THE UTILISATION OF CONSERVATION AGRICULTURE IN EASTERN AND SOUTHERN AFRICA: WHAT, WHY AND HOW

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Submitted in fulfilment of the requirements for the degree of

Doctor of Philosophy

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THE UNIVERSITY of ADELAIDE
“We cannot solve our problems with the same thinking we used when we created them.

Albert Einstein

“We do not need more of the same diffusion research. The challenge for diffusion scholars of the future is to move beyond the proven methods and models of the past, to recognise their shortcomings and limitations, and to broaden their conceptions of the diffusion of innovations.

Everett Rogers


“I hope that this work you are doing does not only end in your research defence, but puts the ideas in practice. Please take the findings to the big men. When you analyse it, please tell the big men what you see in the field. Don’t tell them what they want to hear, but tell them the real situation.

Interview respondent

Sussendenga, Mozambique
Dedication

This body of research is dedicated to African smallholder farmers in the hope that important scientific breakthroughs are able to help them transition towards their concepts for more productive and sustainable livelihoods.
# Table of Contents

**Australian Higher Education Graduation Statement**................................................................................................. V  
**Thesis Abstract**.......................................................................................................................................................... VI  
**Keywords**.................................................................................................................................................................... VII  
**Thesis Graphical Abstract**........................................................................................................................................ VIII  
**Declaration**................................................................................................................................................................... IX  
**Acknowledgements**...................................................................................................................................................... X  
**List of Publications**...................................................................................................................................................... XI  
**List of Abbreviations**................................................................................................................................................ XXIV  
**List of Tables**.............................................................................................................................................................. XV  
**List of Figures**............................................................................................................................................................... XVII

**SECTION A: INTRODUCTION**............................................................................................................................................. 1  
**CHAPTER ONE: OVERVIEW**........................................................................................................................................ 2

**SECTION B: THE ‘WHAT’ OF CA UTILISATION**.................................................................................................................. 13  
**CHAPTER TWO: THE STATUS OF CA UTILISATION IN 2010**............................................................................................ 14  
**CHAPTER THREE: THE STATUS OF MINIMUM TILLAGE UTILISATION IN 2013**............................................................. 29

**SECTION C: THE ‘WHY’ OF CA UTILISATION**.................................................................................................................. 47  
**CHAPTER FOUR: PERSPECTIVE FROM FARMERS NEGATIVELY EVALUATING CA**...................................................... 48  
**CHAPTER FIVE: PERSPECTIVE FROM FARMERS POSITIVELY EVALUATING CA**......................................................... 66  
**CHAPTER SIX: PERSPECTIVE FROM FARMERS CURRENTLY EVALUATING CA**......................................................... 82  
**CHAPTER SEVEN: PERSPECTIVE FROM FARMERS YET TO EVALUATE CA**.............................................................. 104  
**CHAPTER EIGHT: PERSPECTIVE FROM EXTENSION SERVICE PROVIDERS**............................................................... 125  
**CHAPTER NINE: PERSPECTIVE FROM COMMUNITY LEADERS**................................................................................. 138  
**CHAPTER TEN: PERSPECTIVE FROM LOCAL RESEARCHERS**................................................................................... 152

**SECTION D: THE ‘HOW’ OF CA UTILISATION**.................................................................................................................. 169  
**CHAPTER ELEVEN: EXPECTATIONS FOR CA UTILISATION IN AFRICA**.................................................................... 170

**SECTION E: CLOSING**......................................................................................................................................................... 181  
**CHAPTER TWELVE: CONCLUSIONS**............................................................................................................................ 182

**SECTION F: APPENDICES**.................................................................................................................................................... 190
This thesis examines the ‘what’, ‘how’ and ‘why’ of the utilisation of Conservation Agriculture in eastern and southern Africa. Mixed methods are applied to four novel frameworks unified by the conceptualisation of agricultural change as a gradual and incremental utilisation process rather than a singular adoption outcome. The thesis argues for greater flexibility to enable adaptation of Conservation Agriculture and ensure smallholder farmers perceive benefit, relevance and feasibility. To progress this change in approach, leverage points are identified to further develop the institutional environment and empower farmers to transition towards more productive, sustainable and resilient farming systems.
Sustainable intensification of Africa smallholder farming systems is urgently needed to address issues of food insecurity and environmental sustainability. Substantial investment has been provided to catalyse this process, particularly through the promotion of Conservation Agriculture (CA) based farming systems. Over more than five decades of research activities on the African continent such systems have shown strong potential to address constraints with current production systems, yet there has been only limited uptake by smallholder farmers across eastern and southern Africa.

While there is a substantial body of literature that explores CA uptake, much of it is focused on technical benefits accrued to farmers during implementation. This research takes an alternative approach focused on understanding the broader status of CA uptake (i.e. the ‘what’ of CA), the determinants for such a status (i.e. the ‘why’ of CA) and the pathways forward for increasing uptake (i.e. the ‘how’ of CA). The need for such research into improving farming systems in Africa is a part of the growing discourse questioning the effectiveness of current investigations on CA uptake and the intensification of African smallholder agriculture more generally.

A combination of quantitative and qualitative methods are applied to four novel frameworks, with the underlying intention to reach beyond econometric analyses and binary classifications of adoption to create deeper understanding of the uptake of CA and the process of sustainable intensification. In doing this, a broader analytical lens is applied based on the gradual and incremental process of utilisation towards total adoption, as opposed to a focus on total adoption as an outcome. In doing so, this research applies robust frameworks to understand the nuanced uptake of CA and participatory exploration of the reasons for this uptake through local perspectives.
The thesis body is composed of ten manuscripts that first quantitatively explore the status of CA and minimum tillage utilisation to understand the ‘what’ of CA utilisation. This is followed by exploration of the perspectives of various farmer typologies (negatively evaluating; positively evaluating; currently evaluating; and those yet to evaluate due to a lack of information) and non-farm stakeholders (extension services; community leaders; and local research services) to understand the ‘why’ of CA utilisation. Finally, the ‘how’ of CA utilisation is explored through a review of global uptake of CA and comparison of the preconditions required to the current smallholder situation in Africa.

Through this research, two strong themes emerge for further analysis: 1] the functionality of current informational exchange mechanisms; and 2] a lack of feasibility and relevance of CA leading to constrained intensity of utilisation. These themes exist due to institutionalised issues with the mechanisms used to promote CA to farmers. To enable greater utilisation, it is argued that increased flexibility is required regarding how CA is defined and promoted to farmers, particularly noting trends in CA uptake globally. Such conclusions and the research contained within this thesis are hence relevant to the extension, research and policy communities within Africa and the development community more broadly.

Keywords

Sustainable Intensification; Conservation Agriculture; Agricultural Development; Adoption; Africa; Minimum Tillage; Agricultural Extension
Figure A: Thesis graphical abstract
Declaration

I certify that this work contains no material which has been accepted for the award of any other degree or diploma in my name, in any university or other tertiary institution and, to the best of my knowledge and belief, contains no material previously published or written by another person, except where due reference has been made in the text. In addition, I certify that no part of this work will, in the future, be used in a submission in my name, for any other degree or diploma in any university or other tertiary institution without the prior approval of the University of Adelaide and where applicable, any partner institution responsible for the joint-award of this degree.

I acknowledge that copyright of published works contained within this thesis resides with the copyright holder(s) of those works.

I also give permission for the digital version of my thesis to be made available on the web, via the University’s digital research repository, the Library Search and also through web search engines, unless permission has been granted by the University to restrict access for a period of time.

I acknowledge the support I have received for my research through the provision of an Australian Government Research Training Program Scholarship.

Brendan Brown on 17th August 2017
Acknowledgements

First and foremost thanks must be given to all 325 of the key informants that participated in this research. Their views, perspectives and opinions made this research possible. Likewise, I am thankful to all the staff at agricultural research stations in Africa that worked with me to facilitate organisation of logistics, translation and transcription.

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I acknowledge the financial contribution of the International Maize and Wheat Improvement Centre (CIMMYT) towards the fieldwork component of this research, and further for their provision of the quantitative datasets that were used within this research. I also acknowledge CSIRO and the University of Adelaide for their scholarships and operating budgets.

Last, but not least, I want to pass on my thankyou for those individuals that have led me along this path, especially Tim Lennon for catalysing my passion for social justice and Stephen Cooper for showing me tangible pathways to enable impact. A final thankyou goes to those who supported my personal and academic journey, and especially my partner Stacey without whom this journey would not have been as enjoyable and memorable as it has been.

I hope these efforts been worthwhile and this thesis can be of great contribution to the livelihoods of African smallholder farmers.
## List of Publications

### Published peer reviewed journal articles

#### 2017

[https://doi.org/10.1016/j.agsy.2017.01.012](https://doi.org/10.1016/j.agsy.2017.01.012)


#### 2018


[http://dx.doi.org/10.1080/1389224X.2018.1429283](http://dx.doi.org/10.1080/1389224X.2018.1429283)


#### 2019

**Brown, B., Nuberg, I., Llewellyn, R.** (2019) Pathways to intensify the utilisation of conservation agriculture by African smallholder farmers. *Renewable Agriculture and Food Systems*. 34 (6) pp558-570 [https://doi.org/10.1017/S1742170518000108](https://doi.org/10.1017/S1742170518000108)

**Accepted and In Press**


### Conference presentations

**Poster Presentations**


**Three minute thesis presentations**

**Brown, B.** (2017) Agricultural Adoption: are we comparing apples and oranges? Three Minute Thesis at the *Australian Agricultural and Resource Economics Society annual conference*. Brisbane, Australia (video available at: https://www.youtube.com/watch?v=aXM7oF5IAxc&t=66s)

**Brown, B.** (2017) ’Why are African farmers not embracing new science?’ (Three Minute Thesis) at the University of Adelaide: Agriculture 2016 three minute thesis competition (Adelaide, August 2016)

**Book contributions**

Online Articles


### List of Abbreviations

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>AARES</td>
<td>Australian Agricultural and Resource Economics Society</td>
</tr>
<tr>
<td>ACT</td>
<td>African Conservation Tillage Organisation</td>
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<tr>
<td>CA</td>
<td>Conservation Agriculture</td>
</tr>
<tr>
<td>CAAF</td>
<td>Conservation Agricultural Appraisal Framework</td>
</tr>
<tr>
<td>CGIAR</td>
<td>Consultative Group for International Agricultural Research</td>
</tr>
<tr>
<td>CIMMYT</td>
<td>International Maize and Wheat Improvement Centre</td>
</tr>
<tr>
<td>CIRAD</td>
<td>Centre de coopération internationale en recherche agronomique pour le développement</td>
</tr>
<tr>
<td>CRP</td>
<td>CGIAR Research Program</td>
</tr>
<tr>
<td>CSIRO</td>
<td>Commonwealth Scientific and Industrial Research Organisation</td>
</tr>
<tr>
<td>F Component</td>
<td>Farm level indices of intensity of use for a particular component</td>
</tr>
<tr>
<td>F2F</td>
<td>Farmer to Farmer</td>
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<tr>
<td>FAO</td>
<td>Food and Agricultural Organisation of the United Nations</td>
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<tr>
<td>Fig.</td>
<td>Figure</td>
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<tr>
<td>GFS</td>
<td>Global Food Security Conference</td>
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<td>ha</td>
<td>Hectare</td>
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<tr>
<td>ICARDA</td>
<td>International Centre for Agricultural Research in Dry Areas</td>
</tr>
<tr>
<td>ICRAF</td>
<td>International Centre for Research in Agroforestry</td>
</tr>
<tr>
<td>ICRISAT</td>
<td>International Centre for Research in the Semi-Arid Tropics</td>
</tr>
<tr>
<td>LD</td>
<td>Legume Diversification</td>
</tr>
<tr>
<td>LDI</td>
<td>Legume Diversification Index</td>
</tr>
<tr>
<td>LILO</td>
<td>Low Input and Low Output</td>
</tr>
<tr>
<td>LPA</td>
<td>Livelihood Platforms Approach</td>
</tr>
<tr>
<td>MT</td>
<td>Minimum Tillage</td>
</tr>
<tr>
<td>NARS</td>
<td>National Agricultural Research Services</td>
</tr>
<tr>
<td>NEPAD</td>
<td>New partnership for Africa’s Development</td>
</tr>
<tr>
<td>P Component</td>
<td>Plot level indices of intensity of use for a particular component</td>
</tr>
<tr>
<td>PAUF</td>
<td>Process of Agricultural Utilisation Framework</td>
</tr>
<tr>
<td>R&amp;E</td>
<td>Research and Extension</td>
</tr>
<tr>
<td>SC</td>
<td>Stover Cover</td>
</tr>
<tr>
<td>SSA</td>
<td>Sub-Saharan Africa</td>
</tr>
<tr>
<td>T&amp;V</td>
<td>Training and Visitation</td>
</tr>
<tr>
<td>UN</td>
<td>United Nations</td>
</tr>
<tr>
<td>WCCA7</td>
<td>7th World Congress on Conservation Agriculture</td>
</tr>
</tbody>
</table>
List of Tables

Note: Due to manuscript format, numbering of tables restarts for each Chapter to align with the format of submitted manuscripts

Chapter 2

Table 1. Selected districts, villages and households.
Table 2. Summary demographics of farm characteristics for five study countries.

Chapter 3

Table 1: Descriptive information and source of data utilised in this study. Note that while no dataset is available for Malawi for 2015, Malawi has been included in this study as it is often cited as an example of strong minimum tillage adoption.

Chapter 4

Table 1. Livelihood objectives alternative to CA identified by respondents.
Table 2. Physical resource limitations identified by respondents relating to the physical feasibility of CA.
Table 3. Financial implications of the feasibility of CA implementation at household level identified by respondents
Table 4. Mixed information held by respondents due to conflicting prior recommendations.

Chapter 5

Table 1: Summarised characteristics of respondents.
Table 2: Physical resource benefits of CA utilisation identified by respondents.
Table 3: Stover constraints identified by respondents
Table 4: Financial constraints identified by respondents
Table 5: Strategies identified by respondents to increase the availability of informational resources on CA
Table 6: Conflicting and incomplete information identified by respondents

Chapter 6

Table 1: Farmer perspectives on input market limitations
Table 2: Stover security issues identified by respondents
Table 3: Respondent comments regarding access to government extension officers
Chapter 8

Table 1: Key themes identified by more than half of respondents as constraining CA utilisation.

Table 2: Respondents identification of complications in their role due to input provision

Table 3: Respondents issues identified with the farmer-to-farmer extension system

Table 4: Conflicts in messaging that may confuse farmers as identified by respondents

Chapter 9

Table 2: Respondent identified issues with credit market functionality

Table 4: Perceived issues respondents identified for constrained information environment

Chapter 10

Table 1: Identification key used for interview respondents outlining their area of responsibility

Chapter 11

Table 1: A review of the types of CA and CA components implemented in the top 11 countries of CA uptake globally. Ranking and percentage of global area are based on Kassam et al. (2015)

Table 2: A summary of the common processes and developments that enabled the mass utilisation of CA reviewed in this study.
List of Figures

Note: Due to manuscript format, numbering of figures restarts for each Chapter to align with the format of submitted manuscripts. Likewise, Graphical abstracts are denoted with a letter to maintain numbering with the submitted manuscripts.

Preamble:

Figure A: Thesis graphical abstract

Chapter 1:

Figure 1: Global maize yields (1961-2014). Source: FAO (2016)

Chapter 2:

Figure B: Graphical abstract of manuscript 1

Figure 1: Reconceptualisation of the definition and implementation of Conservation Agriculture.

Figure 2: The Conservation Agricultural Appraisal Framework (CAAF) used to determine the intensity of use of various components at plot and farm level.

Figure 3: Reconceptualisation of the classification of adoption of various sub-uses.

Figure 4: The process of Agricultural Utilisation Framework (PAUF).

Figure 5: The classification structure applied to data for implementation of the PAUF.

Figure 6: Binary, CAAF and PAUF results for minimum tillage. Binary results classify any use as a farmer adopting. The CAAF Farm index is given as a box plot. An outlier (>1.5 × interquartile range) is denoted by o and an extreme outlier (>3 × interquartile range) is denoted by *. The mean (in brackets) and statistical grouping (P < 0.05) is given.

Figure 7: Binary, CAAF and PAUF results for stover cover. Binary results classify any use as a farmer adopting. The CAAF Farm index is given as a box plot. An outlier (>1.5 × interquartile range) is denoted by o and an extreme outlier (>3 × interquartile range) is denoted by *. The mean (in brackets) and statistical grouping (P < 0.05) is given.

Figure 8: Binary, CAAF and PAUF results for legume diversification. Binary results classify any use as a farmer adopting. The CAAF Farm index is given as a box plot. An outlier (>1.5 × interquartile range) is denoted by o and an extreme outlier (>3 × interquartile range) is denoted by *. The mean (in brackets) and statistical grouping (P < 0.05) is given.

Figure 9: Binary, Total, CAAF and PAUF results for Conservation Agriculture. Binary results classify any use as a farmer adopting, whilst total adoption applies only to farmers who use the technology unmodified and on all applicable area. The CAAF Farm index is given as a box plot. An outlier (>1.5 × interquartile range) is denoted by o and an extreme outlier (>3 × interquartile range) is denoted by *. The mean (in brackets) and statistical grouping (P < 0.05) is given.
Chapter 3

**Figure C**: Graphical abstract of manuscript 2

**Figure 1**: Classification structure applied to the dataset

**Figure 2**: The types of utilisation of minimum tillage across four countries from 2010 to 2015.

**Figure 3**: The types of non-utilisation of minimum tillage across four countries from 2010 to 2015. Note that disadoption data was not available in 2015.

Chapter 4

**Figure D**: Graphical abstract for manuscript 3

**Figure 1**: The LPA Framework

**Figure 2**: The snowball methodology employed in this study. Grey arrow indicates starting point and black arrows indicate a possible chain reaction selection pathway of respondents. Note that connections are weblike and black arrows indicate only one common pathway.

**Figure 3**: Location and description of respondents for this study (map courtesy of Google Maps, 2017).

**Figure 4**: Visualisation of the underlying cases of household resource constraint at all four resource pillars.

Chapter 5

**Figure E**: Graphical abstract for manuscript 4

**Fig. 1**: The classification of respondent sets and snowball methodology employed in this study, first proposed in Brown et al. (2017a)

**Fig. 2**: Location and classification of respondents (map courtesy of Google Maps, 2017)

**Fig. 3**: The Livelihood Platforms Approach (LPA) framework as proposed by Brown et al. (2017a)

**Fig. 4**: Visualisation of typical research and farmer comparisons being made to evaluate the yield benefit of CA.

**Fig. 5**: Current adoption pathway using CA as a singular technology and based on the expansion of CA area through a field approach.

**Fig. 6**: Example of transitional CA utilisation pathway based on the four principles proposed in this study.

Chapter 6

**Figure F**: Graphical abstract for manuscript 5

**Figure 1**: The classification of respondent sets within and snowball methodology employed in this study, first proposed in Brown et al. (2017a). This study explores the perspectives of
farmer set A, with respondents generally identified by promoting extension officers and subsidised evaluating farmers.

**Figure 2:** Location and classification of respondents (map courtesy of Google Maps, 2017)

**Chapter 7**

**Figure G:** Graphical abstract for manuscript 6

**Figure 1:** The classification of respondent sets and snowball methodology employed in this study, as proposed in Brown, Nuberg, and Llewellyn (2017a).

**Figure 2:** Location and description of respondents for this study (map courtesy of Google Maps, 2017)

**Figure 3:** A visual summary of respondent understanding of their informational gaps using the LPA.

**Chapter 8**

**Figure H:** Graphical abstract for manuscript 7

**Fig 1:** Location and classification of respondents (map courtesy of Google Maps, 2017)

**Fig 2:** The modified Livelihood Platforms Approach (LPA) framework, with the individual platform removed to enable a more focused analysis of the wider context within communities.

**Fig 3:** Visualisation of a typical livelihood for a subsistence farmer within the study countries. Note the transparent livelihood platforms represent a disconnect between the household platform and the community and institutional platforms and hence households are implementing livelihood strategies that are incompatible with CA.

**Fig 4:** Visualisation of the impact of a lack of (visible) policy on promotion and utilisation of CA

**Chapter 9**

**Figure I:** Graphical abstract for manuscript 8

**Figure 1:** The modified Livelihood Platforms Approach (mLPA) framework (Brown et al. 2018b)

**Figure 2:** Location and classification of respondents (map courtesy of Google Maps, 2017)

**Chapter 11**

**Figure J:** Graphical abstract for manuscript 10

**Figure 1:** Types of CA utilisation across maize growing regions in Ethiopia, Kenya, Tanzania, Malawi and Mozambique in 2010 found by Brown et al. (2017a) at the plot level (n = 27,545 plots). Each of the three components of CA is presented separately and then as simultaneously implemented components as part of a Venn diagram. Threshold use is classified using the Conservation Agriculture Appraisal Framework (CAAF) from Brown et al. (2017c) using established thresholds as follows: for Stover cover: 3 t dry matter/ha at
planting; for Minimum tillage: a maximum of one tillage events per season; and for Legume diversification: a legume diversification index of greater than 0.33.

**Figure 2:** A visual summary and comparison of the processes and developments that led to CA utilisation in other contexts in comparison to the African context. This visualisation is based on the Livelihood Platforms Approach (LPA) as used in Brown et al. (2017b) to understand farmer decision making in regards to four livelihood platforms (individual, household, community and institutional) that are supported by four resource pillars.

**Chapter 12**

**Figure K:** Visual summary of the thesis narrative, including the three research themes and implications for research and extension systems.

**Table and figure references:**


This section provides an introduction to this research. Chapter 1 provides a broad overview of the research area and gaps that will be addressed by the research objectives. The thesis narrative, scope and structure are then provided.
1.1 Problem statement

Approximately one out of four people in Sub-Saharan Africa (SSA) are undernourished (FAO, 2015), and one in three children under the age of five are stunted (FAO, 2017). SSA holds an increasing share of the world’s undernourished people (17% in 1990 to 28% in 2016; FAO et al., 2015) and this continues to increase in absolute terms (to 217 million in 2016). While civil unrest is one component of this problem (FAO, 2017), continued food insecurity also reflects limited agricultural productivity growth. SSA’s agricultural productivity is low for staple crops such as maize (Figure 1) with comparatively stagnant cereal yields since the 1960s (World Bank, 2016) and particularly over the past five years (FAO, 2017).

Food insecurity in SSA is further compounded by a rapidly growing population averaging 2.7% annual growth since 1990 (FAO et al., 2015). Such population growth is expected to continue, leading to at least a doubling in demand for cereals in Africa over the coming three decades (van Ittersum et al., 2016). Meeting this demand will need to occur under increased climate uncertainty and with greater emphasis on sustainability, noting the current application of unsustainable land-use practices that already threaten to impact negatively on productivity, the environment and farmer livelihoods (Lobell et al., 2008).

Figure 1: Global maize yields (1961-2014). Source: FAO (2016)
There are also questions raised about the productivity and sustainability of current production systems based on tillage, and the potential impact of continued tillage practices on future production. While tillage has often been used in production systems to positively alter the properties of the soil for plant growth (e.g. water conservation, temperature, infiltration and evapotranspiration processes) the need for tillage has been increasingly debated, with many studies identifying that intensive tillage operations can result in the exploitation of natural resources and contribute to land degradation (Friedrich et al., 2012; Hobbs et al., 2008; Lal, 2009). In a meta-analysis of the effects of tillage, Busari et al (2015) found tillage systems (in comparison to production systems that limited tillage) negatively impacted soil physical, chemical and biological processes, were less adaptable in light of more variable climates, and increased the impact of agricultural activities on the environment in nearly all cases they studied. Hence, the ongoing implementation of tillage activities is a further consideration when addressing the need for more productive and sustainable agricultural systems.

Even if population growth slows, supply-side issues must clearly be addressed. Reardon et al. (1999) highlighted the impracticality of further extensification of African farming systems and argued (sustainable) intensification is the only viable way to address the issue of food insecurity in SSA. This thesis addresses the problem of how to achieve sustainable intensification in the context of resource-poor African smallholder farmers, with the focus on increasing the uptake of improved practices that balance production, economic, social, environmental and climatic objectives.

1.2 Potential solutions: Conservation Agriculture

Whilst there are many pathways to sustainable agricultural intensification in Africa, Conservation Agriculture (CA) has been at the forefront of promotional efforts to address smallholder production, profitability and sustainability (Andersson and D'Souza, 2014; Giller et al., 2009). CA is a crop production system that strives to achieve acceptable profits together with high and sustained production levels, while concurrently conserving the environment through the simultaneous application of three component practices: 1] minimum soil disturbance; 2] continuous soil cover; and 3] diversified crop rotations (FAO, 2014). In practice, CA tends to be various combinations of these three practices, with the practice of minimum soil disturbance as the cornerstone.
The promotion of CA is underwritten by substantial evidence from on-station trials that CA can significantly improve the productivity and sustainability of current farming systems in the African context (Ngwira et al., 2012; Ngwira et al., 2013; Thierfelder et al., 2013). Over the past 15 years, a substantial wave of enthusiasm for CA has occurred, with strong support from the Food and Agriculture Organization of the United Nations (FAO), leading to the incorporation of CA into several governments’ agricultural policies (including Tanzania, Kenya, Malawi, Mozambique and Zambia). It is also actively promoted by many important regional organizations (e.g. the African Conservation Tillage Network [ACT] and the New Partnership for Africa’s Development [NEPAD]), CGIAR centres (e.g. CIMMYT, ICRISAT, CIRAD, ICARDA and ICRAF) and other NGOs (Giller et al, 2015).

Recently, a more nuanced debate has begun around the actual benefits of CA to smallholder farmers, catalysed by Giller et al. (2009). There is growing discourse regarding the contested agronomic claims of CA proponents, particularly concerning the actual benefits that accrue when resource-poor African smallholder farmers apply (elements of) CA on their farms and the high incidence of partial and limited intensity of utilisation (e.g. Giller et al., 2015; Pittelkow et al, 2015; Powlson et al., 2014). This has led to a contested evidence base for CA promotion in SSA, where in most cases the establishment of evidence lags behind the successful claims contained within the narratives of the CA community, be they project outputs, policy, or rhetoric (Whitfield et al., 2015). This has polarised the CA community, leaving limited scope for the middle ground, and politicised the promotion of CA which is now strongly part of the broader political agenda of agricultural transformation in Africa (e.g. such as the language used in the declaration of the 1st Africa Congress in Conservation Agriculture noting that CA is “one of the best food security and profitability options for farmers”).

1.3 Research gaps

Despite more than five decades of CA research in SSA (Wall et al., 2014) and more than three decades of extension efforts in SSA (Corbeels et al., 2014), CA remains a potentially beneficial technology that has not been widely adapted or impactful on African smallholder farmer livelihoods (Corbeels et al., 2014; Tittonell et al., 2009). While there is a large body of literature that estimates and explores the uptake of CA, there is now an expanding body of literature that questions the effectiveness of current investigations specifically for CA and for improved agricultural practices more generally (e.g. Andersson and Giller, 2012; Andersson and D'Souza,
This thesis is focused on understanding beyond the technical benefits of CA to the broader status of CA uptake (i.e. the ‘what’ of CA), the determinants for such a status (i.e. the ‘why’ of CA) and the pathways forward for increasing uptake (i.e. the ‘how’ of CA).

