’ is important in influencing non-FFS farmers to adopt FFS practices.

711

712 Risk in an Eastern and Southern Africa setting such as this region of Mozambique, is
713 associated with primarily moisture stress which is largely to do with insufficient use of
714 rainfall rather than insufficient rainfall amount or distribution (Wall et al., 2013). Seasonal
715 distribution of rainfall is likely to increase in variability coupled with a reduction in rainfall
716 throughout the region as a result of climate change (Lobell et al., 2008). This will
717 undoubtedly exacerbate the risks to production facing farmers. Interestingly, farmers’
718 perception of those with a high intention to use CA indicated that CA performs better in a
719 drought year. Thus, the perception of farmers, in this context, signal that CA reduces the risk
720 associated with drought such as crop failure which may also help to stimulate adoption
721 (particularly for risk-averse farmers). These perceptions may be a result of observation and/or
722 experience on the part of the farmer but also a personal/collective bias built up by shared
723 perceptions in the communities that CA has certain benefits. Thus, it should be noted that
724 farmers’ perceptions may be different from research results in on-station/on-farm
725 experiments or when actual measurement takes place. Research has suggested in the case of
726 rainfall, for instance, that farmers’ perceptions of rainfall reduction over time did not always
727 match reality. Farmers were better at observing extreme events such as severe drought and
728 intense rainfall but were not able to identify with trends in rainfall reduction (Nguyen et al.,

729 2016). The authors' further postulate that the increase and decrease in temperature are
730 'touchable' and are 'felt personally' i.e. based on sensory experiences. Rainfall amount in
731 contrast is not easily observed or perceived by human senses without the use of appropriate
732 instruments. Moreover, farmers' were able to identify with production loss and 'what just
733 happened' or 'what is happening' rather than 'what has been happening' (Nguyen et al., 2016;
734 page 212). This could also be said then of yield, labour and weed reduction in that farmers
735 are able to incorporate 'touchable' attributes into their formulations of perception and
736 decision making. As time used for labour or particular tasks such as weeding are personally
737 felt. Furthermore, although soil quality is hard to measure, in the absence of laboratory
738 testing, the visual soil assessment methodology used in FFS training in this context may
739 explain some of the sensory observations that farmers use when formulating perceptions and
740 thereby decision making. Yield may also be difficult to measure but farmer recall i.e. what
741 just happened or production loss after a severe drought may be more reliable than say
742 perceptions of rainfall or soil quality. Notwithstanding the potential for bias or
743 misrepresentation by farmers the social learning mechanisms described by Nguyen et al.
744 (2016) that are suggested to enable farmers to effectively adapt to climate change are similar
745 to ones found in this study in that they focus on both dimensions of learning (i.e. 'perceiving
746 to learn' and 'learning to perceive'). For example, as one farmer in this study region
747 remarked: *"Before I started CA I had noticed that when I would clear straw from my land
748 and put it at the side of my field (i.e. to clear the main part of the plot for burning and re-
749 planting the year after) the area with straw would still produce a crop and the soil was good.
750 Therefore, I thought that putting straw down was a good idea so when I heard this was part
751 of CA I thought it was a good idea"*. This provides an example of how observation/perception
752 (perceiving to learn) played a role in garnering interest in CA. Another farmer remarked: *"I
753 learnt about CA from the goat association then I decided to attend a field trip to a*

754 *demonstration plot as part of a group. I decided to try and divided my plot with CA and*
755 *without CA and after seeing the difference I now use CA on all of my land".* Thus the
756 participating in the demonstration plot/field trip and then experimenting may constitute as
757 'learning to perceive'. Other farmers also stated similar forms of 'perceiving to learn' and
758 'learning to perceive'. One farmer added: "*Before CA was explained to me I burnt my crop*
759 *residue and did not plant in lines or do any intercrop etc. Now I put mulch and intercrop and*
760 *use a rotation. When I put mulch the soil is good and has good moisture. I also like it because*
761 *I can sell the sesame and eat the maize".* Similarly another farmer remarked: "*Umokazi*
762 *(National NGO) that used to work in the village/district explained about good agricultural*
763 *practices i.e. planting in lines and I had a good experience with it. Then I heard from the Aga*
764 *Khan Foundation village facilitator about CA and because certain principles like planting in*
765 *lines were also used in CA I thought it was a good practice."* These views from farmers
766 provide an example of some of the cognitive processes (e.g. 'perceiving to learn' and
767 'learning to perceive') and social learning interactions which trigger transition from a
768 relatively low knowledge base of sound agricultural practices to the use of CA or to 'good
769 agricultural practices' and eventual sustainable intensification pathways such as CA.

770

771 In sum, farmers' perceptions provide a valuable insight into the adoption process and it is
772 ultimately the 'balance of benefits' that farmers perceive which will determine adoption (Wall
773 et al., 2013). This study has identified that contrary to much of the literature surrounding CA
774 in recent years (in Sub-Saharan Africa) farmers are motivated to use CA (within this farming
775 system) primarily because of their attitude which is strongly influenced by their perceptions
776 towards the benefits of CA vis-à-vis a locally constructed innovation system that has created
777 opportunities for social learning and thereby reduced the risk and uncertainty associated with
778 a 'new' management system such as CA. The results of this study may help to formulate

779 similar research elsewhere in the region which includes socio-psychological factors/models in
780 exploring adoption dynamics. More broadly, it may also encourage further investigation on
781 CA use which relates to what farmers consider important in their contexts (e.g. agro-
782 ecological/socio-economic) and of particular relevance to the poorest. Farmers' expectations
783 and experiences with CA and those of researchers, agricultural scientists and others could
784 also be more closely aligned with further emphasis on the co-construction of knowledge. A
785 need for enhanced 'farmer participatory adaptive research' which accounts for 'farmer
786 preferences' has been one proposal (Wall et al., 2013). Sewell et al. (2014) also provides an
787 example of an approach to innovation and learning whereby a community of farmers, social
788 scientists and agricultural scientists were co-inquirers and through strong ties and trust being
789 forged the co-construction of new knowledge formed. This collaborative approach to learning
790 will likely improve understanding of how to adapt CA to different conditions.

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