For estimates of CA uptake, current investigations provide only limited insight into the realities of use in SSA (Andersson and D’Souza, 2014). Many investigations tend to be constrained by the underpinning theoretical framework of the diffusion of innovations by Rogers (1962), whereby it is assumed that interest in a beneficial technology will eventually lead to a farmer implementing the practice. Such a framework has limited utility in resource constrained environments such as SSA (Giller et al., 2009), and particularly so for complex practices such as CA which require substantial modification to be feasible and relevant to end users (Douthwaite et al., 2001). Hence, modification and semi-spatial utilisation tend to be the dominant forms of use of CA in SSA (Baudron et al., 2007; Gowing and Palmer, 2008; Pannell et al., 2014). Yet most estimates of CA adoption are ambiguous as to how they classify these outcomes, due to a simplistic binary classification of adoption (where a farmer is either an ‘adopter’ or ‘non-adopter’). Hence, the validity of current estimates have been questioned, particularly noting the variations in estimates that regularly occur (see Chapter 2). While there are claims that adoption is lower than current estimates suggest, and that estimates can be more obscuring than revealing (Andersson and D’Souza, 2014), there is yet to be an alternative proposal for more nuanced classification and estimation. In this light, the use of the term ‘adoption’ has been minimised throughout this thesis due to the connotations of agricultural uptake as a binary outcome and ambiguity over its definition. Instead, we favour the term ‘utilisation’ where possible to denote a wider framing of agricultural uptake as a process, and then explore within these various types of adoption such as trialing, partial, semi-spatial and total (This will be further defined in Chapter 2).

For understanding uptake of technologies, there continues to be a dominance of econometric studies that focus on technical performance and household characteristics of adopters, which culminates in a lack of contextualisation of farmer situations and overall limited understanding of the determinants of farmer resource allocation decisions (Glover et al., 2016). Current studies tend to frame their research question as ‘why is adoption (s)low?’, yet this lessens the importance of adaptation of the practice to local contexts and farmer situations. Instead, Sumberg (2005) argues a better question would be ‘how and/or why are resource allocation...
decisions made?’ and in doing so changing the focus from technical performance to local adaptation of practices to enable utilisation.

Such reframing aligns with many studies which recommend a change of focus from technical performance to understanding the broader context for utilisation to occur (i.e. beyond the plot scale). For example, Corbeels et al. (2014) states that “too often projects focus heavily on agronomic, field scale matters, often to the detriment of dealing properly with issues arising at other scales or of a different nature” (p14). This is similar to Giller et al. (2011) in that “technical performance at field level is but one of the determinants of adoption” (p468). In the southern African context, Andersson and D’Souza (2014) highlight an abundance of farm level constraints identified as constraining CA, yet “contextual factors influencing CA (non) adoption have generally received less attention” (p117), arguing the need for analysis of a wider set of socioeconomic, institutional and policy factors in adoption studies.

In addressing this gap, there is a clear need for greater exploration of the perspectives of farmers and other local stakeholders in the innovation process. Sumberg (2005) highlights that such perspectives are integral to the adaptation and uptake of new practices, yet are often forgotten, and to continue to claim that innovations in agricultural research are not being adopted due to well-known contextual issues denies an important step in the design and development process. By focusing on local perspectives, a more mechanistic understanding of farmer decision making is possible (Baudron et al., 2012), allowing us to broaden the understanding of resource allocation decisions beyond household characteristics and technical performance. Doing this requires time intensive, qualitative research that reaches beyond the small proportion of farmers who are participating in a particular development project. Such studies are largely absent in the literature.

Because we are yet to obtain a complete understanding of the status and determinants of CA uptake, there is also limited understanding on the pathways to achieve it. The focus on achieving ‘adoption’ means there has been limited exploration of how subsistence farmers implementing low input farming systems transition into commercially viable higher input production systems based on CA. Current pathways are based on incremental expansion of CA area without modification, which reflects the limited understanding of current status and determinants of CA uptake outlined above. Hence, there is clearly a need for a broader and more nuanced investigation of ways to estimate and understand CA utilisation. Despite this,
there are few operationalised frameworks to do so. Some attempts have been made (e.g. Kuehne et al., 2017; Ndah et al., 2015), but these apply only binary classifications of adoption and do not address the mechanisms for farmer resource allocation. There is a need to find new ways to explore the uptake of CA.

1.4 Research objectives

This thesis addresses three research themes. Each theme is defined by a research question and a research objective. This investigation should not be viewed as a criticism of prior efforts, but as a natural evolution of the discussion to increase the understanding of the fit of CA to African smallholder systems through increased depth of analysis and broadening of the current base of understanding. The three research themes are:

Theme 1: The ‘What’ of CA Utilisation

The first theme explores the way ‘adoption’ is used to classify the uptake of agricultural technologies. The research question addressed is: ‘Can we better understand and classify the uptake of CA by African smallholder farmers?’ In moving beyond a binary classification of adoption, this research question is addressed through the exploration of the intensity, types and stages of CA utilisation that occur across five countries: Ethiopia, Kenya, Tanzania, Malawi and Mozambique. Three novel frameworks are proposed: 1] a standardised CA nomenclature to classify the types of CA utilisation by farmers; 2] the Conservation Agriculture Appraisal framework (CAAF) to classify the intensity of CA utilisation by farmers; and 3] the Process of Agricultural Utilisation Framework (PAUF) to classify the stages of CA utilisation by farmers. In applying these three frameworks to large quantitative household surveys, the first research objective is addressed: Quantification of the ‘what’ of CA utilisation.

Theme 2: The ‘Why’ of CA utilisation

After quantifying the ‘what’ of CA utilisation, the second theme explores the determinants of farmer decision making that contribute to the status of CA uptake in six African countries: Ethiopia, Kenya, Uganda, Malawi, Zambia and Mozambique. The research question addressed is: ‘Can we better contextualise the realities of agricultural practice selection by African smallholder farmers?’ This contextualisation is undertaken noting varying contexts in each of the communities and countries, but within an overall resource and information constrained environment that unites farmers in their decision making processes. The fourth and final novel framework of this thesis is proposed, the Livelihood Platforms Approach (LPA), which provides
a structure to understand and contextualise farmer resource allocation decisions. In applying the LPA to qualitative semi-structured interviews, the second research objective is addressed: Qualification of the ‘Why’ of CA utilisation.

**Theme 3: The ‘How’ of CA utilisation**

The findings of themes 1 and 2 are compared to the ‘what’ and ‘why’ of CA utilisation in other regions to explore the process and expectations for CA utilisation in SSA. The different contexts, drivers and preconditions that enabled adoption in other regions globally are compared with the contexts identified in theme 2. The research question explored is: ‘How might uptake of CA occur in the SSA smallholder context?’ Through this comparison, the third research objective is addressed: Synthesis of the ‘How’ of CA utilisation.

**1.5 Thesis scope and literature context**

This thesis does not enter the ongoing debate on the nuanced biophysical benefits of CA that may materialise to African smallholder farmers (e.g. see Pittelkow et al., 2015), nor does it attempt to understand the characteristics of farmers who adopt (of which there is an abundance of literature). Instead, it explores the perspectives of community members on CA and the issues that drive individuals’ resource allocation decision making within a broader community and institutional context.

This work can be viewed within the lens of the farmer participatory research (FPR) framework (Farrington and Martin, 1988), which acknowledges the complexity of agricultural production and the need for analysis at multiple levels to inform technological development through participation of farmers in the technology development process. It emphasises the need to move away from traditional ‘technology transfer’ research, development and extension strategies towards a more holistic and engaging interaction with communities. Likewise, it is also relevant with the farming systems research (FSR) framework, whereby the implementation of the LPA framework assumes: 1] that farmers are rational in their decision making; 2] that their decision making is based on their available resource base, circumstances, opportunities and knowledge; and 3] farmers typically manage a complex combination of crops, animals, and other on-farm and off-farm activities to satisfy their physical, financial and social needs. As part of these FPR and FSR frameworks, this work is interdisciplinary, integrative, problem-oriented and farmer/community-centric.
In implementing this approach, a broad viewpoint is used to investigate CA as a disaggregated package of individual practices through which gradual increases in the type and intensity of CA implementation can occur. This is in line with much of the recent literature (e.g. Giller et al., 2015) that calls for movement away from dogma and prescriptive approaches around CA to the development of a more holistic basket of options for soil and crop management from which farmers can choose to implement their livelihoods.

It should be noted that this research takes a different approach to the existing literature by exploring the research topics via typologies based on the Process of Agricultural Utilisation Framework (see chapter 2). In doing this, qualitative explorations of farmer decision making are examined via four broad categories: 1] positive utilisation; 2] negative evaluation; 3] current evaluation; and 4] farmers yet to evaluate. This approach is taken as a point of difference to other studies, under the provision that new thinking is required to address ongoing problems in the analysis of farmer decision making. This approach is further applied to the perspectives of extension services, community leaders and research services, which may be interpreted as repetitive by readers. Instead, we hope this approach is interpreted as an attempt to build a strong argument for both the approach applied and the validity of results found. The limitations of this approach are discussed in section 12.5.

1.6 Thesis structure

This thesis is structured in a thesis-by-publication format, with the body of the thesis containing ten manuscripts. Due to this, and in an attempt to limit an excessive word count and repetition, there are no traditional methodology, theoretical framework or literature review sections within this thesis. However, the content that would be expected in these sections can be found within the manuscripts in the body of the thesis. To provide a narrative structure within the thesis, each manuscript is preceded by a summary which provides a concise overview of the manuscript contents, while each section has an introductory summary to unite the thesis narrative. The reader may also note similarities within some papers, reflecting the broad range of journals that have been targeted and subsequent need for each paper to provide sufficient justification of the method to warrant the paper standing alone. Noting this, this thesis is organised into five sections as follows:

Section A (this section) provides an introduction to this thesis and provides an overview, the research gaps to be addressed by the research themes and information on the thesis structure.
Section B addresses the first research objective: the quantification of the ‘what’ of CA uptake. Chapter 2 proposes three theoretical frameworks to explore the types and intensities of CA use across eastern and southern Africa, and applies this to household survey data to provide a robust estimate of the status of CA in 2010 across five countries. Chapter 3 extends two of these frameworks to specifically explore minimum tillage utilisation across the same countries in 2013.

Section C addresses the second research objective: the qualification of the ‘why’ of CA uptake established in Section B. Chapter 4 proposes the fourth theoretical framework of this thesis, which is then used to structure the qualitative assessment of farmer decision making which is applied to understand the negative evaluation of CA by African smallholder farmers. The same theoretical framework is then applied to the remaining chapters of Section C to explore different perspectives from key stakeholders, viz: positive utilisers (Chapter 5), evaluating farmers (Chapter 6), non-exposed farmers (Chapter 7); extension service providers (Chapter 8); community leaders (Chapter 9) and local agricultural researchers (Chapter 10).

Section D addresses the third research objective: the synthesis of the ‘how’ of CA uptake. Chapter 11 explores the features of global uptake of CA and compares this to the findings from Sections B and C, highlighting implications for CA uptake in SSA.

Section E provides the closing remarks for this research. Chapter 12 outlines how each research objective has been addressed as well as limitations and future work regarding this research.

Section F contains then contains appendices of associated work.

1.7 Bibliography


Sumberg, 2005. Constraints to the adoption of agricultural innovations - is it time for a re-think? Outlook on agriculture 34, 7-10.


Section B: The ‘What’ of CA Utilisation

This section contains a quantitative investigation of the status of CA utilisation in Eastern and Southern Africa, which refers to the first research objective. Chapter 2 establishes the need to move beyond narrow estimations of adoption that use binary frameworks, and in doing so proposes three novel frameworks: 1] a standardised CA nomenclature to understand the types of CA utilisation; 2] the Conservation Agriculture Appraisal Framework (CAAF) to quantify the intensity of use of CA and CA components; and 3] the Process of Agricultural Utilisation Framework (PAUF) to classify farmers into various stages of use and non-use. These frameworks are applied to large household datasets collected in 2010 across five countries to understand the types and intensities of CA utilisation. Chapter 3 then extends these frameworks to understand the utilisation of minimum tillage in 2013 across the same five countries. In doing this, Section B establishes the central concept of this research: that farmer uptake of CA has been overestimated and understanding has been limited by binary methods of adoption estimation. Through the novel frameworks proposed, this section also provides the basis for qualitative investigation of the determinants of CA utilisation investigated in Section C. A visual summary of quantitative findings is given in Appendix A3.
Chapter Two: The Status of CA Utilisation in 2010

Chapter 2 contains the first manuscript of this thesis which explores the utilisation of CA by African smallholder farmers in 2010. A summary of the manuscript is provided, followed by the statement of authorship and manuscript 1.

2.1 Manuscript Summary

Figure B: Graphical abstract of manuscript 1

Context:

- Arguments have been made that current estimates of CA adoption are misleading and have limited validity due to: 1] weak methodologies; 2] definitional diversity on both CA and CA adoption; and 3] binary assessment frameworks.
- There is a need for new methodologies to estimate the uptake of CA by African smallholder farmers.

Research objectives:

- To address the identified methodological void through the proposal and implementation of a more nuanced analysis of the types and intensities of CA utilisation.
Methods:
• Three novel interrelated frameworks are proposed to understand the types (CA nomenclature), intensities (CAAF) and stages (PAUF) of CA utilisation.
• These frameworks are applied to large household survey datasets conducted in five African countries in 2010.

Findings:
• Utilisation of CA and CA components is limited in across all studied countries.
• Other studies appear to overestimate utilisation and are potentially misleading, though comparisons are difficult due to ambiguity over their classification structure.
• Two key research questions are identified for further qualitative exploration: 1] why are farmers not obtaining information on CA components?; and 2] once exposed to CA, why are farmers not preferencing their resource allocation decisions towards total utilisation of CA?

Implications:
• Additional meaning is gained through the use of the PAUF and CAAF which highlight the need for stronger classification frameworks to understand utilisation and greater emphasis on understanding the mechanisms determining farmer’s access to information resources and resource allocation decision making.
2.2 Statement of Authorship

Manuscript Details:

| Title of Paper: | Stepwise frameworks for understanding the utilisation of conservation agriculture in Africa |
| Publication Status: | Published |

Principle Author:

| Principle Author: | Brendan Brown (Candidate) |
| Contribution to paper: | Identification of research gap, theoretical conceptualisation, framework development; obtaining of data, analysis of data, interpretation of results, writing of manuscript, acted as corresponding author |
| Overall percentage: | 80% |
| Signature: | Date: 17/08/2017 |

Co-Author Contributions:

By signing the Statement of Authorship, each author certifies that:

i. the candidate’s stated contribution to the publication is accurate (as detailed above);

ii. permission is granted for the candidate in include the publication in the thesis; and

iii. the sum of all co-author contributions is equal to 100% less the candidate’s stated contribution.

| Name of Co-Author | Ian Nuberg |
| Contribution to paper: | Supervision, evaluation and editing of the manuscript |
| Signature: | Date: 17/08/2017 |

| Name of Co-Author | Rick Llewellyn |
| Contribution to paper: | Supervision, evaluation and editing of the manuscript |
| Signature: | Date: 17/08/2017 |
Stepwise frameworks for understanding the utilisation of conservation agriculture in Africa

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\textbf{ABSTRACT}

Despite the large and ongoing investment in the promotion of Conservation Agriculture (CA) to African smallholder farmers, currently available estimates of adoption provide little insight into the realities of their use. Both the technologies and their adoption tend to be poorly defined, leading to large variation in estimates and validity issues. To address this void, we propose two independent but complementary frameworks: the Conservation Agriculture Appraisal Framework (CAAF) is used to quantify the intensity of implementation of CA; and the Process of Agricultural Utilisation Framework (PAUF) is used to classify various types of use and non-use by disaggregating the adoption process into ten stages. These frameworks are applied to household survey data across five eastern and southern African countries from 1,601 village and 6,559 households. Overall, we find a general overestimation of adoption of CA and CA components. By considering in more detail the intensity of implementation and the types of use and non-use, new meaning is found in the status and contributors to limited CA utilisation.

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1. Introduction

Conservation Agriculture (CA) aims to make better use of agricultural resources through the simultaneous implementation of minimum soil disturbance, permanent soil cover and crop diversification (Thiombiano and Mendoza, 2009). Over the past two decades, CA has been extensively promoted as the panacea for areas with low agricultural production in Africa (and more generally) and the dominant paradigm for both climate smart agriculture and sustainable agricultural intensification. The prominence of CA is underpinned by the high potential for increased agronomic and environmental outcomes (Mupangwa et al., 2016; Ndali et al., 2014; Thierfelder et al., 2015; Thierfelder et al., 2016).

Following strong promotion, the area under CA in Africa is claimed to have increased by 57% between 2008/9 and 2013 to more than 1.2 million ha (Kassam et al., 2015). The potential benefits and stated achievements have outlived the view that CA will be the primary solution for improving African smallholder agriculture (Hebblethwaite et al., 1996; Hobbs et al., 2008). In response to the claims of mass adoption of CA, questions have been asked of the validity of such estimates (Andersson and Giller, 2012; Andersson and D’Souza, 2014; Giller et al., 2015; Giller et al., 2009). The core argument made in such papers is that estimates of adoption are often more obscure than revealing and adoption is substantially more limited than most estimates suggest. We use detailed data from farmers in five countries to test these arguments.

This article explores the limitations in CA adoption estimates, and subsequently proposes two interrelated frameworks to address the ‘what’ and ‘how’ of CA adoption. In doing so, we explore the hypothesis that adoption of CA (and CA components) has been more limited than other estimates in five eastern and southern African countries. By moving beyond binary classification, we create new meaning in the types of CA adoption and non-adoption to facilitate evidence based discussion on how to increase the use of CA practices.

1.1. Key limitations with CA adoption estimates

There is now a large body of literature that questions the validity of CA adoption estimates. The basis for such questions stems back to three key limitations: the use of weak methodologies to estimate adoption, definitional diversity of what constitutes CA, and the dominance of binary assessment frameworks.

1.1.1. Weak methodologies

Methodological weakness of prior adoption studies limits our understanding of smallholder CA adoption (Andersson and D’Souza, 2014). Many studies, such as those from the FAO based FAOstat (FAO, 2016) and further published periodic reviews (Friedrich et al., 2012; Kassam et al., 2015)
et al., 2015; Kassam et al., 2009) are based on estimates from ministries of agriculture, by farmer organizations, and/or well-informed individuals in research or development organizations. Likewise, many field studies are based on personal estimates and observations (e.g. Mloza-Banda and Nanthambwe, 2010; Nyagumbo et al., 2011). Whilst common, such methods are not easily repeatable and difficult to independently validate. Furthermore, such estimates are usually made in the context of development projects and thus have the potential to be biased.

1.1.2. Definition and diversity

There is large diversity in what constitutes CA throughout Africa. The formal definition as stated by the FAO (2016) is well established as the simultaneous implementation of three CA components:

- Minimum tillage: a soil disturbed area of less than 15cm (or 24%); and
- Stover cover: 30% ground cover at planting; and
- Crop diversification: Three crops in rotation.

Yet adoption studies tend to lack clarity on the definition of CA they implement and the thresholds they use. Many studies adopt a reductionist approach where one element may constitute CA adoption (e.g. Dersch et al., 2010) where minimum tillage, conservation agriculture and zero tillage are said to be synonymous. Anderson and D’Souza (2014) summarise such issues in southern Africa with the development of different definitions of CA between Zambia, Zimbabwe and Malawi and the complications that arise.

1.1.3. Binary assessment frameworks

The literature body is mostly uniform in the application of binary classifications to understand adoption (i.e. a farmer can be either an ‘adopter’ or ‘non-adopter’). Yet such a framework provides limited insight and can lead to misleading conclusions, noting the lack of understanding in reference to:

Modification and partial adoption

The realities of technology transfer in resource limited contexts, and where economic, social, political or institutional enabling environments may not exist, means that partial CA adoption is the most likely outcome (Baudron et al., 2007; Gillier et al., 2000; Gowing and Palmer, 2008; Pannell et al., 2014). Further, there is considerable literature indicating that partial adoption of CA (i.e. only one or two components of CA) may have poor outcomes, particularly if minimum tillage is done without stover cover (Erenstein et al., 2012; Goto et al., 2011). Despite this, partial adoption is rarely adequately recognised or quantified in the literature.

Intensity of Adoption

It is long-accepted that adoption of most agricultural technologies involves a non-binary process and tends to be partial and incremental (e.g. Baudron et al., 2007; Byerlee and De Polanczyk, 1986). In resource-limited environments, it is understandable that a farmer will reduce the intensity of a beneficial technology to match resource endowments and suit their socio-political circumstance. Currently, farmers who conduct small trials (usually of 10 m × 10 m in the East African context) are grouped together with farmers who may practice on a single plot or those who have fully embraced the technology across several fields. Using a binary classification may obscure our understanding of how a technology fits within the contextual constraints of community.

Incentivised adoption

In the African context, CA is strongly promoted via development projects which provide incentives to practice CA in the form of subsidised or free fertilisers, seeds, herbicides, or artificial market opportunities (Anderson and D’Souza, 2014; Mloza-Banda and Nanthambwe, 2010). This can lead to ‘pseudo-adoption’, where adoption claimed during the course of a development project is not a sustained change in practice but due to the temporary influence of the project (Haggblade and Terekho, 2003) and thus not indicative of longer term adoption (Anderson and Giller, 2012; Anderson and D’Souza, 2014). This has led to limited value in adoption statistics that do not disaggregate those with artificial short-term incentives and those who have truly invested in the innovation.

Determinants of non-adoption

Non-adoption is generally assumed to be a reflection of negative evaluation, be it due to low expected benefit (Kathage et al., 2015), resource availability (Baudron et al., 2014; Foster and Rosenzweig, 2010; Grabowski et al., 2016), institutional arrangements (Rockstrom et al., 2003) or personal preference (Lalani et al., 2016; Van Huist and Posthumus, 2016). Such results may be partly due to use of data aggregation that tends to lessen the importance of issues such as exposure to the technology, which in the African context can be a leading contribution to non-adoption (Ngwira et al., 2014). Without disaggregating non adoption into its various stages, limited meaning can be gained from binary adoption estimates.

1.2. Implications of the limitations of CA adoption estimates

The limitations of CA adoption estimates often lead to ambiguity in what constitutes both CA as a technology and CA adoption. This has led to large variation in adoption estimates. For example, national estimates of the area under CA in Malawi vary nearly seven fold in 2009-10, from 5,407 farmers in Thiombiano and Mchack (2009) to 37,594 farmers in Mloza-Banda and Nanthambwe (2010). Such variation has been highlighted by several studies that suggest caution in the accuracy and validity of current estimates (Anderson and D’Souza, 2014; Giller et al., 2015; Gillier et al., 2008; Glover et al., 2016). This lack of standardisation is acknowledged at national levels, for example by the National Conservation Agriculture Taskforce Secretariat (NCAFS) of Malawi which state that “…in the absence of standardised monitoring tools, critical statistics such as land area under CA are difficult to estimate” (Malawi Ministry of Agriculture, 2012). As such, there is little merit in comparison of CA adoption across studies without addressing the limitations of CA adoption estimates.

2. Theoretical Frameworks

Whilst there are claims that CA adoption is far less than current reports suggest (Anderson and D’Souza, 2014), there has been no framework to facilitate the quantification of such claims. To address this void, we propose two frameworks to estimate the ‘what’ and ‘how’ of CA adoption. The Conservation Agriculture Appraisal Framework (CAAF) is applied to quantify the intensity of use of CA and CA components, whilst the Process of Agricultural Utilisation Framework (PAUF) is applied to understand the types of adoption and non-adoption. These independent, but complementary, frameworks are proposed as a methodology to standardise CA adoption studies and provide increased depth to the reporting and analysis of agricultural adoption estimates.

2.1. Defining the ‘what’ of CA via the Conservation Agriculture Appraisal Framework (CAAF)

Whilst the FAO definition of CA is clear, it has limited applicability for understanding the intensity of use and partial use at farm level. As such, the practical and implemented definition of CA and the theoretical definition of CA have diverged. We propose a standardisation of CA definition to facilitate greater validity in comparisons of CA studies and to ensure ‘like-for-like’ comparisons (visualisation provided in Fig. 1).
To quantify this conceptualisation, the Conservation Agriculture Appraisal Framework (CAAF) is proposed (Fig. 2). The CAAF proposes a framework to quantify the intensity of use of CA and CA components through the defining clear classification thresholds. These thresholds are proposed by The Conservation Agriculture Task Force for Zimbabwe (2008) for minimum tillage, Zimbabwe Conservation Agriculture Task Force (2009) for stover cover and the FAO (2010) for legume diversification. Note that to measure legume diversification at plot level, a Legume Diversification Index (LDI) is proposed as the highest of the below three measures:

a) The ratio of area a legume covers in an intercropped plot; or
b) The ratio of legume area planted in the last 3 years in a plot; or
c) The ratio of applicable area under legumes in the current season (to account for spatial rotation of legumes).

For each CA component, each plot (i.e. individually identified parcel of land a farmer identifies) is given a plot level index ($R_{\text{Component}}$) from 0 (no use) to 1 (full use), with any score in between 0 and 1 reflecting the intensity of partial use. For the aggregate CA score, the average of the 3 components is taken. Each plot score is then weighted according to the area it holds in proportion to the areas that the component could be practiced on the farm (i.e. for CA excluding perennial and tuber crops). For each farmer, the plot scores are summed to provide a farm weighted index ($R_{\text{Component}}$), also from 0 to 1. An $R_{\text{Component}}$ score of zero indicates no use of that component occurred on any plot of a farm, whilst an $R_{\text{Component}}$ score of 1 indicates that all plots of a farm have adequate implementation of that component. Scores between zero and one indicate intensity of use on that farm.

2.2. Defining the ‘how’ of CA via the Process of Agricultural Utilisation Framework (PAUF)

Objective measurement of adoption is challenging (Ciller et al., 2015), yet there is an established need for a more thorough analysis of adoption to reflect various stages of use. Whilst the CAAF provides important insights into the intensity and modification of use of CA and CA components, it does not account for many of the sub-typologies of adoption of non-adoption discussed in Section 1.3. To address this, we propose a shift in terminology from ‘adoption’ (i.e. binary ‘adoption’ and ‘non-adoption’) to a more structured ‘utilisation’ process (i.e. utilisation accounting for various sub-types of use and non-use). Such a change would facilitate key recommendations on building knowledge in modification and intensity of use as recommended by Anderson and D’Souza (2014) and embrace component adoption as an incremental, stepwise process as farmers graduate to more sustainable and productive systems, as recommended by Glover et al. (2016a). This conceptualisation of movement from binary to sub-typologies of use is given in Fig. 3.

Hence, the PAUF is proposed as a framework to understand the various stages of use in the adoption process (Fig. 3). The adoption process is framed in four phases from exposure to non-trial assessment, trial assessment and utilisation, and into 10 distinct stages. Not all stages are sequential, and a farmer is unlikely to move through from stages 1 to 10. Rather, the various stages are given to understand adoption pathways. As such, a farmer may not intrinsically finish at stage 10 or progress through every stage, and the grey feedback arrows show that farmers are in a constant evaluation cycle. However, by understanding the proportionate breakdown of communities, insights into the constraints to adoption can be obtained.

The PAUF frames utilisation through disaggregation of the adoption process into 10 stages which fit into four phases from exposure to utilisation. They are:

Phase 1 - exposure
This phase contains farmers who are in the process of sensitisation, which involves the obtaining of awareness and familiarity. The starting point of a farmer for any technology is that of being ‘Unaware’ (Type 1). Once a technology is recognised as existing, enough information must be obtained (usually via training and extension activities) in order to evaluate the usefulness of the technology. If a farmer is aware of the technology but unsure of its attributes, they are classified ‘Unfamiliar’ (Type 2).

Phase 2 - non-trial assessment
This phase is based on the cognitive recognition of a problem and appreciation that the proposed innovation can be a solution to that problem. This involves a preliminary assessment of feasibility without any personal experience with the technology. If the technology is deemed to be both relevant and attractive, the farmer is classified ‘Interested’.

![Fig. 1. Reconceptualization of the definition and implementation of Conservation Agriculture](image-url)
such a farmer is likely to continue to engage with the technology diffusion process and progress to higher stages. However, if the technology is deemed either not relevant or not attractive, the farmer is classified as ‘Not Interested’ (Type 3) and is unlikely to further engage in the adoption process until they are convinced it is relevant to their needs and is feasible from within their resource base.

**Phase 3 - trial assessment**

This phase contains farmers who are undertaking a trial to assess the feasibility of an innovation under their personal circumstances. This is usually confined to a restricted area of the farm. A distinction is made between those who are supplied resources to implement the trial (Type 5) and those who implement with their own resources (Type 6). This distinction is important to differentiate project subsidised adoption from farmer driven adoption. Note that trial assessment is not always undertaken and may be bypassed if a technology cannot be trialled or farmers only require non trial assessment to adopt.

**Phase 4 - utilisation**

This phase contains farmers who have completed their evaluation of a technology and implemented accordingly. There are four potential outcomes of this confirmation. If the technology is not deemed attractive or feasible, and no longer used, the farmer is classed a ‘Disadapter’ (Type 7). If a farmer uses private resources to change, maintain (in the case of a subsidised trial farmer) or expand a trial, they are deemed to have had a positive trial (stages 8 to 10). If the technology is subsequently applied in modified form, the farmer is classed a ‘Modified Utiliser’ (Type 8). If the technology is in its original form but not applied to any applicable area, that farmer is classed a ‘Semi Utiliser’ (Type 9). If the technology is applied in its original form and on all applicable area, that farmer is classed a ‘Total Utiliser’ (Type 10).

**3. Methods**

The proposed CAAF and PAUJ frameworks are applied to datasets from five countries in eastern and southern Africa as follows.

**3.1. Dataset**

The data used in this study are derived from farm household surveys conducted in late 2010 and early 2011 in Ethiopia, Kenya, Tanzania, Malawi and Mozambique. The survey was developed and led by the International Maize and Wheat Improvement Center (CIMMYT) and implemented by the national agricultural research services of each partner country. The purpose was to investigate the broader theme of sustainable intensification. A structured farmer questionnaire was
prepared and standardised across countries. It consisted of household identified characteristics regarding all household plots as well as individual, household and village characteristics (both agronomic and other). There were 12 sections: village characteristics, household characteristics, social capital and networking, household assets, maize seed variety and practice, crop production, livestock production and marketing, other income sources, financial capital and institutions, household expenditure and impacts of adoption of maize varieties.

3.2. Sampling strategy

A reconnaissance survey was first conducted in each of the five countries to create a broader understanding of maize-legume and livestock production systems in the survey districts (see Table 1). These surveys consisted of secondary data from the Ministry of Agriculture offices and other development organizations, as well as informal discussions with key informants and farmers. Findings from the first stage were

<table>
<thead>
<tr>
<th>Country</th>
<th>Stage 1 - purposeful</th>
<th>Stage 2 - random</th>
<th>Households</th>
<th>Dataset</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ethiopia</td>
<td>39 districts from 5 Regions (Tigray, Amhara, Oromiya, Benishangul-Gumuz, SNNP)</td>
<td>432 peasant associations</td>
<td>2,821</td>
<td>(Mnerua et al., 2015a)</td>
</tr>
<tr>
<td>Kenya</td>
<td>Five districts, two western districts (Bungoma and Siaya) and three eastern districts (Embu, Meru South and Merti South)</td>
<td>117 villages from 30 divisions</td>
<td>610</td>
<td>(Mnerua et al., 2015c)</td>
</tr>
<tr>
<td>Tanzania</td>
<td>Four districts, two eastern districts (Kisasi and Mbarara) and two northern districts (Kilwa and Kagera)</td>
<td>65 villages from 39 wards</td>
<td>701</td>
<td>(Mnerua et al., 2010b)</td>
</tr>
<tr>
<td>Malawi</td>
<td>Six districts: three high potential (Likongwe, Kasungu, Mchinji) and three low potential (Salima, Nchalo, Balaka)</td>
<td>878 villages from 179 extension planning areas</td>
<td>1,917</td>
<td>(Mnerua et al., 2015c)</td>
</tr>
<tr>
<td>Mozambique</td>
<td>Four districts, two in Manica (Sesuandenga, Manica), one in Sofala (Gorongosa) and one in Tete (Anguina)</td>
<td>105 villages from 41 administrative locations</td>
<td>510</td>
<td>(Mnerua et al., 2015a)</td>
</tr>
<tr>
<td>Total</td>
<td>58 districts</td>
<td></td>
<td>6,559</td>
<td></td>
</tr>
</tbody>
</table>
used to refine the survey instrument and sampling methods. Following this, a multi-stage sampling methodology based on a combination of purposive and probability proportional to size sampling methods were employed to select regions, districts, villages and households as follows:

Stage 1: purposeful selection of regions and districts.

For Kenya, Tanzania and Mozambique, the primary focus was placed on maize based farming systems, and as such this was used as an important criterion for purposeful selection of regions and districts. Different agro-ecological zones were sought to balance the dataset, particularly in regard to both high and low rainfall agro-ecologies. For Ethiopia and Malawi, nationally representative datasets were formulated based on purposeful selection of districts across all regions within each country.

Stage 2: random selection with probability proportional to size for villages and households. In each district, villages and households were selected with probability to proportional size to ensure equal representation. The selected districts and villages as well as total households are given in Table 1.

3.3. Implementation of the CAF and PAUF

To implement the CAF and the PAUF, the following information is required:

- Farm characteristics (size, crop types); and
- If the practice is used:
  - Current and prior extent of use of the technology; and
  - Source of inputs for implementation of the technology;
- If the practice is not used:
  - The awareness and perception of the technology.

The CAF classification occurs as part of a two-step process (Fig. 5). Firstly, plots are classified into one of eight plot classes. Following this, farms are then classified into one of ten PAUF stages according to the characteristics of all the farmers’ plots. Note that ‘applicable’ refers to the use of crops that CA can be applied to, and excludes perennial and tuber crops. Also, no specific information was obtained in the survey to disaggregate ‘unaware’ (Type 1) and ‘unfamiliar’ (Type 2) farmers, and as such these two categories were aggregated as a phase level (see Fig. 4) as ‘unexposed’ (Type 1 + 2).

4. Results

The demographic characteristics of respondents in each country are given in Table 2. Whilst Ethiopia had the largest average farm size, it also had the most fragmentation due to a high number of plots per farmer. Ethiopia and Kenya also had the highest proportion of their land allocated to non-CA crops.

Further analysis is presented as the three CA components individually, and then CA as an aggregation of the three components.

4.1. Minimum tillage

In all five countries, use of minimum tillage was constrained (Fig. 6). Under binary classification (i.e. where any use on a farm constitutes adoption), Mozambique (20.8%) and Tanzania (14.3%) showed limited adoption whilst Ethiopia, Kenya and Malawi showed very limited adoption (all <3%). The CAF results show all CAF scores above zero were far outliers, reflecting the limited intensity of use in all countries. The PAUF results show constrained adoption is strongly influenced by the substantial rate of non-exposure in all countries except Mozambique, as well as moderate rates of disinterest. Exposure and disinterest categories combined accounted for between 75% and 96% of farmers, highlighting these as important contributors to limited adoption rates. Use was also constrained by disadoption, particularly in Malawi (71.1% of users disadopted), Kenya (48.5% of users disadopted) and Ethiopia (22.2% of users disadopted).

---

Fig. 5: The classification structure applied to data for implementation of the PAUF
Table 2: Summary demographics of farm characteristics for five study countries.

<table>
<thead>
<tr>
<th>Country</th>
<th>Survey coverage (ha)</th>
<th>Average farm size (ha)</th>
<th>Average CA applicable area (ha)</th>
<th>Average area of farm with CA applicable crops (%)</th>
<th>Average number of plots per farm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ethiopia</td>
<td>6.36G</td>
<td>2.6</td>
<td>1.9</td>
<td>76.0</td>
<td>4.3</td>
</tr>
<tr>
<td>Kenya</td>
<td>922</td>
<td>1.5</td>
<td>1.1</td>
<td>72.8</td>
<td>4.7</td>
</tr>
<tr>
<td>Tanzania</td>
<td>1.24I</td>
<td>1.8</td>
<td>1.7</td>
<td>96.1</td>
<td>2.3</td>
</tr>
<tr>
<td>Malawi</td>
<td>2.45I</td>
<td>1.3</td>
<td>1.1</td>
<td>87.3</td>
<td>3.2</td>
</tr>
<tr>
<td>Mozambique</td>
<td>747</td>
<td>1.5</td>
<td>1.5</td>
<td>97.7</td>
<td>3.2</td>
</tr>
<tr>
<td>Total</td>
<td>11.722</td>
<td>1.9</td>
<td>1.5</td>
<td>83.5</td>
<td>4.5</td>
</tr>
</tbody>
</table>

4.2. Stover cover

Malawi and Mozambique were the highest adopters of stover cover practices both by binary and CAAF measures, followed by Tanzania, Kenya and Ethiopia (Fig. 7). Despite this, Tanzania showed the highest total adoption rate (23%). The PAUF results indicate limited adoption in Kenya and Ethiopia is due to substantial rates of non-exposure and disinterested. There was substantial modified use of stover cover in all countries except Tanzania and substantial semi-use in Mozambique and Malawi.

4.3. Legume diversification

Legume diversification was the most utilised CA component in all countries. Both the binary and CAAF results indicate legume diversification was most adopted in Kenya, and least adopted in Ethiopia (Fig. 8). Total use was comparatively substantial in both Tanzania (38%) and Kenya (35%), whilst semi-utilisation was the dominant form of use in all countries except Tanzania where it was total use. Disinterest was a major contributor to limited use of legumes in Ethiopia, where it accounted for 41% of farmers. The CAAF results indicate that whilst Mozambique was a comparatively high binary adopter, implementation tended to be at a lower intensity, dropping to a ranking of 4th under CAAF results. As such, Tanzania and Kenya ranked above Mozambique due to comparatively high total use.

---

Fig. 6: Binary, CAAF and PAUF results for minimum tillage. Binary results classify any use as a farmer adopting. The CAAF Farm index is given as a box plot. An outlier (> 1.5 × interquartile range) is denoted by * and an extreme outlier (> 3 × interquartile range) is denoted by **. The mean (in brackets) and statistical grouping (P < 0.05) is given.
4.4. Conservation agriculture

The amalgamation of the three CA components shows overall that the majority of farmers in each country practiced some form of CA in some capacity (Fig. 9). However, practices tend to be at a low intensity, mainly due to the dominance of modified use. Modified use accounted for 56% of farmers in Ethiopia and between 89% and 96% in the remaining countries. Only Tanzania had a total utilisation rate of 0.01% (at 3.1%). The CAAF results indicate that Tanzania and Mozambique are the most advanced in terms of aggregate CA use, followed by Malawi, Kenya and Ethiopia. Non-exposure (37%) was a key determinant of the limited use of CA in Ethiopia.

5. Discussion

5.1. Minimum tillage

We did not find any studies that quantified the adoption of minimum tillage in Kenya, Mozambique or Tanzania in the literature. However, our results do conflict with estimates of minimum tillage made in both Ethiopia and Malawi (noting that those studies implement binary classifications where any use is classed as adoption). In Ethiopia, Teklewold et al. (2013) estimated minimum tillage adoption at 12% of plots in 3 districts of Ethiopia in 2009–10 whilst Kassie et al. (2010) estimated minimum tillage adoption at 13% of plots in the Tigray region and 15% of plots in the Amhara region in 1999–2000. We found only 1% rate of use at farmer level, and no total utilisers in Ethiopia. Likewise in Malawi, Ngwira et al. (2014) found a binary adoption rate of 94% (although this appears to only apply to CA adopters and no overall figure is given), compared to our estimate of 2.6%. Such variation is explained by the various definitions applied to adoption and further highlights the need for a standardised framework as proposed by this paper.

Limited minimum tillage was found to be driven by three dominant components across all countries: non-exposure, disinterest and disadoption. That exposure remained an issue in all countries except Mozambique is concerning noting the presence of minimum tillage starting from as early as the 1980s in Malawi (Mloza-Banda, 2002) and 1990s in Kenya (Marenya et al., 2014). This strongly indicates there are issues with information delivery to farmers. Such a conclusion is consistent with Ngwira et al. (2014) who found that 70% of non-adopters of CA in Malawi did so due to a lack of information.
Substantial disinterest and disadoption is likely to be a reflection of conflicts that minimum tillage may have with the social, cultural, and political contexts that farmers operate within. Much has been written about the ‘mindset of the plough’ (e.g. Anderson and D’Souza, 2014; Hobbs et al., 2008) and this is likely reflected through the cultural and institutional contexts of African smallholder farming. In Ethiopia, government policy recommends ploughing to maintain clean seed beds and likewise in southern Africa stover incorporation has been strongly promoted over previous decades as a method to retain soil fertility, and hence disinterest in minimum tillage is a likely outcome. The substantial conversion of users to disadopters further highlights such issues, and is also compounded by the potential for subsidy reliance and subsequent disadoption when projects finish and remove any incentives (Arslan et al., 2014). Such results emphasise a need for further research to understand information delivery issues and potential incompatibility of minimum tillage with farmers wants and needs.

5.2. Stover cover

We did not find any estimates of stover cover adoption in Ethiopia, Kenya, Tanzania or Mozambique in the literature. In Malawi, Ngwira et al. (2014) estimated binary adoption of 97% for stover cover, which is broadly similar to our result of 76%. The difference between scores is likely a reflection of our strict requirement for stover to remain unincorporated.

Overall substantial disinterest, modified and semi use are likely an indication of agronomic difficulties in producing sufficient stover and various competing uses for (limited) stover resources (Baumron et al., 2014). Further to this, the reduced total and binary use results and significant proportion of disinterested farmers in Ethiopia and Kenya are likely a reflection of the importance of mixed farming systems involving large livestock and subsequent stover requirements. Substantial semi-adoption may also reflect farmer’s adoption to a lack of stover security, whereby they will only maintain plots nearby homesteads or easily monitored for stover cover. As such, the risk to stover loss through wildfire and rodent-hunters (especially Malawi and Mozambique) or roaming cattle (especially Kenya and Ethiopia) can be mitigated through semi-adoption.

These results highlight the need for stover cover to be promoted as part of a systems approach that addresses nutrient management (to foster sufficient biomas production) as well as inclusion of various practices that enable livestock to function within a CA system (particularly to negate competing use for stover resources).
5.3. Legume diversification

Only one estimate of crop diversification was available in the literature for the study countries, and we found no study that estimated legume diversification in any of the studied countries. Ngwira et al. (2014) estimated crop diversification at 85% compared to our estimate of 76% farmer adoption of legume diversification. The difference between these two estimates is likely a reflection of the definition implemented, from crop diversification in Ngwira et al. (2014) to our stricter legume diversification. The CAAF results highlighted the importance of understanding intensity of use when reporting adoption. Whilst Mozambique ranked second in terms of binary adoption results, the substantial proportion of semi and partial use led to a drop to fourth in CAAF rankings, significantly below all countries except Ethiopia.

We find semi-use to be an important contributor to legume diversification use in all countries, a reflection of limited land size and the large proportion of land devoted to maize as the staple crop, particularly in Malawi, Mozambique and Kenya (Thierfelder et al., 2013). Substantial total use in Tanzania and Kenya and limited binary use in Ethiopia is also likely to be a reflection of the market opportunities for legumes available to farmers in these countries (Giller et al., 2011; Mazvimavi and Twomlow, 2009; Thierfelder et al., 2013). Further, the substantial level of disinterest in Ethiopia is a reflection of the importance of Teff (Eragrostis tef) in Ethiopian farming systems, particularly as a staple crop alongside maize in northern regions.

5.4. Conservation agriculture

The primary estimates used to compare CA adoption rates are from the FAOstat (FAO, 2016). Whilst FAOstat presents results based on percentage of arable land area under CA, our results are based on farmer status and thus comparisons have limited use. However, FAOstat does indicate limited adoption of CA (Kenya: 0.12%; Tanzania: 0.07%; Malawi: 0.29%; and Mozambique: 0.31%). Our result for Tanzania (where the sum of all unmodified use was 0.05%) could be interpreted as broadly similar. In Malawi, Ngwira et al. (2014) estimates adoption of CA at 18% of farmers, but their definition of CA adoption is not clear and as such, comparison remains difficult. Our results are considerably lower than those proposed by Thierfelder and Muesbeck (2009), Kasalu-Coffin et al. (2011) and Moyo-Banola and Nanthambwe (2010) but there is limited merit in comparisons due to their estimates being
reported in total hectares and the lack of clarity on their implemented definition of CA adoption.

Our CA results most strongly articulate the need for the stronger frameworks and definitions. Whilst under binary classification, CA was implemented by between 57% and 98% of farmers, only Tanzania has total utilisation of above 0.01% of farmers. That modified utilisation was substantial suggests that CA is its current form may not be relevant or feasible to the African smallholder context, and that stronger focus needs to be placed on intensifying CA implementation, rather than transformational change over shorter periods of time (Andersson and D’Souza, 2014; Glover et al., 2016).

6. Conclusions

Noting the limited literature on adoption rates of CA components in many circumstances, we find that, where comparisons are available, there has been a general overestimation of adoption of CA and CA components, and our frameworks have shown strong potential to provide an increased depth of meaning in quantification of adoption and non-adoption. For adoption, we find modified and semi-utilisation to be dominant with total use generally constrained which has been potential masked by the dominance of binary classification systems previously used. Furthermore, we find that our frameworks have identified trends in non-adoption and the balance of exposure, disincentive and disadoption that have not previously been quantified. As such, this paper sets the foundations for further studies such comparison adoption of CA and CA components using a standardised approach, as well as calling for further research to understand the pathways for increasing exposure, interest and total use of CA components, which will require qualitative research that goes beyond econometric analyses to investigate the underlying drivers of CA use and non-use.

Acknowledgements

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References


Chapter Three: The Status of Minimum Tillage Utilisation in 2013

Chapter 3 contains the second manuscript of this thesis which explores the utilisation of minimum tillage by African smallholder farmers from 2010 to 2015. A summary of the manuscript is provided, followed by the statement of authorship and manuscript 2.

3.1 Manuscript Summary

![Graphical abstract of manuscript 2](image)

**Context:**
- Estimating the uptake of minimum tillage remains subject to scrutiny due to current methods implemented. By moving beyond binary estimates of adoption, greater understanding of the uptake of agricultural practices can be achieved.

**Research objectives:**
- To quantify the utilisation of minimum tillage by smallholder farmers across four African countries and three time periods

**Methods:**
- The PAUF is applied to large household datasets from 2010, 2013 and 2015 collected in four countries to understand the status of Minimum tillage uptake.
Findings:

- Both minimum tillage adoption and total utilisation were found to be limited in 2010, with growing uptake in 2013 and 2015, particularly in Tanzania and Kenya.

- There are two varying uptake pathways, with Tanzania having substantial total utilisation while the other three countries containing mainly semi-utilisation and/or trial utilisations.

- For non-utilisation, there were persistent informational constraints leading to limited exposure in all countries.

- Limited uptake was further compounded by the high incidence of negative evaluation once farmers learn about MT.

Implications:

- Noting the limited proportion of farmers interested in or trialling MT, there is a need to further explore the mechanisms for extension dissemination if MT is to be more widely implemented.

- Overall, our study demonstrates the benefits of moving beyond binary classification of adoption and towards a deeper understanding of pathways to sustainably intensify African smallholder agriculture.
3.2 Statement of Authorship

Manuscript Details:

| Title of Paper: | Beyond adoption for a more nuanced understanding of the uptake of minimum tillage in Eastern Africa |
| Publication Status: | Unpublished manuscript |
| Publication Details: | n/a |

Principle Author:

| Principle Author: | Brendan Brown (Candidate) |
| Contribution to paper: | Identification of research gap, theoretical conceptualisation, framework development; obtaining of data, analysis of data, interpretation of results, writing of manuscript, acted as corresponding author |
| Overall percentage: | 90% |
| Signature: | Date: | 17/8/2017 |

Co-Author Contributions:

By signing the Statement of Authorship, each author certifies that:

i. the candidate’s stated contribution to the publication is accurate (as detailed above);

ii. permission is granted for the candidate in include the publication in the thesis; and

iii. the sum of all co-author contributions is equal to 100% less the candidate’s stated contribution.

| Name of Co-Author | Contribution to paper: | Supervision, evaluation and editing of the manuscript |
| Signature: | Date: | 17/08/2017 |

| Name of Co-Author | Contribution to paper: | Supervision, evaluation and editing of the manuscript |
| Signature: | Date: | 17/08/2017 |
Beyond adoption for a more nuanced understanding of the uptake of minimum tillage in Eastern Africa

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Abstract:

Minimum tillage (MT) production systems are seen as an integral part of the sustainable intensification of African smallholder agriculture, in particular due to the recognition of a reduction of tillage events as a primary opportunity to address soil degradation concerns. Despite major investment, recent rigorous cross-country analyses of the uptake of MT in Africa are scarce. In applying the Process of Agricultural Utilisation Framework (PAUF) to datasets across four countries (Ethiopia, Kenya, Tanzania and Malawi) and three time periods (2010, 2013 and 2015) totalling 54,736 plot observations, we provide a more nuanced and granular understanding of the status of MT uptake than the common binary classifications of adoption. We find growing momentum in the uptake of MT in all countries, but particularly in Tanzania and Kenya. We also find two varying uptake pathways, with Tanzania having substantial total utilisation while the other three countries containing mainly semi-utilisation and/or trial utilisations. In analysing the determinants of non-utilisation, we find persistent informational constraints leading to limited exposure. Limited uptake is further compounded by the high incidence of negative evaluation once farmers learn about MT. Noting the limited proportion of farmers interested in or trialling MT, there is a need to further explore the mechanisms for extension dissemination if MT is to be more widely implemented. Overall, our study demonstrates the benefits of moving beyond binary classification of adoption and towards a deeper understanding of pathways to sustainably intensify African smallholder agriculture.
Keywords:
Minimum tillage; Africa; Technology adoption; Sustainable Intensification; Adoption Gap; Conservation Agriculture.

Background
Feeding a growing and more demanding global population within a more variable climate and with reduced externalities is one of the most urgent challenges of the 21st century (Pittelkow et al., 2015; Tilman et al., 2011). This is particularly true in sub-Saharan Africa where smallholder farmers are facing fast declines in soil fertility which threaten both the productivity and sustainability of agricultural production (Sanchez, 2002; Vanlauwe and Giller, 2006). With a growing movement to balance short term productivity and profitability with longer term sustainability, a shift to production systems that reduce tillage events associated with agricultural production (i.e. whereby soil disturbance is minimised in the preparation and management of agricultural lands) has been one method strongly promoted globally.

Across Australia and the Americas (and in some limited cases in Asia), farmers have embraced minimum tillage (MT) production systems, driven primarily by the profitability in substitution of tillage activities with herbicides and the ability to implement more timely planting operations (Brown et al 2017c). The agronomic and environmental benefits of these reduced tillage systems have also been variously documented in the literature (e.g. Hobbs, 2007; Kuntashula et al., 2014; Ngoma et al., 2015; Thierfelder et al., 2016). In a meta-analysis of the effects of tillage, Busari et al (2015) found tillage systems (in comparison to production systems that limited tillage) negatively impacted soil physical, chemical and biological processes, were less adaptable in more variable climates, and increased the impact of agricultural activities on the environment in nearly all cases studied.

Throughout the last three decades, minimum tillage production systems have strongly promoted throughout sub-Saharan Africa (Giller et al 2009), followed by claims of substantial uptake amongst smallholder farmers. For example, Kassam et al. (2015) asserted that adoption of conservation agriculture (CA), of which MT is a core component, expanded by over 150% in sub-Saharan Africa between 2008/9 and 2013. Whilst not fully documented, eastern Africa was identified as region of substantial growth, and many development programs have asserted MT as a success story in the sustainable intensification of African farming systems (see overviews by Andersson and D'Souza, 2014; Giller et al., 2009).
However, uptake has remained difficult to quantify and the methods used to report and monitor adoption have come under increasing scrutiny, resulting in questions of their validity (Andersson and Giller, 2012; Andersson and D'Souza, 2014; Giller et al., 2015; Giller et al., 2009). Many estimations of adoption continue to be based on personal estimates and observations from government ministries, farmer organisations, promoting organisations and/or well-informed individuals. Such sources are difficult to independently validate or compare between studies and have the potential for accusations of bias (Andersson and D'Souza, 2014; Giller et al., 2009).

Likewise, the use of assessment frameworks that define adoption as a binary outcome (i.e. adoption vs non-adoption) are common within the literature. Such frameworks provide limited insight and conclusions regarding the types of adoption or non-adoption that may occur, including modification and partial implementation, intensity of implementation, incentivised implementation and determinants of non-implementation (Brown et al., 2017b). There is also a lack of recent estimates of uptake, with the MT adoption estimates currently available often confounded by varying combinations and definitions of CA (which apart from MT also includes legume rotations and stover retention). Overall, estimates of MT adoption are highly contested and lack comparability across studies, locations and time periods (Andersson and D'Souza, 2014; Giller et al., 2009).

This study aims to provide an updated and more nuanced analysis of the status of MT across eastern Africa. We approach this through a movement beyond binary classification of ‘adoption’ to the broader ‘utilisation’ approach proposed in Brown et al. (2017b) known as the Process of Agricultural Utilisation Framework (PAUF). The PAUF is based on classification of uptake as a process from learning to evaluating to various types of implementation. We apply this to household survey data from across four countries (Ethiopia, Kenya, Tanzania and Malawi) and three time periods (2010, 2013 and 2015), consisting of 54,736 plot observations. These countries were chosen to provide a wider regional lens of understanding in eastern Africa, while that standardisation of definition and approach provides unique cross-country insights. In doing so, we provide an in-depth assessment of both the current status of MT uptake, and trends over a five year period. This provides greater clarity on the nuanced status of MT utilisation across eastern Africa and offers insights into future expectations and pathways to sustainably intensify African agriculture through MT production systems.
Dataset Utilisation

The datasets used in this study are derived from farm household surveys conducted in Ethiopia, Kenya, Tanzania and Malawi in 2010, 2013 and 2015. In total there are 54,736 plot observations (Table 1). The surveys were developed and led by the International Maize and Wheat Improvement Centre (CIMMYT) and implemented by the national agricultural research services of each of the partner countries. The purpose of these surveys was to investigate the broader theme of sustainable intensification. A multi-stage sampling procedure was employed, with purposeful selection of districts based on the importance of maize-based farming systems to farmer livelihoods. Villages and households within these districts were then randomly selected with probability proportional to size. The representativeness and coverage of districts is given in Table 1. Whilst the surveys were mainly conducted in locations with ongoing CIMMYT promotional activities regarding CA, the methodology was applied such that it was representative of the community and not influenced by the activities present in the districts. In the case of Kenya and Tanzania, the survey datasets are not regionally or nationally representative, but can be used to understand the uptake of MT practices within maize dominant areas, a focus of development activities for implementing agencies. All datasets used in this study are freely accessible on the CIMMYT data repository (http://data.cimmyt.org).

Table 1: Descriptive information and source of data utilised in this study. Note that while no dataset is available for Malawi for 2015, Malawi has been included in this study as it is often cited as an example of strong minimum tillage adoption.

<table>
<thead>
<tr>
<th>Country</th>
<th>Year</th>
<th>Farmers</th>
<th>Plots</th>
<th>Hectares</th>
<th>Focus Districts</th>
<th>Dataset</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ethiopia</td>
<td>2010</td>
<td>2,821</td>
<td>15,468</td>
<td>6,362</td>
<td>Nationally representative across 35 districts</td>
<td>Marenya et al. (2016a)</td>
</tr>
<tr>
<td></td>
<td>2013</td>
<td>2,279</td>
<td>11,640</td>
<td>4,102</td>
<td>Shalla, Gubuesyo, Dugda, Adami Tulu, Bako Tibe, Meskan, Hawasa Zurya, Mesrak Badawacho, Pawe</td>
<td>Marenya et al. (2016e)</td>
</tr>
<tr>
<td></td>
<td>2015</td>
<td>793</td>
<td>3,501</td>
<td>1,532</td>
<td></td>
<td>Marenya et al. (2017a)</td>
</tr>
<tr>
<td>Kenya</td>
<td>2010</td>
<td>610</td>
<td>2,841</td>
<td>921</td>
<td>Bungoma, Siaya, Embu, Imenti South, Meru South</td>
<td>Marenya et al. (2016b)</td>
</tr>
<tr>
<td></td>
<td>2013</td>
<td>526</td>
<td>3,715</td>
<td>960</td>
<td></td>
<td>Marenya et al. (2016f)</td>
</tr>
<tr>
<td></td>
<td>2015</td>
<td>479</td>
<td>2,446</td>
<td>947</td>
<td></td>
<td>Marenya et al. (2017b)</td>
</tr>
<tr>
<td>Tanzania</td>
<td>2010</td>
<td>701</td>
<td>1,591</td>
<td>1,246</td>
<td>Karatu, Mbulu, Mvomero, Kilosa</td>
<td>Marenya et al. (2016c)</td>
</tr>
<tr>
<td></td>
<td>2013</td>
<td>526</td>
<td>1,160</td>
<td>975</td>
<td></td>
<td>Marenya et al. (2016g)</td>
</tr>
<tr>
<td></td>
<td>2015</td>
<td>579</td>
<td>1,223</td>
<td>1015</td>
<td></td>
<td>Marenya et al. (2017c)</td>
</tr>
<tr>
<td>Malawi</td>
<td>2010</td>
<td>1,917</td>
<td>6,041</td>
<td>2,454</td>
<td>Representative of central and southern regions of Malawi across 15 districts</td>
<td>Marenya et al. (2016d)</td>
</tr>
<tr>
<td></td>
<td>2013</td>
<td>1,591</td>
<td>5,113</td>
<td>2,140</td>
<td></td>
<td>Marenya et al. (2016h)</td>
</tr>
</tbody>
</table>
Methodological application

Reduced tillage production systems encompass a broad range of practices. Within this study, we define MT as farmer identification of: 1] a plot prepared with one or fewer tillage events; and 2] tillage events occurring in a strategic manner whereby soil disturbance is limited to only the planting area. These tillage events may be via tractor, draught power or hand hoe.

This study applies a multi-stage, non-binary framework to classify the type of MT utilisation (and non-utilisation) by farmers. This is achieved through the application of the PAUF proposed in Brown et al. (2017b). The PAUF disaggregated the adoption process into ten stages, viz: exposure (i.e. 1] awareness and 2] familiarity); non-trial assessment (i.e. 3] interest and 4] disinterest); trial assessment (i.e. 5] subsidised trial and 6] non-subsidised trial); and various utilisations, either negative (i.e. 7] disadoption) or positive (i.e. 8] modification; 9] semi-spatial utilisation; and 10] total utilisation).

The PAUF has been applied to the dataset via the classification structure given in Figure 1. Each plot was classified into one of five categories according to tillage activities, viz: 1] disadoption; 2] non-use; 3] subsidised trial; 4] own trial; or 5] full. These plot level results were then aggregated by farmers, with each farmer being classified into one of nine categories as per the PAUF. Note that modified use was excluded due to the definition of MT applied in this study.

Estimating Adoption

Under binary measures of adoption at the farmer level (i.e. where any farmer with a MT implemented plot is classed an adopter), the uptake of MT practices were minimal in 2010.
Some growth occurred across all four countries in 2013 (Ethiopia: 3%; Kenya: 15%; Tanzania: 27% and Malawi: 5%), with more substantial growth evident in the 2015 period (Ethiopia: 6%; Kenya: 36%; Tanzania: 64%). While all countries showed increasing uptake of MT over each period, Tanzania had the highest estimated adoption of MT in all time periods, followed by Kenya, Malawi and Ethiopia.

Comparisons of our results with other countries are complicated by the ambiguity in definitions applied, particularly between MT and CA, which is symptomatic of the broader literature on MT and CA adoption in Africa (Brown et al., 2017b), as well as a lack of peer-reviewed estimates of MT adoption since 2011 in the studied countries. For example, Kassie et al. (2015) estimated substantially greater adoption using the same datasets as this study at 30% in Ethiopia, 39% in Kenya, 17% in Tanzania and 35% in Malawi in 2010. However, the definition applied in that study encompassed MT with mulching and it is not clear how modified application at sub-optimal levels was interpreted within their binary classification. We do find some similarities with the estimates by Ngwira et al. (2014) in Malawi in 2009-10, who estimated adoption rates (of CA) of 27% and 41% in three districts of Malawi (Dowa, Nkhotakota and Salima), but below 2.5% in another three districts (Balaka, Machinga and Zomba), with our estimates consistent with the latter districts. The estimates of Ndiritu et al. (2014) in Kenya (4.5%) and Kahimba et al. (2014) in Tanzania (23.7% in Arusha region) are also broadly consistent with our results.

**Understanding Utilisation**

In applying the PAUF breakdown we attempt to gain a more granular understanding of the uptake of MT. Firstly, we disaggregate ‘adoption’ into four categories (total utilisateur, semi utilisateur, subsidised trial user and non-subsidised trial user). Along with our binary estimates of adoption, the breakdowns of utilisation for each country are given in Figure 2.
In doing this, we find two distinct patterns of uptake: 1) the strong uptake and proportional dominance of total utilisation in Tanzania, and 2) the lesser uptake and limited proportion of total utilisation in Ethiopia, Kenya and Malawi. This finding is novel, in that Malawi has traditionally been associated, alongside eastern Zambia, as an example of strong uptake of CA (and by extension MT systems) in sub-Saharan Africa (e.g. Kassam et al 2015). Noting this, there has been limited focus on Tanzania from both quantitative and qualitative perspectives within the literature. For example, there have been some in-depth qualitative investigations of MT/CA...
production systems in eastern and southern Africa (e.g. Brown et al 2017a, 2018a), but these studies do not include Tanzania and there remains a gap in understanding of the drivers of MT uptake, both in terms of binary adoption and total utilisation, in Tanzania (or specifically in the districts of Karatu, Mbulu, Mvomero, Kilosa). Clearly, the success of MT in Tanzania is one area that warrants greater attention within the literature.

In Ethiopia, Kenya and Malawi, semi-utilisation of MT is proportionally dominant, which confirms the well-known realities regarding MT utilisation in resource-limited contexts where economic, social, political or institutional enabling environments may not exist (Baudron et al., 2007; Brown et al., 2017b; Giller et al., 2009; Gowing and Palmer, 2008; Pannell et al., 2014; Brown et al 2018a). The comparatively large proportion of subsidised trial farmers in Malawi also highlights the importance of NGOs and government supported programs in the promotion of MT and CA systems. Such findings highlight the importance of disaggregating the types of utilisation to ensure that the complex picture of uptake is obtained, and further points to the need to understand if and how farmers are intensifying their MT activities over time. However, this will require panel data to assess and track implementation patterns, of which there are no known datasets.

**Understanding Non-Utilisation**

Applying the PAUF, we disaggregate non-utilisation into five categories (unawareness, unfamiliarity, interest, disinterest and disadoption. Note that due to differences in the datasets, non-exposure is classified as the aggregate of unawareness and unfamiliarity in the 2010 datasets, and the rate on non-exposure is represented as an orange line to aid in comparison. These results are provided in Figure 3. Important patterns emerge in relation to why farmers do not implement MT activities. In particular, three key trends are present in all four studied countries: 1] issues with farmers gaining exposure to MT; 2] negative evaluation of MT as a common outcome to exposure; and 3] constraint in advancing from interest to higher utilisations of MT.
Information constraints and limited exposure

In all countries, information constraints (i.e. unawareness and unfamiliarity) were substantial contributors to non-uptake of CA, estimated at above 50% of the population in eight of the eleven cases. In all such cases except for Kenya in 2015, non-exposure was the dominant reason for non-utilisation. While there was some progress in reducing exposure gaps in the 2015 period, particularly in Kenya and Tanzania, Ethiopia remained strongly dominated by
informational constraints. These findings are consistent with those of Ngwira et al. (2014) that a lack of information explains the majority of non-adoption of CA in Malawi, and more broadly with those of Simtowe (2011) and Diagne (2009) who found information gaps to be a significant factor in the adoption of improved varieties in eastern and southern Africa.

Such results are particularly concerning given the presence of MT within African research systems for more than five decades (Wall, 2007) and the considerable institutional support provided through development programs (see Giller et al., 2009). These results highlight that obtaining agricultural information remains a central and ongoing constraint to the improvement of African smallholder farmer livelihoods (Ferris and Robbins, 2004; Ozowa, 1995). While this is likely to be strongly influenced by the perennial underfunding of extension systems in sub-Saharan Africa (Akroyd and Smith, 2007), the results also justify calls for greater investigation of the effectiveness of current agricultural extension mechanisms (e.g. Brown et al. 2018b; 2018c; 2017a; Wellard et al., 2013).

Substantial negative evaluation as an outcome of exposure

Negative evaluation (i.e. disinterest or disadoption) was a substantial contributor to the limited implementation of CA in each country, but particularly so in Kenya and Ethiopia. In terms of the outcomes of exposure to CA, more than 65% of farmers in each period in Ethiopia and Malawi negatively evaluated MT once information was obtained, and this trend was also evident in Kenya (more than 40% and up to 69% of exposed farmers negatively evaluated). This was the lowest in Tanzania in 2015, with only 16% of exposed farmers negatively evaluating.

While disadoption data was not available in 2015, there were some concerning trends regarding disadoption present in both 2010 and 2013. When expressed as a proportion of farmers who had ever used MT, disadoption accounted for up to 71% of farmers (in Malawi in 2010). In only one case (Tanzania in 2010) was the conversion of users to disadopters less than 20%. This highlights that a substantial proportion of farmers who have used MT systems had disadopted. This substantial rate of disadoption has largely been overlooked in the literature due to a focus on achieving ‘adoption’ and highlights that the assumption that once farmers implement MT (and CA) systems they will continue to do so appears to be flawed (Brown et al. 2017a).

These issues clearly highlight constraints with the feasibility and relevance of MT to African smallholder farmers. Common issues identified such as low expected benefit (Kathage et al.,
Limited likely advancement towards more intensive utilisation

Impending uptake of a technology is likely to occur where a substantial proportion of the population is classified as interested. However, our results highlight limited interest in MT within the surveyed communities, with only one of 11 cases returning greater than 5% interest in MT. The limited likelihood of large short term increases in MT implementation is further compounded by the limited proportion of unsubsidised trial farmers, the next logical utilisers, which represented above 1.5% of the population in only one case. As an aggregate, farmers with positive intent to implement (i.e. trial farmers and those interested in MT) were only once recorded at above 10% of the population and in the majority of cases was below 5%.

Such results may further indicate a lack of financial relevance of MT due to the costs involved (e.g. herbicides, equipment), and hence the continuation by trial farmers facilitated by long term subsidisation that may be considered as pseudo-adoption (Kiptot et al., 2007). This may reflect the development project context in which MT is promoted, in which incentives are provided in the form of subsidised or free fertilisers, seeds, herbicides, or artificial market opportunities (Andersson and D’Souza, 2014; Mloza-Banda and Nanthambwe, 2010). In both cases, if the constraints are not resolved farmers are likely to negatively evaluate MT (Brown et al., 2017a).

Implications

This paper addresses three aims. Firstly, it provides an update to the uptake of MT in eastern Africa, noting the lack of recent MT adoption estimates. Secondly, it provides insights into the changes in MT uptake over time. In doing this, an upward trend in the uptake of MT was found in all studied countries from 2010 to 2015 (the most recent estimates available in the studies countries according the authors’ awareness). Thirdly, this paper provides a more nuanced and granular understanding of the utilisation of MT through the implementation of the PAUF. In doing this, we find a need to investigate why Tanzania has achieved substantially more uptake of MT than the remaining three studies countries. We quantitatively confirm the importance of semi-utilisation in Ethiopia, Kenya and Malawi, which provide evidence of the stepwise
pathways that farmers are applying in implementing practice change regarding MT. In exploring non-utilisation, we find the substantial importance of informational gaps, as well as the dominance of negative evaluation. These two key issues will need to be addressed to increase the currently limited interest in MT, which in turn limits the likely uptake of MT in the studied communities. This paper should hence be viewed as a step towards a more nuanced understanding of farmer uptake of MT and, by extension, of CA. The next steps include the analysis of panel data and the leverage of such data to understand the characteristics of different typologies of farmers according to the PAUF.

Datasets


References


Brown, B., Nuberg, I., Llewellyn, R. (2018a) Pathways to intensify the utilisation of conservation agriculture by African smallholder farmers. Renewable Agriculture and Food Systems
https://doi.org/10.1017/S1742170518000108


Section C: The ‘Why’ of CA Utilisation

Section B found CA to be limited in utilisation, reflecting two key themes: 1] informational resource constraints (as evidenced by substantial levels of non-exposure to CA); and 2] potential incompatibility between CA and the African smallholder context (as evidenced by substantial negative evaluation, issues with farmer progression beyond positive intent and utilisation of CA tending to be at low intensity due to modified and semi utilisations). Section C qualitatively explores with key stakeholders the determinants of these two themes, and in doing so addresses the second research objective. To do this, the third theoretical framework is proposed, the Livelihood Platforms Approach (LPA). The origins of the LPA as well as the methodology for dataset collection and analysis are provided in Chapter 4.

Each Chapter of section C explores the perspectives of various subsets of local African communities using semi-structured interviews with farmers (See appendix A1) and non-farmer stakeholders (See appendix A2). Chapters 4 to 7 explore the perspectives of farmers, specifically farmers negatively evaluating CA (Chapter 4), farmers positively evaluating and are now utilising CA (Chapter 5), farmers currently evaluating CA (Chapter 6), and farmers remaining unexposed to CA (Chapter 7). Chapters 8 to 10 then explores non-farmer perspectives, specifically extension services (Chapter 8), community leaders (Chapter 9) and local researchers (Chapter 10). The results of this are visualised in Appendix A4 (for informational constraints) and Appendix A5 (for implementation constraints). In doing this, Section C provides an explanation for the trends identified in Section B and the basis for exploration of the pathways to intensify CA utilisation in Section D.
Chapter Four:  
Perspective from Farmers Negatively Evaluating CA

Chapter 4 contains the third manuscript of this thesis which qualitatively explores the negative evaluation of CA by African smallholder farmers. A summary of the manuscript is provided, followed by the statement of authorship and manuscript 3.

4.1 Manuscript Summary

Context:
- Despite decades of CA promotion, CA remains limited in its utilisation by African smallholder farmers. This partly reflects substantial negative evaluation of CA.
- While a substantial body of literature econometrically identifies the household characteristics that correlate with adoption, there is a need for a deeper qualitative exploration of the farmer decision making process and perspectives from farmers who themselves have negatively evaluated CA.
Research objectives:
• To understand why farmers negatively evaluate CA; and
• To identify leverage points to foster positive evaluation and greater progression of farmers towards more intensive CA utilisations.

Methods:
• The Livelihood Platforms Approach (LPA) is proposed as a structured framework for qualitative investigation of farmer decision making.
• Using the LPA, semi-structured interviews with 35 farmers who have negatively evaluated CA, both in terms of pre-use disinterest and post use disadoption are analysed to understand their resource allocation decision making.

Findings:
• Whilst there were some issues with perceived benefit and relevance of CA utilisation, the primary driver of negative evaluation was found to be feasibility constraints.
• The common narrative was that CA was perceived to require greater resources for implementation (in terms of physical, financial, human and informational resources), yet farmers did not hold such resources, nor could they obtain supplementary resources at the community platform. This often reflected institutional issues.

Implications:
• Current interventions targeting household resources appear unlikely to facilitate greater positive evaluation of CA due to overarching community and institutional contexts.
• Instead, there is instead a need for: 1] development of financially viable adoption pathways; 2] integration of wider livelihood objectives; 3] revision of extension policy; and 4] development of policies complementary to CA utilisation.
## 4.2 Statement of Authorship

### Manuscript Details:

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<td>Publication Status:</td>
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### Principle Author:

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<th>Brendan Brown (Candidate)</th>
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<tr>
<td>Contribution to paper:</td>
<td>Identification of research gap, theoretical conceptualisation, fieldwork design, fieldwork to collect data, analysis of data, interpretation of results, writing of manuscript, acted as corresponding author</td>
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<tr>
<td>Overall percentage:</td>
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### Co-Author Contributions:

By signing the Statement of Authorship, each author certifies that:

1. the candidate’s stated contribution to the publication is accurate (as detailed above);
2. permission is granted for the candidate to include the publication in the thesis; and
3. the sum of all co-author contributions is equal to 100% less the candidate’s stated contribution.

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<td>Ian Nuberg</td>
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4.3 Manuscript 3

Negative evaluation of conservation agriculture: perspectives from African smallholder farmers

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ABSTRACT

Despite more than three decades of promotion, conservation agriculture (CA) has not been widely adopted by smallholder farmer in sub-Saharan Africa. This low rate of adoption reflects substantial negative evaluation of CA by many smallholder farmers, the causes of which have not been adequately explored in an in-depth, qualitative manner. Hence, we implement the Livelihoods Platforms Approach to explore directly with negatively evaluating farmers the reasons why they chose not to implement CA using semi-structured interviews with 35 farmers from 23 communities in 6 African countries. While there are issues with perceived benefit and relevance, the primary driver of negative evaluation of CA was found to be the feasibility of implementation. The required resources to implement CA (financial, physical, human and informational) are limited by community and institutional constraints which appear unlikely to be overcome through interventions targeted at addressing household resources. More positive evaluation of CA by smallholder farmers requires: (1) development of financially viable CA adoption pathways; (2) incorporation of wider livelihood objectives into a CA ‘package’; (3) re-evaluation of current extension policy; and (4) development of CA-complementary agricultural policies. Without addressing these issues, the potential benefits of CA adoption are unlikely to be achieved in African smallholder systems.

KEYWORDS

Qualitative assessment; conservation agriculture; technology adoption; Africa: adoption gap; farming systems research

1. Introduction

Over the past four decades, African agriculture has been unable to sustain productivity increases sufficient to feed its growing population (Abdulai, Barrett, & Hazell, 2004; Pretty, Toulmin, & Williams, 2011), and there is increasing concern over stagnant productivity of key food crops, food security and environmental sustainability. To address these concerns, conservation agriculture (CA) has been promoted as the primary way for African smallholder farmers to sustainably intensify their farming systems (i.e. increasing productivity and profitability whilst reducing environmental externalities). By combining the practices of minimum soil disturbance, permanent soil cover and legume diversification, CA has shown high potential for increased agronomic and environmental outcomes (Mupangwa, Mutenje, Thierfelder, & Nyagumbo, 2016; Ndah et al., 2014; Thierfelder, Bunderson, & Mupangwa, 2015; Thierfelder et al., 2016).

Despite claims of widespread adoption of CA (Derpsch, Friedrich, Kassam, & Hongwen, 2010; Friedrich, Derpsch, & Kassam, 2012; Kassam, Friedrich, Derpsch, & Kienzle, 2015), recent evidence suggests that this wide promotion has not translated into appreciable levels of CA adoption (Arslan, McCarthy, Lipper, Asfaw, & Cattaneo, 2014; Brown, Nuberg, & Llewellyn, 2017), and questions have been raised on the applicability of CA to the livelihoods of smallholder farmers (Andersson & Giller, 2012; Giller, Witter, Corbeels, & Tittonell, 2009). Brown et al. (2017) found that substantial rates of negative farmer evaluation contribute to constrained adoption and questions of applicability. Post-use negative evaluation (i.e.
disadoption) of minimum tillage (one component of CA) accounted for 48% users in Kenya and 71% of users in Malawi in 2010. Likewise, pre-use negative evaluation (i.e. disinterest) accounted for more than 75% of farmers who were aware of minimum tillage in Ethiopia, Kenya, Malawi and Mozambique in 2010. Hence, there are substantial questions on why African smallholder farmers are negatively evaluating CA.

A growing body of work has explored the reasons for limited adoption of CA, but only a limited understanding can be gained to the methods used. Such studies typically involve selecting a number of potential independent variables and testing via regression analysis to understand how they statistically correlate with adoption or non-adoption (Feder, Just, & Zilberman, 1985). Although often involving a large number of farms, such studies have generally utilized standardized questionnaires and binary econometric models to understand relationships between variables (Arslan et al., 2014; Baudron, Jaleta, Okitoi, & Tegegn, 2014; Bekele & Drake, 2003; Kathage, Kassie, Shiferaw, & Qaim, 2015; Ngoma, Mason, & Sitho, 2015; Pedzisa, Rugabe, Winter-Nelson, Baylis, & Mazvimavi, 2015; Suri, 2011). Hence, the underlying determinants of such relationships and farmer perspectives on their decision-making, including the broader livelihood context, are potentially overlooked (Andersson & D’Souza, 2014) and a need exists for deeper analysis of farmer decision-making and the underlying determinants of CA adoption (Giller et al., 2009).

As such, we propose the ‘Livelihood Platforms Approach’ (LPA) as a framework to structure qualitative analysis of farmer decision-making. Using the LPA, we implement a series of semi-structured interviews with farmers who have negatively evaluated CA to understand the core determinants of their decision-making. In the context of this study, a farmer is deemed to have negatively evaluated CA if they have obtained sufficient information to evaluate CA and chosen not to currently implement it. Such classification has its origins in the Process of Agricultural Utilisation Framework (PAUF) proposed by Brown et al. (2017) and specifically refers to two stages: PAUF stage 3 of pre-use disinterest and PAUF stage 7 of post-use disadoption. In both stages, information held by farmers has culminated in no use of CA.

Our research question is: why do farmers negatively evaluate CA, and, if applicable, what can be done to reduce it? We explore farmer perceptions of the perceived benefit, relevance and feasibility of CA to find pathways for greater utilization. Undertaken in six countries, this research provides a unique qualitative exploration conducted directly with farmers who have negatively evaluated CA. We further provide a point of difference from other investigations through the disaggregation of negative evaluation between pre-use disinterest and post-use disadoption. Such an approach facilitates the identification of underlying causes of negative evaluation beyond household levels and thus new perspectives for the development of evidence-based policy to intensify CA utilization.

2. Methods

2.1. Theoretical framework

We propose the Livelihood Platforms Approach (LPA) as a novel framework that combines elements of various theoretical frameworks together to build understanding of farmer decision-making. At the core of the LPA is the concept of livelihoods as the capabilities, assets and activities required for a means of living (Chambers & Conway, 1991). To understand how livelihoods are selected, we create a hierarchical structure of platforms which build on each other, similar to Nizamedinkhodayeva (2007). At the apex is the individual, who builds a livelihood based on resources at the household, community and institutional platforms (both formal [e.g. policy directives] and informal [e.g. cultural and historical implications]). These resources are categorized similar to the sustainable livelihoods approach (Carney, 1998), as physical, financial, human and informational resources. However, the LPA places social capital as the linkage between household and community resources, highlighting the importance of networks and social structures that dictate access and exchange. Individual decision-making is based on the perceived benefit, relevance and feasibility of implementation as proposed by Sumberg (2005). Livelihood platforms should not be confused with innovation platforms (Schut et al., 2015), which aim to create a forum of stakeholders to foster interaction and discussion. However, the LPA may be seen as a useful addition to such an approach by providing a formal framework to identify constraints and required actors to facilitate innovation. The balance of these four resource pillars at the household, community and institutional levels
determines how a technology is evaluated and implemented by an individual (Figure 1).

2.2. Study implementation

This paper is part of a wider investigation of the sustainable intensification of maize-legume farming systems in eastern and southern Africa. In total, 325 semi-structured interviews were conducted in 85 communities across 20 case study locations in 6 countries (Ethiopia, Kenya, Uganda, Malawi, Zambia and Mozambique). Case study locations were purposefully selected due to the importance of maize-legume systems for farmer livelihoods and subsequent high potential impact of CA to impact their livelihoods, as well as for having promotional activities on CA currently active in the district. Within case studies, respondents were purposefully selected to ensure a diversity of perspectives were obtained, and it should be noted that this work is not intended to provide a representative sample of communities, but specifically seeks a diversity of farmer perspectives.

Using the PAUF proposed by Brown et al. (2017), farmers at various stages of adoption of CA were selected as respondents, as well as various non-farm actors, who were grouped into various sets. Once an interview was completed, respondents were asked to identify others in the community that fit within various sets, in a snowball sampling methodology. Such a methodology has been variously used in qualitative research in order to provide access to otherwise hidden populations (e.g. Browne, 2005), but has to the authors understanding not been implemented in the research of CA in Africa. The classification of various sets of farmers and non-farm actors which were targeted in this research is given in Figure 2. Additionally, the common pathway that occurred via the snowball sampling is given as an example, but is only one common pathway. The uniqueness of each community and the social connections dictate that each
case study had a different pathway that linked sets to each other. What links all case studies is the starting point of the promoting government extension officer and the subsidized lead farmer who provide the initial linkages to other respondents.

This work is specifically focused on why farmers choose not to implement CA, and as such targets Farmer set C: negative evaluation. This comprises two farmer stages: pre-use disinterest and post-use disadoption. Hence, we focus on this sub-sample of 35 respondents from 25 villages in 16 case studies from 6 countries. Ten were classified as ‘disinterested’ and 25 were classified as ‘disadopters’. Each respondent was given an alphanumerical code (shown in Figure 3), which is used in the following results and discussion to identify them with their characteristics.

An interview schedule was developed based on the LPA to provide the opportunity for each respondent to explore their four livelihood platforms and four resource categories. For farmers, the interview schedule was structured within the following interview schedule: identification of current practices; discussion of trends and potential change to farm practices; preferences; resources available; community interactions; and institutional drivers.

Written informed consent was obtained from all study participants upon undertaking the interviews. Except in two locations in Ethiopia where custom demands it, no remunerations were made to farmers to participate in the discussion. Interviews were conducted primarily in the preferred local language, except in cases where the respondent was comfortable in expressing themselves in English. A translator was utilized from a local agricultural research station, and was, in the majority of cases, unknown to the respondent. Audio of the interviews was digitally recorded and transcribed independent of the translator to English. The average length of the interviews was 40 minutes, but ranged between 13 and 92 minutes. The interview subset for this paper includes 36 1/2 hours of
interview. All transcribed interviews were coded according to the various elements of the LPA using Nvivo™ (version 11) content analysis software.

3. Results

3.1. Farmer perception of the comparative benefits of CA adoption

Disinterested farmers (i.e. farmers who negatively evaluate without having used the technology) tended to perceive CA systems as lower yielding than their existing tillage-based systems. This was primarily linked to non-supportive soil conditions (e.g. minimum tillage cannot provide fertility to our land and the plants cannot penetrate easily to get minerals from the soil’ – H7), reduced planting density (e.g. ‘it is a waste of land’ – S4) or increased weed pressure (e.g. ‘Last year my friend used minimum tillage and I think it did not work out well for him and he abandoned it because the weeds grow so fast with CA’ – J3). In contrast, disadopters (i.e. farmers who have previously used the technology but have since ceased practice) were nearly unanimously positive about the yield benefits of CA, with only one disadopting farmer stating CA has negative yield outcomes and only three having no ambition to re-adopt. As such, disinterested farmers tended to...
have reservations about the overall benefit of CA implementation, whilst disadoption farmers were positive in the perceived benefit of CA implementation. Additionally, there were two cases where perceived benefit of CA was positive but disadoption occurred due to intra-household gender dynamics. That is, the female household head positively perceived CA but the male household head made the implementation decisions (e.g. ‘CA is good but this season my husband said that we are only going to go back to that old method again’ – E7).

3.2. Farmer assessment of the relevance of CA

Respondents were generally aware that CA could address some of their livelihood objectives, particularly in terms of production. More than 75% of respondents identified a desire to increase their yields and profitability, with most not content with their current productivity (e.g. ‘I work so hard and I get such little products and so little money … I am not satisfied’ – J3). This discontent was also evident with perceived poor profitability of current cash crops and the search for CA relevant crops (e.g. ‘I think I will abandon cotton, many of us will. We want to try other crops and the lead farmers are telling us that soybean and sunflower can make us money so a lot of people want to try those crops’ – F12). More than 75% of respondents also identified the need to adapt to climate uncertainty and the risk it posed to their current and future livelihoods. Changed rainfall patterns were described as ‘the biggest problem to our lives’ (H7) and that ‘I can’t stop (seeking new technologies) because of the climate change’ (F12). As such, CA was perceived to address relevant requirements for improved livelihoods by the respondents.

Despite this, respondents had two key reservations about the relevance of CA to their livelihood: the requirement for external inputs and the desire to implement alternative livelihoods.

3.2.1. Limiting reliance on external inputs

All but 5 of the 35 respondents had the ambition to reduce their reliance on external inputs (and perceived CA as an input increasing practice) leading them to question the financial relevance of CA. Primarily, farmers were concerned about adopting or continuing a production system that appeared increasingly out of their financial abilities (e.g. ‘I won’t be able to afford it [inputs in the future]. I am already finding it difficult now’ – K10). This lack of finances ultimately led many farmers to disadoption (e.g. ‘I have no option but turn back to traditional farming’ – W8) and farmers actively sought low input, lower yielding systems (e.g. ‘zero input and low yield is better. Because to get high yield it is very hard and you have to have money to start’ – G4). The lack of financial resources also led many farmers to remove themselves from the information diffusion system (e.g. ‘Our income level is not the same with the model farmers and the income status for them is much higher, so the technologies they get we cannot do’ – H8).

3.2.2. Implementation of non-compatible livelihood objectives

Nine of the 10 disinterested and 18 of the 25 disadoption farmers identified their ambition to diversify their

<table>
<thead>
<tr>
<th>Livelihood objectives</th>
<th>Example quotations regarding non CA objectives</th>
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<tbody>
<tr>
<td>Alternative cash crops</td>
<td>Cotton and tobacco</td>
</tr>
<tr>
<td>Horticulture</td>
<td>1 have a pond built by an NGO and I want to expand into vegetables up to 2 ha for income’ (S4)</td>
</tr>
<tr>
<td>Animal-based livelihoods</td>
<td>Dairy production</td>
</tr>
<tr>
<td>Oxen (for tillage rental)</td>
<td>1 intend to have two zero grazing animals and two oxen for ploughing. So, I intend to add to this to increase animals for milk and rental (of oxen)’ (Q1)</td>
</tr>
<tr>
<td>Oxen (for own tillage)</td>
<td>Those with many livestock are seen as rich persons traditionally’ (W8)</td>
</tr>
<tr>
<td>Non-farm livelihoods</td>
<td>Brickmaking</td>
</tr>
<tr>
<td>Agro-trading</td>
<td>1 have not been concentrating on farming. I have mainly concentrated on trading agro products and I don’t focus my efforts on farming’ (J3)</td>
</tr>
<tr>
<td>Town based activities</td>
<td>I am feeling as the age is coming, I may have interest to go into town and do something else’ (Q1)</td>
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</tbody>
</table>
Table 2. Physical resource limitations identified by respondents relating to the physical feasibility of CA.

<table>
<thead>
<tr>
<th>Physical resource</th>
<th>Issue</th>
<th>Example quotations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Seed</td>
<td>Scarcity</td>
<td>'Yes it (growing legumes) is a good idea. But in reality there is shortage of seed'</td>
</tr>
<tr>
<td></td>
<td>Access</td>
<td>'I did not grow legumes because although I wanted to do it, I could not get the seed. It was not available to me'</td>
</tr>
<tr>
<td></td>
<td>Timing</td>
<td>'The seeds and fertilizer are not available on time for us to grow early. It comes late'</td>
</tr>
<tr>
<td></td>
<td>Quantity</td>
<td>'We must use the black-market when we need to buy in a quantity that the government cannot give to us, because of the small amounts we need'</td>
</tr>
<tr>
<td></td>
<td>Quality</td>
<td>'The legume seed in market is not so good'</td>
</tr>
<tr>
<td>Herbicides</td>
<td>Scarcity</td>
<td>'I used CA for one year. Then I could not find the chemicals for weed control so I stopped'</td>
</tr>
<tr>
<td></td>
<td>Timing</td>
<td>'The demand is so high so you find when you need the herbicides they are finished'</td>
</tr>
<tr>
<td></td>
<td>Quality</td>
<td>'We heard about the herbicides from a project but they did not bring the herbicides for all of us. So when this person came to sell it to us we just had to trust him ... but it did not work'</td>
</tr>
<tr>
<td>Tillage equipment</td>
<td>Scarcity</td>
<td>'The only people that were using the ripper were committee members of the project. That ripper was not reaching us, so that is why I couldn’t carry on (with Minimum tillage)'</td>
</tr>
<tr>
<td>Stover</td>
<td>Scarcity</td>
<td>'Leaving residue is good. But for me I cannot, because I need it very much in the short run for animal forage and fuel'</td>
</tr>
<tr>
<td></td>
<td>National policy</td>
<td>'I don’t have many stalks and others refuse to give me theirs. They say they are wanting to incorporate in their field or make manure'</td>
</tr>
<tr>
<td></td>
<td>Communal</td>
<td>'Most people have already burned the stover... because they fear that the oxen will graze in their fields and harden the soil'</td>
</tr>
<tr>
<td></td>
<td>Jealousy</td>
<td>'Then others are burning their stover out of jealousy that the people from projects will get it and improve'</td>
</tr>
<tr>
<td></td>
<td>Local policy</td>
<td>'The chief has to put a by law that prohibits people from burning other people’s fields'</td>
</tr>
<tr>
<td></td>
<td>Cultural norms</td>
<td>'It is not good as other people’s cattle will eat it. I need to take completely and store one place for the purpose of my cattle forage'</td>
</tr>
<tr>
<td></td>
<td>Cultural norms</td>
<td>'We all know it is good for soil fertility. But there is no grazing land any more so we have to have free grazing'</td>
</tr>
<tr>
<td>Land</td>
<td>Availability</td>
<td>'My grandfather and father did this (stover retention) previously. But now it is not possible because all of the land is under cultivation, there is no land for grazing and we need to feed the animals'</td>
</tr>
<tr>
<td></td>
<td>Cultural norms</td>
<td>'Sometimes when the field is far mice hunters do destroy it all with fire when hunting... CA plots should be near to the house... because you need to visit it often (to ensure stover is not burned)'</td>
</tr>
<tr>
<td>Postharvest storage</td>
<td>Scarcity</td>
<td>'When we harvest, unless you have good storage facilitates and you treat it, it does not benefit me. I don’t want to store on my farm as I might lose it so I just sell at low price because of that disease'</td>
</tr>
</tbody>
</table>

3.3. Farmer perception of the feasibility of CA

This section explores respondents’ perceptions of the feasibility of CA implementation via the four resource categories of the LPA: physical, financial, human and informational resources.

3.3.1. Physical resources

Twenty-two of the 35 respondents identified physical resource limitations in their assessment of the feasibility of CA to their livelihoods. However, scarcity of physical resources was only part of this limitation, with concerns about reliable access to quality inputs the primary feasibility issue. Particularly for stover management, both formal and informal institutional issues impacted on household level constraints. A summary of the major physical resource limitations is given in Table 2.

3.3.2. Financial resources

At the household platform, all respondents identified issues with the compatibility of their financial resources and the requirements of CA (examples given in Table 3). Responses tended to acknowledge CA as good system, but that respondents lacked the financial resources to implement it. A lack of financial resources manifested in the majority of farmers implementing low-input systems (e.g. 'I lack capital to enter the type of farming that uses fertilizer' – J3) and strongly reflected on their assessment of the relevance of CA to their livelihoods (see Section 3.2.1).

The lack of household financial resources related to farmer interactions at the community platform. Most respondents identified that they were not able to build financial capital through agricultural livelihoods due to a decrease in their purchasing power (e.g. 'When we buy seeds, the price is high, but when we
**Table 3. Financial implications of the feasibility of CA implementation at household level identified by respondents.**

<table>
<thead>
<tr>
<th>ID</th>
<th>Quotations discussing financial feasibility of CA</th>
</tr>
</thead>
<tbody>
<tr>
<td>G9</td>
<td>‘In fact we cannot do it (CA). As we are trying, we cannot make it exactly like they do (lead farmers). Even if they try, the yield will not come like us, because we don’t have the money for seed and fertilizer’.</td>
</tr>
<tr>
<td>J3</td>
<td>‘CA is good but I don’t have the money to begin’</td>
</tr>
<tr>
<td>X17</td>
<td>‘I cannot use that one because it requires money’</td>
</tr>
<tr>
<td>F8</td>
<td>‘That year I didn’t have money to buy fertilizer so what I thought was just to apply the conventional method’</td>
</tr>
<tr>
<td>H7</td>
<td>‘CA is ok but I have no money to buy inputs to increase my products’</td>
</tr>
<tr>
<td>Y18</td>
<td>‘In the future I do not think we can do it. They know the yield is good but because of money . . . it is not that we don’t like CA, we like to do it because it gives us more. It is the problem of finances’</td>
</tr>
<tr>
<td>E14</td>
<td>‘If I had money can I do it (CA)’</td>
</tr>
<tr>
<td>M9</td>
<td>‘If I had money I would definitely buy all the farm inputs without any problem and I would also continue with conservation agriculture because of the benefits I saw in it the time I tried it’</td>
</tr>
</tbody>
</table>

The reason for dis-adoption is that at the beginning we had a meeting were we were told that there was 8 million [Malawian kwacha] that would help 200 farmers in the area then they choose only 6 people . . . so people would continue to wait to be given inputs from this. (K7)

Such experiences create a disincentive to invest in CA, despite resources potentially being available. For example, ‘I stopped because I was angry . . . The problem is that others are receiving while I was not’ (K8) and ‘we lost interest because the seeds . . . We can use our own seeds but we also still want seeds from the project’ (G10). Such is the handout culture that the initial adoption decisions made by many dis-adaptors were based on handouts, not belief in the benefits of CA. For example:

The harvest [for CA] was good, but I was offended that I was only given fertilizer in small quantities so I dis-adopted . . . What happened is that in the group only six people were given bags of fertilizer while the rest of us were given fertilizer on a small plate. (K10)

and ‘One time they told us to prepare our land and that they would give us resources but they didn’t so I saw it as a tiresome job’ (X2). This handout culture also affected how farmers chose to engage with the community platform (e.g. ‘When they [lead farmers] come and tell people what to do we just ignore their messages. They are just encouraging their friends because they have received something and it is not for the rest of us’ – M9).

### 3.3.3. Human resources

Human resources were a key factor particularly identified by dis-adaptors as a limitation to the implementation of CA, but again was not only a factor of availability. Labour feasibility was most strongly linked with the respondent’s management of herbicides and the need for stover importation from other fields (as a weed mitigation practice). Farmers who used herbicides tended to evaluate CA as labour saving, whilst non-herbicide CA farmers identified increased labour burden from weeding and stover importation as a major limitation (e.g. ‘If I had access to herbicides then I would expand CA easily but because I don’t have access to herbicide then I can’t expand since I cannot manage to uproot a big farm’ – D2).

Again, scarcity itself was rarely the driving limitation. Most respondents identified that whilst CA reduced labour, the work was ‘tedious’, ‘tiresome’ or ‘labourious’. For example ‘we appreciate these methods are very laborious but you get enough
Table 4. Mixed information held by respondents due to conflicting prior recommendations.

<table>
<thead>
<tr>
<th>Method</th>
<th>Key quotations discussing information held on</th>
</tr>
</thead>
<tbody>
<tr>
<td>Multiple tillage events</td>
<td>Experts or extension officers tell us to plough three or four times. So I do not want to do this minimum tillage ... It is not government policy to support this anyways' (S5)</td>
</tr>
<tr>
<td>Tillage</td>
<td>'The problem is that using a ripper you do not turn the soil and if the top soil doesn't do down and when the crop germinates it will be stunted' (X8)</td>
</tr>
<tr>
<td>Fire (for ash)</td>
<td>'If we burn the stover it gives us high yield. We burn because the ash, so it will becomes fertilizer for the land' (B8)</td>
</tr>
<tr>
<td>Manure</td>
<td>'We take al and feed to the livestock. Afterwards we return them to the field as manure' (Q16)</td>
</tr>
<tr>
<td>Soil inversion</td>
<td>'I don't have fertilizer so I want to turn the soil so that the fertile soil should come on top ... because the topsoil is less fertile' (D2)</td>
</tr>
<tr>
<td>Stover incorporation</td>
<td>'I get high yield where I incorporate the stalks more that where I put ridges because the stalks decompose and they form manure' (C9)</td>
</tr>
<tr>
<td>Stover cover (trash lines)</td>
<td>'Also believe in the trash line not to cover everywhere so I can concentrate the fertility' (E14)</td>
</tr>
<tr>
<td>Herbicide (and soil health)</td>
<td>'I think it (herbicides) may have problems and people talk about it, that it can cause negative effects in the soil, so that is why I don't do it and I fear it on my farm' (G4)</td>
</tr>
<tr>
<td>Herbicide (and animal health)</td>
<td>'If I am spraying and I use my animals to dig, won't it be dangerous for them?' (J3)</td>
</tr>
<tr>
<td>Herbicide (and human health)</td>
<td>'The difficulties in CA – sometimes what I have learned from other people is that they are reactive to the chemicals. So once the spraying is done, sometimes they are affected with some problems with human health, so we fear it' (Q1)</td>
</tr>
</tbody>
</table>

yields' (J17). CA without herbicide is often promoted through stover importation from other fields, but this was often poorly perceived (e.g. ‘We think that laying the stover is a big job ... A lot of people say that it is difficult to lay the stover’ – K10). There were further issues with the concentration of intensive labour at inconvenient times, particularly in preparation of basins in hot, dry periods (e.g. ‘we like herbicides because it saves labour a lot at weeding but the basins are labour intensive so we say it's time wasting’ (J17). CA can also require concentration of labour resources with multiple roles to be done at the one time (e.g. measuring row spacing, creating planting stations and micro dosing fertilizer with planted seed). For example, ‘the new system reduces labour, but it needs you to plant everything at once in one day’ (G10) and this was often perceived to be beyond household labour resources. As such, CA requires interaction with the community platform, but community labour was often insufficiently skilled or willing to work with CA techniques due to a lack of awareness on how to implement or the perception it was tedious work. For example, ‘Since the technology is new it's not easy to find people who have no jobs and are trained in CA’ (J17) and ‘we just wanted to hire someone to help do the weeding and land preparation but we couldn’t find anyone [trained in CA]’ (Y18).

3.3.4. Information resources
Thirty-four out of 35 respondents identified a lack of household information resources to implement CA, and in some cases a lack of information was the primary determinant of disadoption (e.g. ‘I don't have enough information and that is why I stopped ... that I wasn’t trained about this and I was just doing what I saw so it was difficult for me’ – M9). The quality of information held at household level was also low, often due to households having pre-existing information from prior extension messages that was contradictory to CA principles (examples in Table 4).

At the community platform, respondents perceived scarcity in information resources. Many perceived that government extension services, whilst preferable, were not available to them (e.g. ‘as of now I need the information but right now it is difficult since the camp officer stays far from here’ – X8 and ‘there is no problem with government extension officers, just that they are always struggling to teach us, because there is not enough of them’ – H7). These perceptions of scarcity were mirrored with lead farmers (e.g. ‘There are just two or three model farmers for the whole village, so we can't all learn from them. Sometimes there is no model farmer in the village so we would have to travel far to experience the technologies.’ (H7))

Even if training was obtained, there were issues with their adequacy (e.g. ‘the training was not enough because they were brief since they were doing it in a hurry’ – C7).

Respondents also claimed that while information resources existed on their community platform they were frustrated by a lack of access to them (e.g. ‘I think there are technologies in the community, but as per now, there is no way for me to get the
information’ – G4). Most farmers attributed a lack of access to the lead farmer approach and subsequent exclusivity in learning opportunities (e.g. ‘I may not know [about new information] because when the extension worker comes, he only visits those that were given the inputs’ – K7). Respondents often lamented that services were not provided to them (e.g. ‘they teach us in view of our status and wealth on different meetings. So because I am poor and landless I don’t have access to training’ – B8), leading to anger about the current information delivery mechanisms. For example,

It is unfair. We are invited to be in the group but we can see there are some who are given things and then they are seen as the important ones, yet we still don’t know what was going on and the technologies are not clear to us. (E7)

Overall, farmers believed that current information delivery systems were not meeting their needs. For example,

Sometimes I feel very much forgotten. Why do they get selected and I do not? I have two legs and two hands, so why can’t I be selected to get training and improve myself? I think that for many of us, we can’t learn from the model farmer. (H8)

These perceptions were often a reflection of issues at the institutional level. Issues were raised particularly with the compatibility of the lead farmer system with culture (e.g. ‘We in Kenya do not trust our fellow colleagues. In truth, people may come together, but the objective at the end is to be the big man and so this system [of lead farmers] is not very successful’ – Q20). Such a breakdown in trust was also evident in the view farmers have of the government extension service. For example,

The problem is that the officers want to show that they have done a lot, made impact. But in an actual sense, it is limited… Occasionally, these officers give some information, but mostly, they just want their name to be known highly. But actually on the ground there is no trust… Our people have the energy to do work, but we have a barrier between these officers and the farmers. (Q20)

4. Discussion

4.1. Feasibility of implementation the key driver of the negative evaluation of CA

CA has the potential to address many of the identified objectives of the respondents, particularly with issues of climate change (Jat et al., 2015; Rockström et al., 2009) and increased yields and incomes (Ngoma et al., 2015; Rockström et al., 2009; Teklewold, Kassie, Shiferaw, & Köhlin, 2013). Our results confirm that farmers who negatively evaluate CA acknowledge these as key issues to their future livelihoods. Disadapting farmers were nearly unanimously positive about the benefit of CA adoption, and the majority had the intention to re-adapt. As such we find that, at least for our respondents, disadoption is not primarily a factor of perceived benefit but instead is mainly due to issues with the feasibility of CA implementation.

Disinterested respondents held opposite views on perceived benefit. Such disparity between perceived benefit of CA implementation appears to be a reflection of the information resources held at the household level. Disinterested respondents tended to hold conflicting information on how CA may benefit their livelihoods and particularly perceptions on the negative consequences in terms of yield, fertility and productivity. It is beyond the scope of this study to investigate if this reflects particular characteristics of farmers (e.g. there is a relationship between the resource endowments of disadopters that allowed them to benefit more in implementing CA). However, we find that information access for disinterested farmers is limited leading them to hold negative perceptions of benefit. Such polarizing views of perceived benefit between disadopting (positive) and disinterest (negative) farmer highlight a potential breakdown of information exchange mechanisms at the community platform.

4.2. Feasibility issues reflect underlying institutional limitations

There is a large body of work that has reached similar conclusions on the lack of feasibility of CA (e.g. Chompolola & Kaonga, 2016; Grabowski, Kerr, Haggblade, & Kabwe, 2016; Kalungu & Leal Filho, 2016; Kassie, Teklewold, Jaleta, Marenya, & Erenstein, 2015; Ngombe, Kalinda, Tembo, & Kuntashula, 2014; Ngwira, Johnsen, Aune, Mekuria, & Thierfelder, 2014; Pedzisa, Rugube, Winter-Nelson, Baylis, & Mazvimavi, 2016). However, as most studies use econometric analyses, they focus on household level constraints. Our findings indicate that constraints affecting adoption by households are determined by drivers located at the community and institutional platforms. Indeed, there is a common theme throughout all four resource pillars: farmers perceived CA to require more
resources, of which the household do not possess. Further, there were consistent assertions that community resources were not available, or if they were available, they could not be accessed due to limiting community exchange mechanisms. Using the LPA, we find that often this is a reflection of a lack of institutional enabling environments, both at the formal and informal platforms. This common theme across all four resource pillars is visualized in Figure 4.

For physical resources, there were clear assertions that input market infrastructure could not reliably meet the respondents consumption needs. Particular issues were found with stover availability, which was strongly linked to a lack of bylaws to protect stover retained on fields (from communal grazing in Kenya, Uganda and Ethiopia or rodent hunters in Malawi, Zambia and Mozambique) as well as ambiguous policy on best management practices of stover for soil fertility (particularly for stover incorporation) leading to a lack of stover exchange at the community platform. A lack of credit at the community platform was a reflection of lingering historical issues such as prior lack of repayment and a lack of trust in local savings institutions. Human resources were further impacted by this, as community labour tended to seek more financially viable activities limiting available household and community labour for CA implementation. Finally, household information resources were heavily impacted by the availability and access of informational resources at the community level. This reflects on the dominant extension mechanism, the lead farmer approach, which appears to be ineffective at disseminating information to the respondents in this study. Indeed, we find the approach has contributed to a financial dependency culture that further compounds the negative evaluation of CA.

4.3. Feasibility issues unlikely to be addressed through increasing resources

Through identification of these underlying drivers of household constraint, we find that increasing household or community level resources is unlikely to decrease the incidence of negative evaluation. Whilst studies such as Pedzisa et al. (2016) find a lack of financial feasibility in the implementation of CA (as we do), they conclude that farmers require financial support to adopt CA. We propose that such an approach is unlikely to be successful as it focuses on provision of
resources to artificially manipulate the context to the technology, as opposed to modifying the technology to fit the context. Under such an approach, we further confirm the findings of Lukuyu, Place, Franzel, and Kiptot (2012) that provision of resources (particularly at a household level) is unlikely to be successful or sustainable. Firstly, financial subsidization only addresses one pillar of the IPA despite our findings indicating constraints at all pillars and financial resources are unlikely to be utilized to obtain other resources due to limited access to non-functional markets for inputs, labour and information. Further, CA is unlikely to be broadly feasible until institutional issues are addressed, both formal (especially the lack of enabling policy environments) and informal (especially the cultural importance of communal grazing, occurrence of rodent hunting and the financial dependency syndrome).

4.4. Pathways to address negative evaluation of CA

To reduce the negative evaluation of CA, there is a need for a balanced approach combining both continued participatory development of CA to suit local contexts, as well as reform of policy to ensure adequate enabling environments. This reflects recent work that highlights the missing link in technological change lies in institutional development and domain specific technological development (e.g. Hounkonou, Brouwers, Huis, & Traoré, 2016; Schut et al., 2016). Specifically, we identify the need to promote CA within an adaptive development context as opposed to a technological rollout. As such, we propose a two-pronged strategy:

4.4.1. ‘Bottom-up’ participatory modification of CA to fit local contexts

CA has tended to be developed and tested at research stations or in researcher managed trials which has led to limited modification to match the problems and priorities of smallholder farmers (Friedrich & Kassam, 2009; Stoop & Kassam, 2005). We confirm the need for continued modification of CA to decrease negative evaluation, and specifically two key areas for further research:

A. Development of financially viable entry points as pathways to incremental CA use. Promotion of CA as an input or energy reducing practice (Mutuku, Heir, & Shisanya, 2014; Singh et al., 2011) is unlikely to resonate with farmers who have limited use of external inputs and no capital to invest in CA. In such circumstances, CA is viewed as an input increasing technology, and this has led respondents to question the financial feasibility and relevance of CA. Noting institutional issues with credit provision, there is a clear need to develop pathways for CA adoption for farmers with limited initial resources to invest (i.e. development of a pathways approach that builds both the benefits of CA and financial requirements for implementation over time). Such an approach may benefit from a disaggregation of CA components, such that legume use is promoted as a capital raising exercise from which inputs and equipment can be purchased (e.g. fertilizer and seed so that biomass production is sufficient to achieve soil cover). Building household capital may also increase the viability of microcredit schemes which currently struggle due to lack of principal to guarantee loans. Such a transitional approach would overcome the perceptions of prohibitive costs that many negative evaluating farmers hold and thus increase the financial viability of CA implementation.

B. Integration of non-crop livelihoods to a CA package. The vulnerability of smallholder farmers is reduced through livelihood diversification, particularly with livestock providing financial resilience and cash flow in otherwise financially constrained periods (Tittonell, 2014). Respondents clearly expressed their desire pursue such objectives, often leading to negative evaluation of CA. Through greater integration of livestock objectives, CA would become more relevant to respondents, and several opportunities exist for such integration (e.g. poultry and legume crops, larger livestock and forage crops). Importantly, such initiatives would reduce conflicts in the competing uses for stover and enhance the objectives of CA through increased resilience, productivity, profitability and soil fertility.

4.4.2. Top-down policy reform to ensure enabling environments for CA adoption

Further to the suggested participatory modifications of CA, we confirm the findings of Schut et al. (2016) in the need for a re-evaluation of the institutional enabling environments in which smallholder farmers operate in. Specifically, there is a need for:

A. Re-evaluation of current extension mechanisms. A lack of access to information has led many respondents to negative evaluation as well as fail to build
skilled and willing community labour resources and demand for CA inputs at local markets. According to respondents, the lack of access to quality informational resources is a direct reflection of the use of farmer-to-farmer extension mechanisms, which are the dominant extension methodology used by extension providers in sub-Saharan Africa (Masangano & Mthinda, 2012). Farmers have shown clear frustrations with such mechanisms, and we find strong implications to community cohesion (e.g. frustration, jealousy and a lack of trust). Further, we find that the direct subsidization of households within resource-constrained communities have compounded these issues and established a dependency culture of financial expectation, similar to the findings of Nhod, Gukurumbe, and Mafongoye (2011). As such, we confirm a strong need for re-evaluate of current extension mechanisms (Wellard, Rafanomezana, Nyirenda, Okotel, & Subbey, 2013), especially beyond subsidized lead and fellow farmers that tend to be the focus of investigations of farmer-to-farmer mechanisms (e.g. Fisher, Holden, & Katengeza, 2017; Lukuyu et al., 2012; Mwambi, Kiptot, & Franzel, 2015; Tsafack, Degrande, Franzel, & Simpson, 2015). A movement towards more open and inclusive mechanisms such as innovation platforms that encourage dialogue between farmers and other stakeholders is required (Schut et al., 2015), which may be strengthened by the use of the LPA.

**B. Development of CA complementary agricultural policies.** We find, particularly for minimum tillage and stover management practices, that negative evaluation is often a consequence of non-favourable agricultural policy. Whilst national policies remain inconsistent with the principles of CA, farmers will continue to doubt its benefit, relevance and feasibility. Thus, we find a need for the development of coherent and complementary policy on best management principles that are reflected in national agricultural policies. It appears unlikely that CA adoption can flourish until national policies are framed to complement the principles of CA.

**5. Conclusions**

Using the novel LPA, we find the negative evaluation of CA to be primarily a reflection of an experienced and perceived lack of feasibility of CA implementation. However, this qualitative assessment finds household level feasibility issues are strongly linked to issues at community and institutional levels. As such, increasing the volume of resources at household or community level is unlikely to decrease the incidence of negative evaluation due to issues with access to community resources and institutional constraints.

This has important implications for CA research and extension. Primarily it highlights the need to move from a technological roll out to a more adaptive technological development with farmers. In this context, we see the need for the following undertakings to reduce the negative evaluation of CA:

1. Development of financially viable entry points as pathways to incremental CA use;
2. Integration of non-crop livelihoods to a CA package.
3. Re-evaluation of current extension mechanisms (specifically the subsidized lead farmer approach); and
4. Development of CA complementary agricultural policies.

CA provides a strong opportunity for the sustainable agricultural intensification of African farming systems, but without further modification of the technology package and attention to the policy and extension environment, wholesale adoption appears unlikely.

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**Disclosure statement**

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Kassam, A., Friedrich, T., Derpsch, R., & Kienzle, J. (2015). Overview of the worldwide spread of conservation agriculture (Field Actions Science Reports [Online]).


Chapter 5 contains the fifth manuscript of this thesis which qualitatively explores the positive evaluation of CA by African smallholder farmers. A summary of the manuscript is provided, followed by the statement of authorship and manuscript 4.

5.1 Manuscript Summary

Context:

- Incomplete utilisation of CA is not well understood because various types of utilisation tend to be aggregated together as singular adoption, overlooking the dominance and determinants of modified and semi-spatial utilisations.

- Farmer perspectives and contextualisation of farmer decision making are largely absent from the CA adoption literature and there has been only limited qualitative exploration of why some farmers implement CA systems while others do not.
Research objectives:

• To explore with positively utilising farmers what they require to intensity their CA activities; and

• To understand the broader context of CA utilisation within communities and why CA has been limited in overall utilisation.

Methods:

• Semi-structured interviews with 57 smallholder farmers currently utilising CA (in either modified, semi or total forms) are analysed to understand the positive evaluation of CA.

• The Livelihood Platforms Approach (LPA) is applied.

Findings:

• CA is perceived as highly beneficial, but this is strongly linked to increased input usage (especially herbicides).

• Intensifying CA activities was constrained due to community and institutional issues, mainly: stover resources and security; the functionality of input markets; financial viability; the types and amounts of labour required; and access to high quality information on CA.

• Overall, CA was perceived to require greater engagement with the community platform, yet the community platform often was often not perceived as able to supply the required resources to implement CA.

Implications:

• The current assumed adoption pathway is based on area expansion of CA in complete form over time, but is likely to have only limited success due to various issues mainly at the community and institutional platforms that such a pathway does not address.

• A more nuanced approach is proposed that focuses on adaptation of CA to farmer contexts, as opposed to the current adaptation of contexts to CA through subsidisation.

• This involves a reframing of CA principles and a focus on transitional pathways that periodically increase the intensity of CA use towards an ultimate objective of total CA utilisation.
5.2 Statement of Authorship

Manuscript Details:

| Title of Paper: | Pathways to intensify the utilisation of conservation agriculture by African smallholder farmers |
| Publication Status: | Published |

Principle Author:

| Principle Author: | Brendan Brown (Candidate) |
| Contribution to paper: | Identification of research gap, theoretical conceptualisation, fieldwork design, fieldwork to collect data, analysis of data, interpretation of results, writing of manuscript, acted as corresponding author |
| Overall percentage: | 90% |
| Signature: |  |
| Date: | 17/08/2017 |

Co-Author Contributions:

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iii. the sum of all co-author contributions is equal to 100% less the candidate’s stated contribution.

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Pathways to intensify the utilization of conservation agriculture by African smallholder farmers

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Abstract
If the United Nations Sustainable Development Goals are to be achieved, African smallholder farmers will need to embrace new technologies such as conservation agriculture (CA) in order to increase both their productivity and sustainability. Yet farmers have been slow to embrace CA and when they have, they are inclined to do so at limited intensities. Current investigations tend to apply binary frameworks that classify all utilizations as ‘adoption’, and do not consider in depth the farmer perspectives and contextual realities that affect farmer decision-making on the intensity of use. We analyze 57 in-depth, semi-structured interviews with farmers who implement CA to understand why they tend to do so at limited intensities and what is required to intensify their CA activities, both for them and others within their communities. While most farmers reported substantial yield benefits from using CA, this was mainly related to input intensification (particularly herbicides) and was limited by constrained financial resources. Overall, the intensity of CA utilization was constrained due to farmer-identified constraints across their physical, financial, human and informational resources. Because of this, stagnation at low intensities of CA utilization was common, reflecting the assumed transformational adoption pathway for CA and the focus on binary adoption, as opposed to modification and the broader utilization process. To overcome this, we propose a more nuanced transitional approach focused on the intensification of four broader principles of CA over time (i.e., (1) strategic tillage, (2) soil protection, (3) crop diversification and (4) input management) as opposed to the strict packaging of CA practices. Such a change in approach will foster increased positive perceptions within the community and allow farmers to locally adapt CA to build their own way toward complete CA utilization and with less need for subsidization.

Introduction
Agricultural production in sub-Saharan Africa (SSA) faces a challenging future in light of a more variable climate (Jones and Thornton, 2003) and increasing land degradation (Bai et al., 2008). Noting SSA’s growing demographic pressures (Fuglie et al., 2012), demand for cereals is likely to triple over the coming three decades (van Ittersum et al., 2016). Yet current productivity for key food crops in Africa remains nearly stagnant (FAO, 2016), leading to rising concerns over food security and environmental sustainability.

Much of the discourse on these issues has focused on conservation agriculture (CA), defined as the grouping of three inter-related principles that are often promoted in a restricted way and thus interpreted as prescribed practices: minimal soil disturbance, permanent soil cover and rotation of diverse crops (FAO, 2014). CA has shown extensive potential for agro-nomic and environmental improvements (Ndah et al., 2014; Thierfelder et al., 2015, 2016; Mupangwa et al., 2016), yet despite more than five decades of CA within the research and extension systems throughout eastern and southern Africa, the uptake of CA remains limited. According to Brown et al. (2017b), this limited uptake reflects two key themes: (1) the limited uptake of CA by smallholder farmers; and (2) a tendency for the smallholder farmers who do apply CA to do so at low intensities.

The literature has generally addressed the limited uptake of CA through binary classifications of farmers as either ‘adopters’ or ‘non-adopters’. In doing this, there has been limited exploration beyond the ‘success’ and/or explanation of ‘adoption’ and limited understanding of the intensity of CA use by farmers, and particularly of modification by farmers to meet their local contextual realities (Glover et al., 2016). This is in strong contrast to the growing body of literature suggesting that incomplete adoption of CA dominates uptake in Africa and that three-factor CA is rarely fully embraced (Baudron et al., 2007; Gowling and Palmer, 2008; Gillier et al., 2009; Pannell et al., 2014). Brown et al. (2017b) found that while binary adoption of CA was considerable amongst eastern and southern African smallholder farmers (Ethiopia:
57%, Kenya: 89%, Tanzania: 94%, Malawi: 94% and Mozambique: 98%). 99% of CA implementation was in modified forms and the intensity of CA use was constrained to below 40% in all five studied countries. This highlights a need to specifically explore with farmers who are implementing CA why they do so at limited intensities, yet this is often overlooked due to the application of binary classifications that treat all utilizations as adoption.

The literature body also has a tendency to apply econometric lenses to household survey data (e.g., Bekele and Drake, 2003; Suri, 2011; Arslan et al., 2014; Baudron et al., 2014; Kathage et al., 2015; Ngoma et al., 2015; Fedzisa et al., 2015). While such approaches can identify commonalities in the features of ‘adopters’ or ‘non-adopters’, they tend to lack in-depth understanding of farmer decision-making and the determinants of the various forms and intensities of CA utilization (Andersson and D’Souza, 2014; Brown et al., 2017b). Chambers (2000) argued the need for a deeper exploration of perceptions of those involved in rural development programs, noting that such explorations are rare but important in understanding decision-making. Such qualitative explorations are critically important for probing farmer experiences and eliciting key lessons that can help to improve on farm outcomes, as well as R&D efforts in support of small farms, with several recent studies affirming such a need (Andersson and D’Souza, 2014; Glover et al., 2016; Brown et al., 2017b).

The purpose of this study is to deeply explore directly with farmers the reasons for their limited intensity of CA utilization, an area within the literature body that is yet to be deeply explored. Analysis of this subset of farmers is particularly important noting that the perceptions of users are influential and important in both the scale of their uptake and the generation of positive message for potential nearby users. Furthermore, these perspectives have rarely been analyzed beyond the success of ‘adoption’, leaving a void in the understanding of the diverse implementations of CA that occur in practice. Hence, we work from the example set in Brown et al. (2017a) who explored the negative evaluation of CA by African smallholder farmers with this study exploring positive evaluation, and more specifically the decision-making of farmers in implementing low-intensity CA activities once positive evaluation has occurred. Hence, all respondents in this study have positively evaluated CA and have been able to implement in some capacity. Farmers who negatively evaluate CA, who are currently evaluating without making an implementation decision, or who are yet to begin evaluation due to a lack of information are excluded in order to understand our specific research question: Why do farmers choose to implement CA at low intensities?

Exploring the perspectives of this subset of utilizing farmers provides an opportunity to increase our understanding of the benefits, feasibility and relevance of CA to African smallholder farmers based on utilizing farmers’ lived experience. Such perspectives are largely absent from the literature, and hence this study provides a unique exploration of how to increase the intensity of utilization for both utilizing and non-utilizing African smallholder farmers.

Methods

This study implements qualitative methods to deeply explore directly with utilizing farmers the reasons for their resource allocation decision-making in general, and for the intensity of CA utilization more specifically. We acknowledge that qualitative methodologies have limitations as they may not be representative of larger populations and may lead to bias in reporting. Yet such work is required to reach beyond current understandings based on quantitative analysis of household surveys. The methodology outlined in this section attempts to address many of the known limitations of qualitative research methods.

Study implementation

Details of broader investigation

This paper forms part of a broader exploration of the sustainable intensification of maize–legume farming systems in eastern and southern Africa through exploration of various perspectives from the subsets of African communities, the first of which is Brown et al. (2017a) which explores the negative evaluation of CA by African smallholder farmers. Twenty case study locations were purposively selected on the basis of: (1) the importance of maize-legume systems for farmer livelihoods; (2) subsequent high potential impact of CA on farmer livelihoods (3) and existence of promotional activities on CA currently active in the district. Respondents were then purposively selected via a snowball sampling methodology (Fig. 1) to ensure a diversity of perspectives were obtained. Snowball methodologies have been variously used in qualitative research to access otherwise hidden populations (e.g., Browne, 2005) and it should be noted that this work is not intended to provide a representative sample of communities, but specifically seeks a diversity of perspectives and then investigates them in a disaggregated manner to avoid confounding different subsets of farmer decision-making.

Details of specific study

The total dataset of the broader study consists of 325 semi-structured interviews conducted in 85 communities across 20 case study locations in six countries (Ethiopia, Kenya, Uganda, Malawi, Zambia and Mozambique). As the purpose of this paper is to explore the experiences and decision-making of farmers utilizing CA, a subset of respondents from the larger dataset was utilized. As such, this study explores a subset of 57 respondents from 47 villages in 17 case studies from six countries. As per the snowball methodology (Fig. 1), this paper explores Farmer Set B (current utilizers) which comprises:

- Modified utilizers: Farmers implementing elements of CA but in a modified form (i.e., not in a ‘complete’ three-factor form; 29 respondents);
- Semi utilizers: Farmers implementing CA in a three-factor form on some area of their farm, but not on all available area (25 respondents); and
- Total utilizers: Farmers implementing CA in a three-factor form on all available area of their farm (three respondents).

Despite all efforts to identify total utilizers in each case study, only three total utilizers were identified. This reflects the strict classification of total CA utilization for the purposes of this study and hence the limited total utilizers that exist in each of the studied countries (see Brown et al., 2017b).

Details of interviews and analysis

An interview schedule was developed to provide the opportunity for each respondent to explore their decision-making regarding their CA activities and broader livelihoods. Written informed consent was obtained from all study participants prior to the interviews. Except in two locations in Ethiopia where custom demands it, no remuneration was made to farmers to participate
in the discussion. Interviews were conducted primarily in the preferred local language, except in cases where the respondent was comfortable expressing themselves in English. A translator was used from a local agricultural research station, and was, in the majority of cases, unknown to the respondent.

Interviews were digitally recorded and transcribed independently of the translator to English. All transcribed interviews were coded using NVivo™ (Version 11) content analysis software. The average length of the interviews was 40 min, but ranged between 13 and 92 min. The interview subset for this article includes 40 h of interview. Figure 2 provides the characteristics of respondents in the subset, alongside an alphanumeric code that is used in the results to identify respondents by characteristic/s.

Theoretical framework

This paper implements the livelihood platforms approach (LPA) proposed by Brown et al. (2017a; Fig. 3). The LPA provides a framework to explore farmer decision-making embedded within the wider community and institutional context. Farmer decision-making is proposed as a function of three farmer evaluations:

1. Will utilization of the practice be potentially beneficial?
2. Is the practice feasible with the resources I have or can access?
3. Does the technology fit within my livelihood objectives and broader context?

Farmers undertake these three evaluations based on the balance of four livelihood platforms (individual, household, community and institutional) which are supported by four resource pillars (physical, financial, human and informational).

Results

Respondents were generally involved in a CA program and averaged 3.7 years of experience with CA. A summary of characteristics of respondents, including the types of implementation, is given in Table 1. Despite specific efforts to locate utilizers (modifying, semi or total), we were unable to identify utilizers in three of our 20 case studies and only three ‘total’ utilizers were identified (Fig. 3). Respondents confirmed limited utilization of CA, with the majority of respondents estimating utilization of CA in any form to be below 5% in their community, and a quarter identifying themselves, to the best of their knowledge, as the only utilizers of CA in their community. Even where respondents identified some use of CA in their community, it was generally in limited forms (e.g., ‘most of them are doing CA on just [0.025 acres]’—K3).

Perceived benefits of CA

Physical resource benefits

No respondent identified yield as decreasing under a CA system, and respondents generally estimated substantial yield benefits from CA (e.g., ‘Since starting CA, I am now getting 18 bags not 10 bags, so double’—Q14). This reflected three perceived physical benefits of CA: improved soil fertility, reduced erosion and increased moisture retention (Table 2).

Human resource benefits

CA utilization was perceived to reduce labor requirements by 37 of our 58 respondents. The reduced need for weeding due to herbicide use was perceived to be a major benefit of the shift to CA (e.g., ‘CA is better because once I apply the herbicides I don’t go back again for weeding’—F15). Some farmers also identified that CA allowed them to
Fig. 2. Location and classification of respondents (map courtesy of Google Maps, 2017).
modify their calendar of events and move labor to less constrained times (e.g., ‘If we are serious that we are planting an acre of CA, we can take four days to prepare and plant, but this can be done in the dry season’—K4). Traditional tillage practices were also perceived as labor intensive (e.g., ‘we spend much time ridging the land which is wasteful’—G11).

Financial resource benefits
The major financial benefit of CA was linked to the use of herbicides (primarily glyphosate) and a reduction in the need for hired labor (e.g., ‘If I buy one packet of Weedall® non-selective post-emergence glyphosate herbicide, it is around 400 [Kenyan] shillings. My field is one acre so I use two packets to spray and it will enable me to prepare my land for just 800 shilling, which I am able to do. But ploughing, it might cost almost 3000 or 4000 shilling [with hired oxen]. For a tractor it is even 4500 shilling’—Q15).

Constraints, adaptations and pathways to greater CA utilization
Physical resources
Stover resources. Even with the identified increase in yield, respondents identified stover resources as the primary physical resource constraint (e.g., ‘We are doing half an acre of CA. This size of the field is not ideal and we wished to do much more but we do not have stover’—K18). Stover constraints primarily reflected high competition for stover residues, limited community availability and the security of stover in CA fields (Table 3). To overcome substantial stover deficits, many respondents stated they address stover constraints through planting alternative forage and fuel sources (e.g., ‘At every border of my farm I have Napier grass. So I can use that, and I have also established these fodder trees’—Q6; ‘we will plant more trees so that we should be using them as firewood instead of using stalks’—U8). When this was not the case, respondents identified the need to concentrate CA in one location through the importation of stover from surrounding fields (e.g., ‘I add from other fields because mine are always not enough’—M15). However, this often increased the cost of implementing CA (e.g., ‘It is very hard [to find stover] as I have to travel far to find them...[and] I need money to pay for stover to be carried to my field’—Y13).

Due to stover security concerns, stover was often imported from fields nearby to residences to monitor stover loss (e.g., ‘Our field hasn’t been [burned] because we do it close to our house’—K16). An alternative adaptation was periodic removal of stover (e.g., ‘If we just leave the stalks there sometimes they do burn so when we bundle them and lay them [when the rain comes] so they don’t bother us’—X3). Kenyan respondents indicated that most animal rearing occurred in enclosures and this reduced stover security concerns (e.g., ‘People keep the zero grazing in their place so their cows don’t go to other places’—E5), while in southern Africa, some respondents indicated that local by-laws helped ensure their stover security (e.g., ‘We do not worry because there is a by-law that has been put in place by the chiefs’—K2). However, other respondents identified concerns over their implementation (e.g., ‘They can put a rule that people should not burn... We have that now but it is not seriously enforced at the moment’—K5).

Input markets. Respondents identified that increasing the intensity of their CA activities was challenging due to issues with the availability and quality of, and access to, inputs required to implement CA (e.g., ‘You want to use the method but you can’t get what you want... I would say availability of those materials is a big hindrance’—E15) and most respondents emphasized that obtaining inputs took substantial effort (e.g., ‘If herbicide is available widely, we could expand... The problem of herbicide is that it is not available, not a finance issue, but one has to go to Adama or even Addis Ababa to get the supply’—S2). The quality of inputs on the market was also an issue (e.g., ‘That is something which is burning farmers. They are losing faith in buying inputs... these agro inputs like chemicals, like herbicides, they are fake. They don’t do what they are supposed to do. That is what also is scaring the people’—G11). Despite project-aligned farmers obtaining inputs directly from their associated projects, there were often issues with the sharing of equipment which also limited their intensity of use (e.g., ‘We do not have a sprayer, we just borrow... at times it becomes very busy and the owner is using it and I want to use it at the same time. By the time I have access to it the weeds have grown’—Z2).

Financial resources
More than half of respondents identified constrained financial resources as their reason for limited CA intensity, reflecting a lack of capital, limited credit and low financial return for output (Table 4).

In exploring the financial context of their communities, farmers tended to identify poverty as a key determinant of the limited CA utilization (e.g., ‘Most people are poor so they fail to buy farm inputs’—F9). Because of this, when respondents interacted with others in their community to promote CA, there was an expectation that inputs be provided to facilitate CA adoption (e.g., ‘people expect to receive something from the technology, so if the project brings nothing the adoption rate becomes very low’—T9). This was related to a history of input provision by projects to encourage
### Table 1. Summarized characteristics of respondents

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Modified use</th>
<th>Semi use</th>
<th>Total use</th>
<th>Overall</th>
</tr>
</thead>
<tbody>
<tr>
<td>Involvement with CA program</td>
<td>76%</td>
<td>89%</td>
<td>100%</td>
<td>79%</td>
</tr>
<tr>
<td>Years of experience with CA</td>
<td>4.0</td>
<td>3.5</td>
<td>3.7</td>
<td>3.7</td>
</tr>
<tr>
<td>Proportion of farm under CA</td>
<td>43%</td>
<td>22%</td>
<td>100%</td>
<td>37%</td>
</tr>
<tr>
<td>Area of CA (acres)</td>
<td>2.6</td>
<td>3.1</td>
<td>1.5</td>
<td>1.9</td>
</tr>
<tr>
<td>Herbicide use</td>
<td>76%</td>
<td>68%</td>
<td>100%</td>
<td>74%</td>
</tr>
</tbody>
</table>

#### Tillage practice
- Ripples: 14%<br>- Basins: 17%<br>- Dibble: 9%<br>- Full use: 52%<br>- Periodic: 14%<br>- No: 14%

#### Soil cover
- Full use: 28%<br>- Incorporation: 17%<br>- Periodic removal: 17%<br>- Low intensity: 31%<br>- No: 7%

#### Legume use
- Rotation: 31%<br>- Intercrop: 28%<br>- Full use: 52%<br>- Low intensity: 24%<br>- No: 17%

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the use of new technologies (e.g., ‘People are difficult. They are accustomed to receive things when they are told what to do’—Z9).

**Human resources**

Only a minority of farmers identified that labor constraints were a reason for their low intensity of CA use. When respondents did identify labor constraints, they tended to assert that:

1. Stover importation was a labor burden and poorly perceived by the community members (e.g., ‘They think I’m crazy when I’m doing it... People laugh at you when carrying the stalks thinking that you are crazy’—M15) and often led respondents to reduced intensity of CA utilization (e.g., ‘What stops me from expanding is when it comes to gathering stalks... it is a tiresome job’—F9).
2. Community labor was often unwilling to import stover (e.g., ‘It is difficult to find labour to lay the stover even if it is a cheaper method. The labour force prefers to make ridges rather than carry the stover’—K5).
3. Herbicides were required to reduce labor compared with conventional practices (e.g., ‘If you have not applied the herbicides that’s when CA becomes a problem [for labour]’—F15).
4. Irrigated production often limited farmers’ time and hence ability to implement dry land CA activities (e.g., ‘After harvest a lot of people produce in the lower lands with irrigation, so they go and spend a lot of time there’—Y2).

### Table 2. Physical resource benefits of CA utilization identified by respondents

<table>
<thead>
<tr>
<th>Benefit</th>
<th>Representative quotation(s)</th>
<th>ID</th>
</tr>
</thead>
<tbody>
<tr>
<td>Soil fertility</td>
<td>Nitrogen fixation by legumes</td>
<td>X18</td>
</tr>
<tr>
<td></td>
<td>‘I understand that groundnuts fix nitrogen so when we plant maize where there was groundnuts the maize will do well’</td>
<td></td>
</tr>
<tr>
<td>Soil erosion</td>
<td>Crop residue breakdown to humus</td>
<td>F15</td>
</tr>
<tr>
<td></td>
<td>‘Every time I am putting the residues they are turning into manure, thereby increasing the fertility’</td>
<td></td>
</tr>
<tr>
<td>Soil moisture retention</td>
<td>Reduction in loss of topsoil</td>
<td>K3</td>
</tr>
<tr>
<td></td>
<td>‘When you till the land the soil becomes very loose. After some time you notice that what remains in the fields where you make ridges is just sand, the good soil is taken by the wind and water. But when you do CA that is not happening’</td>
<td></td>
</tr>
<tr>
<td>Climate adaptation</td>
<td>Stover cover</td>
<td>E3</td>
</tr>
<tr>
<td></td>
<td>‘I covered the soil with the trash and the water remains in the soil and then maize grows well’</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Climate adaptation</td>
<td>C10</td>
</tr>
<tr>
<td></td>
<td>‘Where I did CA, even though there was no sufficient rain, maize did very well while in the conventional field the maize wilted’</td>
<td></td>
</tr>
</tbody>
</table>
Table 3. Stover constraints identified by respondents

<table>
<thead>
<tr>
<th>Constraint</th>
<th>Example quotation(s)</th>
<th>ID</th>
</tr>
</thead>
<tbody>
<tr>
<td>Competing uses</td>
<td>We know that if we leave stover on field it is good for the soil. But in reality we need to feed our livestock</td>
<td>S2</td>
</tr>
<tr>
<td>Firewood</td>
<td>“It’s not that we can’t do CA but it is because of the problem of stalks. We need for fuel”</td>
<td>U8</td>
</tr>
<tr>
<td>Manure production</td>
<td>“I collect some of the stovers to feed the livestock... then the manure I get from that animal I take it to the farm”</td>
<td>E3</td>
</tr>
<tr>
<td>Tobacco preparation</td>
<td>“We use a lot of stover to go and burn where we plant the tobacco nurseries”</td>
<td>K16</td>
</tr>
<tr>
<td>Income generation</td>
<td>“Some (crop residues) we sell to those who have cows”</td>
<td>E5</td>
</tr>
<tr>
<td>Transport issues</td>
<td>“I fail to expand because I don't have the means of stover transportation”</td>
<td>M15</td>
</tr>
<tr>
<td>Limited community availability</td>
<td>“What hinders is me is lack of stalks because others refuse to give me their stalks”</td>
<td>C10</td>
</tr>
<tr>
<td>Stover security</td>
<td>Rodent hunting</td>
<td>Z1</td>
</tr>
<tr>
<td>Communal grazing</td>
<td>“The residues can be a big problem. Right now there is competition between us and the livestock of others”</td>
<td>F15</td>
</tr>
<tr>
<td>Theft</td>
<td>“What makes it difficult is that there are only a few people in this area who practice CA so people have a tendency of taking our stalks and using them as firewood”</td>
<td>U8</td>
</tr>
<tr>
<td>Fire (general)</td>
<td>“I and many other farmers fail to do CA because we think that other people may burn our stalks with their own reasons”</td>
<td>M15</td>
</tr>
<tr>
<td>Uncontrolled wild fire</td>
<td>“I just worry that maybe my neighbour will burn his/her field and the fire will reach into my field”</td>
<td>K4</td>
</tr>
<tr>
<td>Jealousy</td>
<td>“We are not able to increase the acreage because where we were getting the stover has been burnt... it is because of jealousy for these farmers saw our good harvest so they burnt the stover”</td>
<td>K18</td>
</tr>
</tbody>
</table>

Many respondents attributed their utilization of CA to their focus on farming activities and devotion of labor only to farming (e.g., ‘I am not employed anywhere, as I am just totally depending on my farm’—Q6). The opportunity cost of agricultural labor was also important in case studies that were located close to major trading hubs and towns (especially near Emba, Bungoma and Lira), where farmers were not willing to invest their labor in farm activities (e.g., ‘In our village, people plant maize but not well as they are busy doing other things... they go to town for trading and business, so they are not serious’—Q9; ‘most people need to participate in business around town... Farming here is for home consumption and very few do it for business’—G11).

Informational resources

Access to and availability of informational resources. Respondents were generally well connected to information sources, with only 12 out of the 57 respondents not having been involved in a CA project at some point. The majority of the respondents identified themselves as CA lead farmers who were receiving inputs to provide CA demonstrations to the community, and often identified

Table 4. Financial constraints identified by respondents

<table>
<thead>
<tr>
<th>Constraint</th>
<th>Example quotation</th>
<th>ID</th>
</tr>
</thead>
<tbody>
<tr>
<td>Household</td>
<td>Capital requirements</td>
<td>Z19</td>
</tr>
<tr>
<td>Increasing price</td>
<td>“The inputs I use now are the same as before but the price is much higher. It used to pay 500 Ethiopian birr for SNP [fertilizer] but now it is 1500 Ethiopian birr”</td>
<td>S2</td>
</tr>
<tr>
<td>Credit markets</td>
<td>Credit availability</td>
<td>Y2</td>
</tr>
<tr>
<td>Credit risk</td>
<td>“we avoid these loans because sometimes at the end of the year we have problems and cannot repay the loan so we sit in fear”</td>
<td>E12</td>
</tr>
<tr>
<td>Credit cost</td>
<td>Repayments are very high and require much money and cattle and other assets to guarantee the loan. So it is too expensive and I don’t want to do it”</td>
<td>Y2</td>
</tr>
<tr>
<td>Credit does not match requirements</td>
<td>“taking credit may be a burden on me in future... the amount they give is not as you want”</td>
<td>S2</td>
</tr>
<tr>
<td>Output markets</td>
<td>Unreliable markets</td>
<td>X1</td>
</tr>
<tr>
<td>Low returns</td>
<td>“It is difficult to find the money to buy fertilizer even after we sell the produce”</td>
<td>K2</td>
</tr>
<tr>
<td>No pathways to build capital</td>
<td>“It took me so long to expand because of the way I was finding resources. It was so hard for me to have funds to purchase fertilizer and seeds”</td>
<td>X1</td>
</tr>
<tr>
<td>Market access</td>
<td>“the challenge is that we have to transport our produce to them (good markets)”</td>
<td>Z2</td>
</tr>
</tbody>
</table>
Table 5. Strategies identified by respondents to increase the availability of informational resources on CA

<table>
<thead>
<tr>
<th>Requirement</th>
<th>Example quotation</th>
<th>ID</th>
</tr>
</thead>
<tbody>
<tr>
<td>More extension activities</td>
<td>‘Increase the number of lead farmers to reach the remaining farmers’</td>
<td>T9</td>
</tr>
<tr>
<td></td>
<td>'We need more field officers to change the community, more field days and they can also attend and change their way of farming and life'</td>
<td>Q14</td>
</tr>
<tr>
<td></td>
<td>'I think if the extension workers can organise more meetings to address the farmers it can help'</td>
<td>F6</td>
</tr>
<tr>
<td>Reduce burden on extension officers</td>
<td>‘There is less extension staff. You might find that in our case, our ward, we only have one extension officer handling the whole ward... We are praying hard for government to employ more extension officers’</td>
<td>Q5</td>
</tr>
<tr>
<td></td>
<td>'In this sub-county, there is only one extension officer. But in the sub county you can find eight parishes. So as that one person cannot be able to move within those parishes to talk about this idea of CA. So the extension workers are few and they cannot do it'</td>
<td>J4</td>
</tr>
<tr>
<td>Increase practicality of learning opportunities</td>
<td>‘If the extension would teach and then do the practical, going through fields and teaching, that would be helpful’</td>
<td>Z10</td>
</tr>
<tr>
<td>Provide ongoing follow up training</td>
<td>‘What I say is teaching. Not only once and twice but continuous teaching. The extension agents once they train, they do not come and follow up’</td>
<td>B6</td>
</tr>
</tbody>
</table>

Direct lines of contact with government extension officers (e.g., ‘I will call my officer for agriculture... I like him because when I call him he runs to come here’—Q9) or substantial personal engagement (e.g., ‘She comes often, three to four days a week’—C10). Despite this, respondents consistently asserted concerns about their knowledge of CA (e.g., ‘I am satisfied with CA but I still need more information to continue with it’—Q13).

Respondents identified that information about CA was difficult to access in their communities (e.g., ‘I am not able to learn anywhere, even though this year I am interested to learn’—Y15) and particularly so if a farmer was not connected with a project (e.g., ‘It would have been difficult [for other farmers to gain information] because other than the (CA) project, we have never seen any group training in the use of CA methods’—J4). Overall, information constraints were generally seen as the larger inhibitor of wider utilization of CA in their communities (e.g., ‘Training is the most important... Unless people get the necessary training change is not expected’—S2). To achieve this, respondents identified key strategies to facilitate greater informational exchange (Table 5).

Quality of informational resources. Respondents identified that a confusing informational environment existed for them and within their communities, which reflected incomplete information and multiple conflicting messages regarding CA (Table 6). Conflicting information manifested itself in issues such as stover incorporation due to prior messaging on stover management (e.g., ‘we re-pack the soil so that the fertile top soil and the residues of the crop are moved lower. It is for fertility’—Y2).

Discussion

Benefits of CA implementation

The net benefits of CA utilization for African smallholder farmers continue to polarize the agricultural R&D community (Andersson and D’Souza, 2014; Giller et al., 2018; Pittelkow et al., 2015). A meta-analysis of CA studies by Pittelkow et al. (2015) found that, on average, no-tillage in itself resulted in a yield penalty. Our results indicate that utilizing farmers did not perceive a yield gap. This likely reflects that most studies compare tillage and no tillage systems with the same input usage, but the comparison generally made by African smallholder farmers is between a low input, traditional tillage system with a high input, CA-based system (visualized in Fig. 4). Our findings confirm that much of the perceived benefit of CA implementation is related to input use (Kirkegaard et al., 2014), particularly noting the nitrogen depletion common in the soils of SSA (Lundy et al., 2015).

Themes contributing to the low intensity of utilization of CA

Key themes emerged in the reasons why farmers were led to incomplete utilization, and why others in their communities

Table 6. Conflicting and incomplete information identified by respondents

<table>
<thead>
<tr>
<th>Conflicting issue</th>
<th>Example quotation</th>
<th>ID</th>
</tr>
</thead>
<tbody>
<tr>
<td>Herbicide safety</td>
<td>‘they fear chemicals will spoil their soil when they plant’</td>
<td>Q13</td>
</tr>
<tr>
<td></td>
<td>‘some of them fear that if they spray and they have animals they will go and graze there and die’</td>
<td>Q15</td>
</tr>
<tr>
<td>Between projects, NGOs and government</td>
<td>‘Right now, they (organisations) say different things and when it comes to the ministry, they tell you to plough and the NGO say plough and the project tell you to practice conservation agriculture. So it seems as if we are working separately’</td>
<td>Q21</td>
</tr>
<tr>
<td>Community leaders</td>
<td>‘Extension staff should continue talking to the chief so that the chief can encourage the subjects on CA’</td>
<td>K18</td>
</tr>
<tr>
<td>Religious teachings</td>
<td>‘Some are saying even in the bible there is chapter saying you dig the land in order to get enough air (for plant growth)’</td>
<td>E1</td>
</tr>
<tr>
<td>Government subsidies</td>
<td>‘They [the government] are contradicting themselves. Because now we have six subsidised tractor in Bungoma and 15 in Busia. So there is that confusion. As much as they try to tell us to practice CA, there is that contradiction’</td>
<td>Q14</td>
</tr>
</tbody>
</table>
failed to utilize CA. These issues tended to originate from issues at the community and institutional platforms, and as such are embedded within wider socio-economic and system constraints (Andersson and D’Souza, 2014; Arslan et al., 2014). There were key themes at each of the four resource pillars of the LPA:

**Physical resources.** Competition for limited stover resources defined a farmer’s intensity of CA utilization, confirming the previously identified importance of stover resources to African smallholder CA implementation (Valbuena et al., 2012; Baudron et al., 2014). The functionality of input markets was also limiting, particularly when farmers were not aligned with a project promoting CA.

**Financial resources.** The overall financial viability of smallholder farmers hindered the intensity of CA utilization. This reflected a lack of household capital, and limited credit facilities and financial return through output markets, leading to the continued use of low input agricultural practices (i.e., although use of agronomic inputs may be financially beneficial, their use is beyond many farmers’ financial means and hence benefit cannot be achieved). The limited use of inputs that dominates within communities also hampered the development of functional input and output markets, because demand is not sufficient to incentivize supply.

**Human resources.** Our results confirm the findings of various studies that assert CA without herbicides becomes challenging in terms of labor required (Giller et al., 2009; Marongwe et al., 2011; Grabowsi and Kerr, 2013; Rustanmohodzi, 2015). The promotion of stover importation as a form of ‘no-herbicide’ CA was also poorly perceived due to the cost or type of labor involved, confirming a need to create more biomass through fertiliser application (Vanlauwe et al., 2014) to reduce biomass competition and labour requirements.

**Informational resources.** We find an overall information-poor environment for respondents, despite respondents being the most strongly connected to informational providers and hence having the greatest opportunity for learning about CA compared with other community members. Hence, there is further justification for the investigation of the functionality of informational exchange mechanisms that a growing body of literature question (Diagne, 2009; Simtowe, 2011; Wellard et al., 2013; Ngwira et al., 2014; Brown et al., 2018).

While a diversity of constraints are identified, there is a common narrative: the juxtaposition of the need for increased engagement with the community platform and the limited resources present at that platform to facilitate CA use. A key example is respondents perceiving a need for financial resources for herbicides, fertilizer and/or stover importation, yet a limited ability to build or access financial capital to facilitate this. These results further contribute to the literature questioning the relevance of CA as a ‘pro-poor’ technology (Giller et al., 2009; Andersson and D’Souza, 2014; Corbeels et al., 2014; Pannell et al., 2014).

**Current transformational CA adoption pathways**

At the core of the identified constraints to CA utilization is the limited adaptation of CA to local contexts. CA has commonly been framed as a narrow amalgamation and promoted as a singular practice (Giller et al., 2009; Andersson and D’Souza, 2014; Stevenson et al., 2014; Glover et al., 2016). Because of the constrained financial context and limited input and output markets, implementation of CA has been dominated by project-supported adoption as evidenced by the high number of respondents that continue to be subsidized. In essence, the farmers’ limited financial context has been altered through subsidization to enhance the ‘fit’ of CA and facilitate utilization. The assumed adoption pathway for CA is hence overwritten by a technology transfer approach, whereby CA is promoted as a singular technology as opposed to an amalgamation of principles. These adoption pathways tend to be based on the expansion of CA area, with CA as a singular technology (Fig. 5).

Such promotion is problematic to facilitating total adoption of CA, and usually culminates in low-intensity semi-utilization and modified adoption (Brown et al., 2017b), because:

- CA has substantial overhead costs that limit the feasibility of small area implementation (e.g., spraying equipment, tillage equipment, time invested in knowledge, costs of obtaining resources from distant locations) that create the need for subsidization;
- Such a system limits overall CA area within the community and does not allow a sufficient scale to be reached to demand facilitating by-laws, markets and policy changes (e.g., input markets, community grazing practices);
- Limited application is unlikely to build financial resources sufficiently to sustain the expansion of CA activities due to small return and considerable costs in meeting basic needs;
- Perceptions often arise that promoting farmers are ‘playing games’ because of the small size of such demonstrations and trials; and
- Promotion of CA as a singular technology lessens the importance of building on existing farming systems and tends to lead to CA being perceived as new, difficult or non-feasible.

These approaches also limit the understanding of modified and semi-spatial utilization because of the ambiguity around how to classify such utilization strategies (Brown et al., 2017b). This can be particularly important in the case of modification of CA and potential negative outcomes (Guto et al., 2011; Erzenstein et al., 2012; Pettelow et al., 2013). Because of these issues, we find there to be a significant need to re-evaluate the adoption pathways for CA.

**Reframing the promotion of CA**

To address these inadequacies, there is a need for greater adaptation of CA to local contexts, as opposed to adaptation of local contexts to CA (i.e., through subsidization). To do this, we propose a widening from CA practices to CA principles and a
movement to transitional adoption pathways. An approach like this is integral to fostering locally relevant utilization of CA that meets the physical, financial, human and informational constraints that limit broader and total CA utilization.

**From CA practices to CA principles**

The current definition of CA as the simultaneous implementation of minimum tillage, cover crop and legume diversification (FAO, 2014) is highly restrictive and does not facilitate a stepwise approach to adoption. Instead a focus should be placed on finding the best suited set of practices for a farmer’s realities, objectives and resource endowments (Tittonell et al., 2009). As such, the objectives of development organizations should not be to create CA adoption, but to facilitate locally relevant adaptation of CA within a set of broader objectives. This involves showcasing a set of options through which farmers choose their most suitable way to sustainably implement their agricultural livelihoods (Giller et al., 2009).

We propose that, in line with Vanlauwe et al. (2014), there are four principles around which CA promotion should be framed:

1. **Strategic Tillage**: Beyond prescriptive minimum or zero tillage, we propose a shift to strategic tillage, where the objective is to reduce soil disturbance, to strategic, necessary events required for healthy crop growth and ease of management. This may include a reduction in tillage events before an eventual movement toward direct seeding, periodic tillage or shallow strategic tillage.

2. **Soil protection**: Promoting stover cover within the context of low biomass and high competing uses appears limited in potential over the short term, even in light of some emerging local by-laws to facilitate stover security. Hence, we propose a shift to soil protection, with the objective being to reduce erosion and maintain soil moisture. This may include green manure cover crops, permanent terracing and border plantations alongside crop residue retention, some of which are already present in African communities. The success of promotion must be tied within a flexible systems approach so as to address previous issues with their promotion.

3. **Crop diversification**: Locally specific cash crops should be the focus of this principle, with the objective of maximizing profit to enable a household to meet its basic needs and re-invest in agriculture. This may be achieved through a broadening of CA promotion to non-food crops that are currently preferred by farmers (e.g., sugar cane and cotton) in order to increase the financial relevance of CA, and then ‘spill-over’ into other food crops. This departs from the current approach that emphasizes legume diversification, often for legumes that do not have a ready market, but creates a need for alternative soil fertility management.

4. **Input management**: The objective of this principle is to focus input management not only to maximize net returns, but to address the farmer’s objectives in biomass and labor outcomes to ensure CA is both feasible and relevant. This might originally be addressed through organic inputs with an overall objective for farmers to reach an agronomically and financially sustainable production system. It is important to note that all intensification, conventional or otherwise, requires input management and will have implications on environmental outcomes as intensification occurs. However, we specifically propose this as a fourth principle for CA due to the integral requirements for biomass production and labor reduction as indicated by respondents. As the studied countries increase their local production of agrochemicals, the financial burden in addressing this principle should ease.

**Transitional CA adoption pathways**

Our findings indicate that transformational adoption pathways have shown a propensity to perpetuate financial dependency, as previously identified by Brown et al. (2017a) who highlighted that the current promotion of CA tends to lead to reliance on donor provision of input and donor dependency to implement CA. To alleviate these constraints, there is a need to rethink the adoption pathways for CA utilization. As opposed to the current intense focus of development organizations on achieving ‘adoption’ under a binary classification and an associated provision of inputs to enable immediate (but often short-lived) practice change, we propose a transitional approach that aims to foster utilization via stepwise, progressive intensification of our four proposed CA principles. Under this utilization pathway, we maintain the end goal of (four factor) CA, but have a series of progressive, locally relevant stepping stones to achieve total utilization. This is based not on expansion of CA as a singular technology,
but on disaggregation of the principles and stepwise intensification of utilization. It also places CA within a wider farming context, whereby the goal is to first diversify, then intensify resource use and this then makes the additional CA principles a more attractive proposition.

One such example is proposed in Figure 6. In the first instance, a locally relevant cash crop is used to build financial capital. This might be supported through soft loans of seed to stimulate local demand and hence overall community supply. Once sufficient capital is built to meet various household basic needs and reinvest into agriculture, financial capital could be used to invest in the input required for CA (such as herbicides, fertilizers and seed for alternative soil protection strategies and fodder/fuel crops). As soil protection is increased, further financial capital could be invested in strategic tillage equipment and other diversification strategies. The creation of financial capital in such a way is also likely to underwrite the improved functionality of credit facilities and build demand in both input and output markets over time. A transitional approach also provides a higher potential pathway for farmers to build their way out of subsistence farming over time and with minimized financial requirements from outside promotional organizations and governments.
Such a change in focus would also allow promoting organizations to focus their efforts on enabling environments for CA utilization. This includes market development, local by-law creation and working with research and extension organizations to create a more coherent informational environment based on the four proposed CA principles. Particularly for the informational environment, CA can be framed more broadly, facilitating greater understanding and local adaptation within the four proposed CA principles. It will also decrease the complexity of CA utilization because change occurs transitionally over time, requiring less transformational change and therefore less perceived risk by farmers.

However, this approach will require greater investment in the extension systems of the target countries to ensure that modifications and stepwise iterations of CA are locally beneficial and feasible. In all of our six study countries, agricultural research is underfunded based on the ratio of agricultural GDP: investment in agricultural research (Lele et al., 2010), which will considerably diminish the ability of research and extension services to facilitate transitional adoption pathways. To facilitate both greater total use and utilization more generally, there is a need to address not only the adoption pathways, but funding for the institutional system that develops and delivers CA to African smallholder farmers.

Conclusions
This paper explores how to facilitate wider CA utilization in eastern and southern Africa, both in terms of the intensity of currently utilizing farmers and the uptake of CA within the broader community. We find that while perceived as beneficial to yield, financial and labor benefits are limited by the low use of inputs, particularly herbicides. The feasibility of CA implementation was also limited across all of physical, financial, human and informational resources, and usually related to constraints at the community and institutional platforms. We find this to be linked to the assumed transformational adoption pathway for CA and the focus on binary adoption, as opposed to modification and intensification of utilization. We propose a more nuanced approach focused on four broader principles as opposed to the strict packaging of CA practices, as well as the promotion of CA via transitional pathways that are focused on smallholder farmers building their intensity of CA utilization over time. This will reduce the burden of CA implementation, both financially and informationally and allow for spontaneous, as opposed to subsidized, utilization of CA. Implementing transitional pathways will require greater funding of research and extension services, but provides greater potential for African smallholder farmers to sustainably intensify their farming systems, noting the contextual realities that currently constrain the intensity of CA utilization.

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Chapter Six: Perspective from Farmers Currently Evaluating CA

Chapter 5 contains the fourth manuscript of this thesis which qualitatively explores the ongoing evaluation of CA by African smallholder farmers. A summary of the manuscript is provided, followed by the statement of authorship and manuscript 5.

6.1 Manuscript Summary

**Figure F: Graphical abstract for manuscript 5.**

**Context:**
- CA is an integral component to the sustainable intensification of African smallholder agriculture, yet there is limited understanding of the process farmers apply in evaluating it for their purposes.
- The decision mechanism for farmer evaluation of CA and the utilisation pathways to enable farmers to move to positive evaluation and increased intensity of CA utilisation are poorly understood due to a tendency for evaluating farmers to be considered adopters.
Research objectives:
- To explore with evaluating farmers their decision making process regarding CA; and
- To explore what is required for evaluating farmers to progress to positive evaluation and more intensive CA utilisation.

Methods:
- Semi-structured interviews with 58 smallholder farmers currently evaluating CA but yet to progress in their utilisation (either: interested but yet to apply CA; subsidised lead farmers who are yet to progress to greater use; or farmers who are conducting experiments on CA on a limited area to evaluate it for their purposes).
- Application of the Livelihood Platforms Approach (LPA).

Findings:
- Respondents had obtained substantial experience with CA, but were yet to expand their activities. This reflected limitations with the perceived benefit, feasibility and relevance of CA.
- There were three overarching themes that drove these limitations: 1] limited financial viability; 2] a lack of stover resources and security of stover resources; and 3] constrained informational resources held to evaluate CA.

Implications:
- To progress farmers to greater intensity of CA use, a broader focus beyond the plot level is required, particularly in addressing issues at the community and institutional platforms.
- This will involve a refocus on the pathways to CA utilisation through progressive and incremental use of inputs and growth in interaction with, and trust of, the community platform.
6.2 Statement of Authorship

**Manuscript Details:**

| Title of Paper: | From interest to implementation: exploring farmer progression of conservation agriculture in Eastern and Southern Africa |
| Publication Status: | Published |

**Principle Author:**

| Principle Author: | Brendan Brown (Candidate) |
| Contribution to paper: | Identification of research gap, theoretical conceptualisation, fieldwork design, fieldwork to collect data, analysis of data, interpretation of results, writing of manuscript, acted as corresponding author |
| Overall percentage: | 90% |
| Signature: | Date: 17/08/2017 |

**Co-Author Contributions:**

By signing the Statement of Authorship, each author certifies that:

i. the candidate’s stated contribution to the publication is accurate (as detailed above);

ii. permission is granted for the candidate in include the publication in the thesis; and

iii. the sum of all co-author contributions is equal to 100% less the candidate’s stated contribution.

| Name of Co-Author | Contribution to paper: Supervision, evaluation and editing of the manuscript |
| Signature: | Date: 17/08/2017 |

| Name of Co-Author | Contribution to paper: Supervision, evaluation and editing of the manuscript |
| Signature: | Date: 17/08/2017 |
From interest to implementation: exploring farmer progression of conservation agriculture in Eastern and Southern Africa

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Abstract
Sub-Saharan Africa needs to produce more food, feed and fibre to support its growing population, and the sustainable intensification of smallholder agriculture is a crucial component of any strategy towards achieving this goal. Conservation agriculture (CA) has been widely promoted as a means to this, yet African smallholder farmers who have expressed interest in CA have generally not progressed to implementation on their farms. Examinations of this trend remain underanalysed, particularly from non-econometric explorations of farmers’ lived experiences and perspectives. This presents an opportunity to understand what drives farmers’ expression of interest in CA and if such expression of interest could be targeted for other farmers (particularly if CA is to continue to be promoted to African smallholder farmers). We implement in-depth, semi-structured interviews with 58 farmers who have expressed interest in and are currently evaluating CA for their situation to explore their perspectives on what drives their interest in, and limits their progression to higher intensities of, CA. Respondents indicated mixed perceptions of the benefits, feasibility and relevance of CA to their livelihoods, adding to the ongoing discourse regarding the applicability of CA to African smallholder agriculture. If CA is to continue to be promoted, the respondents indicated a need to address issues related to financial viability, stover competition, small-scale mechanisation and informational exchange mechanisms. If farmer interest in CA is to be based on the technology itself and not perverse incentives, and that interest is to be progressed to implementation, respondents indicate that CA will need to be further adapted to fit within their contextual realities. To achieve this, more flexible and transitional promotion of CA by its components facilitated through greater community participation in research and extension systems will be required.

Keywords  Farmer attitudes · Qualitative methods · Smallholder farmers · Conservation agriculture · Adoption dynamics · Africa · Decision-making

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1 Introduction

Smallholder agriculture sustains the majority of households in sub-Saharan Africa, and there has been a strong policy commitment by governments and developmental organisations to promote it as the main route for economic development and poverty alleviation (Collier and Dercon 2014). Despite this focus, overall agricultural productivity growth across sub-Saharan Africa has not kept pace with population growth (FAO 2016). Even with the limited signs of recent improvement, production growth of the major food crops of sub-Saharan Africa (i.e. maize and root crops) since the 1980s has been based mostly on extensification of cultivated area rather than yield growth (Brink and Eva 2009; Evenson and Golin 2003). The population of sub-Saharan Africa is expected to more than double by 2050 (Fuglie et al. 2012), and with that will come a tripling of demand for cereals (van Ittersum et al. 2016). This demand will need to be met in light of a more variable climate and a reduced potential for land extensification.

Conservation agriculture (CA) has been promoted as a set of technologies to address these problems, particularly by the FAO, CGIAR, international and local NGOs (Whitfield et al. 2015; Giller et al. 2015). CA combines three interrelated principles of minimum soil disturbance, permanent soil cover and crop diversification as a pathway to increase productivity and environmental sustainability. CA has been shown to have high potential for increased agronomic and environmental outcomes in various situations across the African continent (Mupangwa et al. 2016; Ndah et al. 2014; Thierfelder et al. 2015, 2016). Despite a growing questioning of its applicability in smallholder situations (e.g. Andersson and D’Souza 2014; Giller et al. 2009; Pittelkow et al. 2015), CA continues to be promoted as a dominant component of the sustainable intensification agenda for African smallholder systems (Whitfield et al. 2015). Yet, the limited uptake of CA by African smallholder farmers (Arslan et al. 2014; Brown et al. 2017b) has led to demands for alternative pathways to effectively scale up CA adoption so that more farmers may benefit.

Andersson and D’Souza (2014) highlight a reliance of the literature on exploring the limited uptake of CA by African smallholder farmers through application of econometric studies (e.g. Arslan et al. 2014; Baudron et al. 2014; Bekele and Drake 2003; Kathage et al. 2015; Ngoma et al. 2015; Pedzisa et al. 2015; Suri 2011). Such studies typically involve selecting a number of potential independent variables and testing via regression analysis to understand how they statistically correlate with adoption or non-adoption (Feder et al. 1985). However, the dominance of such studies has led to limited understanding of farmers’ decision-making processes, especially those of evaluating farmers. Key problems arise with current econometric analyses regarding farmer decision-making because:

1. Farmer perceptions and the mechanisms for decision-making tend to be overlooked in economic analyses focused at the farm level, and with that the wider socioeconomic, political and institutional contexts that impact on farmer decision-making regarding CA are poorly understood (Andersson and D’Souza 2014; Giller et al. 2009). Despite considerable literature on the adoption (or non-adoption) of CA over the past decade, Glover et al. (2016) asserted that the evaluation process and decision-making of evaluating farmers remain under-researched;

2. Such analyses tend to apply a binary classification system that classify farmers as either adopters or non-adopters, under which evaluating farmers are not easily classified (Brown et al. 2017b). Evaluating farmers are neither adopters nor non-adopters, but at a critical junction between adoption, non-adoption and dis-adoption. Hence, there tends
to be a misclassification and misunderstanding of the decision-making of evaluating farmers and the processes which can facilitate their progression to full implementation;

3. In the context of CA in Africa, subsidisation dominates the promotion of CA. This leads to issues with subsidised farmers implementing a technology based on perverse incentives (e.g. obtaining exclusive opportunities, credit, inputs or prestige), and not due to the benefits of the technology itself (Kiptot et al. 2007). Such issues tend to be overlooked in binary econometric analyses; and

4. Norms established in the developed world that CA experimentation generally leads to continued use of a technology (e.g. Llewellyn et al. 2012) are often assumed to be relevant to smallholder behaviour in Africa. This has led to the classification of any implementation of CA (e.g. through experimentation or subsidisation) as adoption. Yet, Brown et al. (2017b) found dis-adoptions was a major outcome of the use of minimum tillage (as a component of CA), suggesting that such assumptions may not be valid for CA in Africa.

In this light, this study defines evaluating farmers through the Process of Agricultural Utilisation Framework proposed by Brown et al. (2017b) as farmers who either: (A) express an interest in CA without implementing; (B) apply CA only with subsidised inputs; or (C) are experimenting with CA on a limited area. This methodology is used to overcome the above limitations identified in applying binary and econometric analyses.

Putting aside the ongoing discourse on if CA should be promoted (e.g. Giller et al. 2015), CA will remain a politically relevant set of practices likely to continue to be promoted to African smallholder farmers in the short to medium term (Whitfield et al. 2015). Due to this, there are benefits to be accrued in improving our understanding of evaluating farmers’ resource allocation decisions in relation to CA. Further, targeting evaluating farmers is critical for several reasons: (1) these farmers are important targets to increase CA uptake over the short term; (2) understanding these farmers’ decision-making may be useful in engaging other disinterested or non-exposed farmers to implement CA; and (3) evaluating farmers are often model farmers tasked with engaging other community members, so their successful progression will aid in the broader uptake of CA within their communities over the longer term.

This study aims to qualitatively investigate the decision-making process of smallholder farmers evaluating CA. It applies the Livelihood Platforms Approach (LPA), previously used to understand both negative evaluation (Brown et al. 2017a) and positive evaluation (Brown et al. 2018a) of CA in the same communities as this study. In doing this, we explore two key questions: (1) What are the reasons for farmers expressing interest in CA?; and (2) Why has this expressed interest in CA not progressed to more intensive CA implementation? We explore this in relation to 58 in-depth, semi-structured interviews with evaluating farmers from 20 case studies in six countries in eastern and southern Africa (Ethiopia, Kenya, Uganda, Malawi, Zambia and Mozambique).

As a qualitative study, our findings may be viewed with caution due to a potential lack of representativeness. Yet, it is impractical to conduct in-depth, semi-structured interviews on a large scale and as such the methodology implemented attempts to balance the need for representativeness with the limited resources often available for participatory qualitative research. In taking this approach, we aim to provide a bridge between large econometric analyses of baseline data and the farmer’s actual situation and perspectives. The perspectives of respondents in this study provide alternative insights into understanding how African smallholder farmers are evaluating CA and what implications this has on its continued
promotion. These insights are valuable to the promotion and intensification of CA activities by African smallholder farmers beyond the interviewed respondents, especially noting the numbers of farmers yet to obtain information on CA in the studied countries (Brown et al. 2017b), as well as for the more generic sustainable intensification of African smallholder farming systems.

2 Methods

This paper forms part of a broader examination of the sustainable intensification of maize–legume farming systems in eastern and southern Africa through exploration of various perspectives from subsets of African communities. Case study locations were purposely selected due to the importance of maize–legume systems for farmer livelihoods and the subsequent high potential of CA to impact farmer livelihoods, as well as for having promotional activities on CA currently active in the district. The total dataset of the broader study consists of 325 semi-structured interviews conducted in 85 communities across 20 case study locations in six countries (Ethiopia, Kenya, Uganda, Malawi, Zambia and Mozambique).

An interview schedule was developed based on the Livelihood Platforms Approach (LPA; Brown et al. 2017a) to enable farmers to individually explore in a semi-structured way their livelihoods and decision-making behaviour in relation to their individual, household, community and institutional situation. This discussion was based around four resource categories (human, physical, informational and financial), and farmers were asked to explore the benefits, feasibility and relevance of CA implementation within their wider livelihood activities.

Written informed consent was obtained from all study participants prior to the interviews. The interviewer, and in the majority of cases a translator, were unknown to the respondent. At the onset of the individual interviews, it was made clear that the discussion in no way affected their involvement with any promotional activities and no remuneration was made to farmers to participate in the discussion (except in two locations in Ethiopia where custom demanded it occur). The interview process was designed to encourage broad discussion and enable the respondents to freely and openly voice their views without repercussion. Interviews were conducted primarily in the preferred local language, except in cases where the respondent was comfortable expressing themselves in English. Interviews were digitally recorded and transcribed independently of the translator to English. All transcribed interviews were coded according to the various resource pillars and livelihood platforms of the LPA using Nvivo™ (version 11) content analysis software.

Within case studies, respondents were then purposely selected via a snowball sampling methodology (Fig. 1) with a concerted effort to ensure a diversity of perspectives were obtained (including various ages, genders, and social and economic statuses) through this methodology. Perspectives from farmers based within and outside various CA promotion activities were also sought. It should be noted that this work is not intended to provide a representative sample of communities, but specifically seeks a diversity of farmer and non-farmer perspectives.

As the purpose of this paper is to explore the experiences and decision-making of evaluating farmers, a subset of respondents from our larger dataset were utilised. As per the proposed snowball methodology, this paper explores “Farmer Set A”, containing farmers undertaking both subsidised or their own evaluation of CA. For the purposes of
this study, CA is defined as per the FAO definition as the simultaneous application of all three CA components on the plot of land used for experimentation. In practice, the majority of farmers implemented either permanent basins or dribble stick planting, with retention (or importation) of maize stover residues and intercropping of legume species (dependant on their locality). This differs from farmers who modified their CA utilisation or expanded their area of CA beyond experimentation which is explored in Brown et al. (2018a). This definition is applied so as to align with the definition of the majority of development projects in the studied regions and does not intend to reflect the ongoing discourse on the defining of CA (e.g. Andersson and D’Souza 2014).

As such, this study utilises a subset of 58 respondents from 32 villages in 20 case studies from six countries. The breakdown of respondents is as follows:

- 16 interested non-users (Expressing interest after CA exposure, yet do not practice);
- 23 subsidised lead farmers (receive subsidies to implement CA on a limited area);
- 10 subsidised follow farmers (receives subsidies, but more limited than a lead farmer, to implement CA on a small area); and
- 9 unsubsidised follow farmers (implement CA on a limited area as part of an evaluation and receive no subsidies to do so).
The average length of CA experimentation at the time of interview was 3.7 years for subsidised lead respondents, 2.1 years for subsidised follow respondents and 1.7 years for unsubsidised follow respondents. Nineteen of the 23 subsidised lead respondents had more than three years of experience implementing CA, and the average CA experimentation area was less than 0.1 hectare. The interview subset for this article includes 40 h of interview, with the average length of the interviews 40 min, but ranging between 13 and 92 min. Figure 2 provides the characteristics of respondents in the subset, alongside an alphanumerical code that is used in the results section to identify respondents with their characteristics.

Fig. 2 Location and classification of respondents (map courtesy of Google Maps 2017)
3 Results

The results section is structured according to the two research questions explored with respondents: (1) Why are you interested in implementing CA?; and (2) Why haven’t you progressed your CA activities?

3.1 Why are you interested in implementing CA?

There were four key themes that drove respondents’ interest in implementing CA, though there was no common consensus and each theme tended to be variously contested.

3.1.1 Yield and soil conditions

Nearly, all subsidised farmers, and the majority of respondents overall, were positive about the yield benefits of CA. This generally related to the favourable soil conditions that stover cover practices created in terms of both moisture retention (e.g. “When the residues are in the garden they are used to mulch and the soil moisture is kept, and the crops will grow well in case of any dry spell”—G1) and soil fertility (e.g. “putting maize stalks in the field is helping because when they decompose they make manure which helps our crops to grow well and make our soil more fertile”—M1). When farmers were less positive regarding CA yield, it tended to reflect conflicting beliefs regarding the best management of stover (e.g. “we incorporate stover into the soil during land preparation… [If we do not then] there won’t be fertility in the soil”—N3) or waterlogging in wet years, particularly in Malawi (e.g. “The problem that I face with this type of planting is that sometimes there is too much water in the soil”—N1).

3.1.2 Reduced weeding (labour)

Where herbicides were available, respondents tended to be positive about the impact of CA on a reduction in weeds (e.g. “Weeds do not grow that much and we find time to relax since it does not need much labour [to spray with herbicides as opposed to hand weeding]”—U2) and the corresponding reduction in the cost of hired labour (“It reduces hired manpower and so expenses come down… when you spray, it is much cheaper than hiring people [for weeding]”—E16). Yet without herbicides, perceptions of CA were mainly negative due to increased weed incidence (e.g. “When herbicides are limited, weeds emerge fast”—D1). “No herbicide CA” has been promoted through stover importation (i.e. the movement of stover from other fields or grasses from communal lands to cover the soil and reduce weed growth), but this has generally led CA to be perceived as a tiresome task (e.g. “When we don’t have enough stalks we get them from our friends and it gets tiresome transferring the stalks”—M5).

3.1.3 Climate adaptation

Nearly, all farmers acknowledged that CA was a positive way to facilitate climate change adaptation (e.g. “Because of the change in climate I think it’s good we raise the
campaign of putting residues in our farms so that our crops should still survive when rain has stopped before its normal time”—M1).

3.1.4 Benefits from membership in CA programme

Noting some mixed responses regarding the benefits of CA, respondents were asked to explore why they maintained interest in, or experimental plots of, CA. The majority did not identify a perception of CA as beneficial as the reason for their interest. Instead, the most likely reason a household maintained interest in CA or joined a CA programme was because they were instructed to do so and were given (or assumed they would receive) resources (e.g. “I was approached by the extension worker telling me I should practice CA, with his support [of inputs]”—M10).

3.2 Why haven’t you progressed your CA activities?

The discussion of the reasons for farmers’ lack of progression in CA was discussed via the four resource pillars of the LPA.

3.2.1 Physical resources

3.2.1.1 Input markets Input market functionality was a key limitation for the implementation and expansion of CA, with the majority of respondents identifying problems with accessing the perceived input requirements for CA (Table 1). Even when subsidised farmers were provided with resources for experimentation, these were often identified as limiting (e.g. “We only have one sprayer and it is shared by all the lead farmers. Six of us share one sprayer so it is not good. Also, I don’t know how to buy one and the program cannot supply my own when I asked”—Y7).

3.2.1.2 Stover resources Issues with stover resources reflected issues with both feasibility and relevance constraints. Despite the perceived benefit of stover retention practices, respondents tended to preference non-compatible livelihoods that utilised stover resources for animal objectives (e.g. “For those who have knowledge of CA, they have cattle, so they can’t save it for the soil as they would have no options to feed their cattle”—W1), for soil preparation in tobacco nurseries (e.g. “Most of us make use of the maize stover at the tobacco nurseries”—K17) or for general fuel purposes (e.g. “The area is dry, so there is little fuel, so we need to use the residues for [cooking] fuel”—W1). These competing uses led to constraints regarding the availability of stover (e.g. “No farmer does CA on a large area. The problem for all is the same—the stover is too hard to find”—Y7).

The importance of livestock as part of livelihood activities reflected personal considerations, mainly a desire to diversify and reduce risk (e.g. “The difference is the cows are continuous money and the maize is seasonal, so it is a balance”—Q5) and/or cultural considerations (e.g. “The owning of cows is for the big men, and it makes us very happy. You are important if you own a cow”—Y14). To overcome this, respondents identified a need for alternative fodder and fuel options (e.g. CA adoption will not occur “until there is some forage issues addressed because the farmers have no other options. We need forage trees and grasses”—S3).

While many respondents identified a lack of stover, the majority of respondents were more concerned with the security of stover used in CA activities. While many respondents
<table>
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<tr>
<th>Issue</th>
<th>Quotation(s) demonstrating issue</th>
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<tbody>
<tr>
<td>Timing</td>
<td>“The fertilizer and chemicals come to us late and even now they are not with us”</td>
<td>H2</td>
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<tr>
<td>Availability</td>
<td>“Seed is the major problem. We don’t have seed in the market”</td>
<td>Y17</td>
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<td></td>
<td>“Herbicide is not available here. It is cheap but it does not exist here”</td>
<td>S3</td>
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<td></td>
<td>“Herbicides are not found in the market. We are given them by the NGO but if they stop giving us those herbicides then we won’t be able to continue on our own”</td>
<td>U9</td>
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<tr>
<td>Quality</td>
<td>“We always have problems with these markets. There is a lot of complaints, like that the inputs are fake or low quality”</td>
<td>G1</td>
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<tr>
<td>Market information</td>
<td>“The problem is there is no minimum tillage equipment here and we don’t know where to find them. People want to use them but nobody can find them to buy or use”</td>
<td>Y7</td>
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<td>Issue</td>
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<tr>
<td>Rodent hunters</td>
<td>“I had intention of doing CA this season but I can’t do it because the mice hunters burnt my field”</td>
<td>K17</td>
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<tr>
<td>Communal grazing</td>
<td>“My stover was eaten by livestock though we had left it on the field initially”</td>
<td>Z3</td>
</tr>
<tr>
<td>Theft</td>
<td>“If I am not around I am worried they will be stolen”</td>
<td>U3</td>
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<tr>
<td></td>
<td>“They do steal my stover, they steal when I am away from the farm”</td>
<td>Q18</td>
</tr>
<tr>
<td>Jealousy</td>
<td>“They burn my field to annoy me, so that I will stop doing CA. They are jealous because of the resources I receive as a lead farmer”</td>
<td>F5</td>
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<td>“This burning has been happening every year for the past three years since I started practicing CA… I think they want me to stop because of the benefits that I get from this type of farming… the harvest benefits and the subsidies”</td>
<td>M4</td>
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were willing to use their limited stover for CA implementation, they did not feel that if they chose to do so their stover resources would be safe from outside interference (see Table 2).

Respondents identified a desire for local by-laws to facilitate stover security, particularly to address communal grazing in Ethiopia, Kenya and Uganda, and rodent hunters in Malawi, Mozambique and Zambia (e.g. “If laws can be set to stop people from burning stalks and regulate livestock from going in other people’s farms then CA can work”—F5), but in general there was ambivalence that this would be effective in addressing the issues (e.g. in Zambia, “The mice hunters do what they want. They come from different places and walk long distances; they are not from this area. They come at night from even 50 km around. They know not to do in the home location so they find a different location”—Z15).

The main adaption to such issues was to only implement CA on a small area nearby the house to facilitate stover security (e.g. “I can only implement CA at my house where I have a nice fence, so I can keep it and protect it”—W1). However, the cost of fencing was often prohibitive (e.g. “The main problem is fencing the whole land that takes a lot of time and labour, and my land is scattered. So there is much travel to put fences and each plant for the fence is costly plus the labour to plant it”—S3). There were also potential social implications from fencing and associated social stigma (e.g. “I tried to fence my land for the last three years. In fact, my neighbours have gossiped [negatively] about me”—W2).

### 3.2.2 Financial resources

Financial resources were the primary reason respondents failed to progress in their CA implementation, with 55 of the 58 respondents identifying they did not possess, or could not access, the perceived financial resources to intensify their implementation of CA. Unsubsidised respondents tended to have low use of external inputs in their existing systems and identified that their current financial endowments did not allow them to purchase the perceived inputs required for CA (e.g. “I lack money to do what I want so I have to minimise the practices I want to do”—E16). Subsidised farmers also lacked the financial capital to move beyond their experimentations (e.g. “I fail to expand my area due to lack of finances, I do not have enough money to buy seeds and fertilizer”—M4). This was also complicated by ongoing concerns from respondents about the future feasibility of CA, noting the continuing increase in the cost of fertiliser and seed (e.g. “I do get scared because as of now the price of fertilizer is increasing every year”—F1).

The financial limitations experienced by farmers reflected the opportunities available within the community, which reach beyond CA and point to issues with the overall viability of smallholder agricultural livelihoods. There were constraints with credit functionality, be it availability (e.g. “As to my knowledge, there is no credit”—B1), reluctance due to cost (e.g. “I am afraid of the interest”—F1) or the principle required (e.g. “A farmer who wants a loan from the credit institution, they will ask if they have a land title, and some agreement for your house or plot. So you end up fearing not going for a loan [in case you then lose your house or land]”—J1). There were also issues with the functionality of output markets and the opportunities to create financial resources through them (e.g. “Another major problem we have is the market. To make money is very difficult”—Q12). This was particularly an issue for legumes in Ethiopia where there is no established use for them (e.g. “The problem is the markets. We have a maize market, but for soybean, we can get high yield, but there is no market. We are learning how to cook and eat it but it’s not what we are used to”—B1). Some farmers identified their reluctance to grow for market due to...
these issues (e.g. “The system in the country, whereby you are left to market your crops at any price you may be offered is discouraging”—G1).

Due to limited opportunity to build (through markets) or borrow (through credit) financial resources, many farmers identified that CA could only be done with subsidies (e.g. “In this area there is no one who does CA without free inputs”—U2). These farmers identified that these subsidies, as opposed to the proposed benefits, drove their interest in CA (e.g. “Many people adore my farm but most of them adore me because of the subsidies that I get, they wish they were also given the resources for them to start CA”—M5; “Many farmers just want to use the seed and fertilizer that comes with the technology”—W1).

Noting this, unsubsidised respondents tended to perceive subsidised farmers negatively (e.g. “Honestly it hurts to see our friends receiving free inputs”—N8). Likewise, most subsidised farmers were aware that community members were jealous that they received free inputs (e.g. “The inputs I was given to do that plot, they were given to me free, so many of them were annoyed that I am given these things. I think even 75% or 80% got jealous of me”—Z15). This jealousy was usually related to the exclusivity of opportunity (e.g. “At first we were interested but things changed when the lead farmer chose only ten people to receive the subsidies so people that were left out got frustrated that they did not receive anything. This is when they started shunning this technology”—M4). Ultimately, this may contribute to potential conflict within the community (e.g. “It’s not good [subsidising lead farmers] because it brings conflicts in the community”—M16).

3.2.3 Human resources

Like stover resources, the labour required to implement CA activities reflected issues with both the feasibility and relevance of CA activities. The type of labour required to implement CA was often perceived as undesirable, particularly for: (1) the digging of basins (e.g. “the hardest part is that CA requires very hard labour, especially when it comes to digging the basins”—G1; “Sometimes it is more work and harder so it is a problem with the mindset, even if one can get the bigger yield”—B1), and (2) stover importation activities (e.g. “If I am to be transferring stalks from other fields to mine then it’s going to be a tiresome job”—N1).

In terms of feasibility, the primary labour issues related to the concentration of labour at planting (e.g. “When it comes to planting it is a bit difficult because you need many people if you want to finish quickly. If you want to plant one small field you cannot do it alone… you need to have two people just marking with the dibble stick, then another is planting the maize. Then another is applying the compost, and then the final is covering the planting area. Then the rope needs to be moved again so five people are needed”—Z15). Such perspectives tended to be moderated by the household size, with small households more negative (e.g. “CA is too hard to do it with just me, because the children are at school or too young so it is just for me to do”—Y12) and larger households more positive (e.g. “CA is not difficult because I have children who will help me”—C8).

3.2.4 Informational resources

The majority of respondents identified household information on CA as a limitation to the expansion of their CA activities. While such assertions were stronger with unsubsidised respondents, subsidised respondents also identified a lack of adequate training (e.g. “I have had five years of training but I am not yet satisfied. That is why I said that I still need
more training”—D1). There were strong assertions that it was difficult to obtain information (e.g. “It is difficult for me to learn new things”—T2; “We really have no access to information”—J1), leading many respondents to become frustrated (e.g. “I have been upset on many occasions due to a lack of training”—P9).

The difficulty in obtaining CA information primarily related to a lack of connection to information sources, particularly government extension officers (Table 3), and even if farmers obtained training, they often claimed it was inadequate (e.g. “We have only just received training [after 3 years] and it is not yet enough... The training would have really required 10 or 12 days, but it was congested into just 5 days”—G1; “I did learn from the extension officers but I don’t think I did enough training on CA to expand my plot”—F1).

Regarding farmer-to-farmer extension mechanisms, unsubsidised farmers tended to assert that lead farmers were not providing information to the community (e.g. “It is difficult to get information, especially because the demo field is far away... There is no one in this area”—Z3). Lead farmers explained this reflected the large number of farmers to which they were tasked with providing information (e.g. “Each parish should have one model farmer like me, and we have a group that we have at least started spreading things. But I am just one person to teach all of the parish—just me!”—G1). Non-lead respondents were also concerned about the equality of access to information and opportunities to learn about CA (e.g. “All I can ask is that all farmers would be considered to go for trainings as lead farmers do”—M5; “The selected farmers were small and the opportunities given for lead farmers only”—H2).

There were also assertions that lead farmers were not accessible, and especially perceptions of exclusivity (e.g. “There have been boundaries created [within the community] because people say that we are not part of the project so we can’t learn this technology. This view is in the community strongly... because there is never training that all are welcome, it

<table>
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<th>ID</th>
<th>Example quotations on access to government extension officers</th>
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<tr>
<td>P9</td>
<td>“No one has clearly taught or given us the required education or training on CA. The extension officer does not serve me”</td>
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<td>Z3</td>
<td>“The extension officers have forgotten about us. As we are getting very close the rainy season, no one has come to teach us on how to go about CA... they don’t come. It is difficult to find a person to teach CA”</td>
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<td>Q5</td>
<td>“We rely on the agricultural government officers, but sometimes they do not reach to the farmers because we are far and nobody can reach and give us education”</td>
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<td>Q12</td>
<td>“Our extension officer is not very conversant with the farmer. He is not present, just very rare”</td>
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<tr>
<td>Z15</td>
<td>“Extension workers are committed to so many events, so they don’t have enough time to teach people... so many trainings are cancelled because they are too busy”</td>
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<tr>
<td>Y14</td>
<td>“The extension officer never comes here”</td>
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<td>J1</td>
<td>“Getting information is the issue... extension services are rare. Especially on the government side”</td>
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<td>G1</td>
<td>“The extension staff do not come here in the village. You call them and request for them and nothing... At this time, there is completely no trainings, no sensitisation”</td>
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<td>K12</td>
<td>“On CA, the extension worker hasn’t taught about it”</td>
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<td>N8</td>
<td>“The extension staff... they have never visited my farm”</td>
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<td>Q5</td>
<td>“It is difficult... I don’t know anyone teaching CA”</td>
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<tr>
<td>Y10</td>
<td>“I have never received information on CA from the extension officer”</td>
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<td>M8</td>
<td>“I can say I have never learnt anything from him”</td>
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has never been done. It is only for those who are from the program... What is required is to have awareness meetings that are open to each and every one. Don’t make it exclusive but let it be open”—Z15). Due to this, many farmers developed anger at the perceived favouritism towards lead farmers (e.g. “What I feel is that the extension worker is more focused on the farmers that have already adopted the technology which is so unfair. They have nothing to do with those that have not yet adopted instead of doing the opposite”—N8; “The extension officers only help those that receive free inputs”—U3).

This reflected an overall poor understanding of the role of lead farmers. Lead farmers in this study tended to lack ownership of the trial or demonstration (e.g. “Really we did not take that field seriously, that we should replicate it in our fields”—Z17) and in many cases, lead farmers did not understand that they were able to expand beyond their subsidised plot (e.g. “I thought that we can only do CA on the project plot only”—M4; “I cannot extend on my own because we were told to do on a small portion so we also have to wait for them to tell us what step to take”—M10). Lead farmers were also aware that the size of the field meant that many other farmers did not appreciate the reason for the trial (e.g. “People laugh at me because the plot that I practice CA on is too small so they look at it as if am just playing and that I can’t get anything out of that farm... they say I am humiliating myself with a toy”—M8).

The lack of interaction was highlighted in the estimates by lead farmers of their interactions with their communities. Only two lead farmers identified being approached by more than five community members to learn about CA in the preceding 12 months, and the majority of lead farmers had never trained anyone on CA since becoming a lead farmer.

Respondents also raised issues with the confusing informational environment on CA, particularly in Ethiopia (e.g. “The government teaches us to plough three or five times, but then CA is confusing people because it [CA] does not do this”—W2). There were also issues with the changing of extension messaging in quick succession (e.g. “The extension officers come one day and ask to do one thing, then they return again and ask to do something else, these same people. So, should we keep changing from here to there? They create confusion... so now many people will just concentrate on how their parents taught them to farm”—Z15). Many farmers claimed that such conflicts in information affected their decision-making on CA (e.g. “Confusion on CA is very easy”—Q10; “What the extension tells me can sometimes confuse me”—P3).

4 Discussion

The culmination of nearly twenty years of institutional support (including from the FAO, CGIAR and NGOs) has led to CA becoming a dominant component of the efforts to sustainably intensify African smallholder systems, as evidenced by the incorporation of CA into both regional (e.g. NEPAD) and national agricultural policies, including in Tanzania, Kenya, Malawi, Mozambique and Zambia (Giller et al. 2015). Despite this, there has been only limited evidence of its uptake by smallholder farmers across eastern and southern Africa. The perspectives given by respondents indicate that limited uptake of CA, at least in their lived experiences, reflects contested benefits in implementation matched with a limited enabling environment.

The general consensus amongst respondents was that CA was only practiced on a larger scale when subsidies were provided to incentivise implementation, and that the main driver of interest in CA was the perverse incentives offered to catalyse uptake. Indeed,
respondents self-identified that they were unlikely to progress their CA activities beyond interest to implementation on their farms. Such findings further enhance the argument that CA may not be applicable (at least in its current packaging) to African smallholder farmers (e.g. Andersson and D’Souza 2014; Giller et al. 2009; Pittelkow et al. 2015), but provides this in a novel way through farmers lived experiences.

Noting that CA is now part of a wider political agenda with considerable institutional support and willpower (Whitfield et al. 2015), CA is likely to continue as an important technology promoted by donor organisations and governments. In such a scenario, we summarise four common issues raised by respondents across their varied contexts which will need to be addressed if farmer interest in CA is to be progressed to implementation and impact from CA interventions is to be achieved more broadly.

4.1 Addressing the financial viability of CA

CA is known to require inputs, especially to facilitate biomass production and enable production of a sufficient, marketable volume (Vanlauwe et al. 2014), and this concept was confirmed by the perceived requirements of CA as identified by nearly all respondents. Importantly, herbicides were identified by nearly all respondents as of integral importance in reducing the additional burden of weeding in CA systems. Yet nearly unanimously, respondents identified that the perceived inputs required to implement CA were beyond their financial capacity. This reflected limited household financial resources, as well as limited ability to access credit or build financial resources through remunerative markets for farm output. Due to these financial constraints, nearly all respondents implemented low input production systems that limited their demand for inputs and in turn the level of community demand required for functional markets. Giller et al. (2009) highlighted this to be the case for legume markets, but we find this extends for smallholder farming more generally.

To address this, there is a need to amend the adoption pathways for CA which are currently based on adapting the farmer’s financial situation to CA (i.e. through subsidisation). We propose that this be reversed, such that CA be adapted to farmer’s financial situations. Locally adapted adoption pathways based on low cost entry points that incrementally build financial capital and the use of external inputs over time will create greater potential for farmer adoption and ensure more equitable community development and sustainability for promoting organisations. Many respondents also indicated that they were not yet convinced of the viability of commercially oriented production systems as evidenced by a hesitance to increases their input use, and hence, more transitional approaches would allow for trust and confidence to develop over time.

4.2 Reducing stover competition

The majority of respondents in this study confirmed the importance of the competition for limited stover resources as found by numerous other studies (e.g. Baudron et al. 2014; Giller et al. 2009; Valbuena et al. 2012), as well as the need to address the security of stover to facilitate CA implementation (Brown et al. 2017a). The lack of stover resources further extended to the labour resources required to implement CA, particularly in terms of stover importation. Although stover importation is commonly promoted in Africa, the importation of stover was highly undesirable and a key contributor to a lack of implementation or expansion.
In addressing this constraint, there is a need to further develop the uptake pathways for CA regarding: (1) greater production of biomass through improved practices, input intensification and breeding (De Groote et al. 2013); (2) reduced competition for stover resources through diversification of biomass production (e.g. forage crops, fuel wood and agroforestry initiatives); and (3) ensuring stover security from communal grazing practices (especially in Ethiopia, Uganda, Kenya) and from the use of fire by rodent hunters (especially in Malawi, Mozambique and Zambia) through the local development and implementation of by-laws. All of these will involve a wider framing of CA as a farming system beyond the current promotion of CA as a plot-level cropping intervention.

4.3 Reducing labour requirements

A strong perception from respondents emerged regarding the undesirability of CA labour, particularly regarding land preparation and stover importation. Many respondents indicated concerns over the concentration of labour at peak periods where hired labour may be either expensive or unavailable. One pathway to address this may be through the promotion of small-scale mechanisation to reduce the time required for agricultural activities, as has occurred in other small-scale situations such as South Asia and South America (Brown et al. 2017c). There would also be an added benefit in the movement from draught power to small-scale mechanisation, in the reduction in competition for stover residues required to feed draught animals (Baudron et al. 2015). This would require further economic development to occur, noting the limited financial resources of farmers, or could be achieved through stimulating the local service sector to provide for-hire agricultural activities, as has occurred in smallholder systems such as in India.

4.4 Reconsidering information and adoption pathways

In the context of continued promotion of CA with limited perceived benefit and questionable feasibility and relevance, incentive mechanisms have been used to enable farmers to implement CA. Such mechanisms led to the majority respondents identifying their primary interest in CA as the input provision provided by donors. Hence, farmers appear to pursue CA for perverse incentives as opposed to the benefits of adoption itself, as also found by Lukuya et al. (2012) and Nhodlo et al. (2011). This gives weight to the arguments of the counterproductive impact of subsidisation on: community dynamics (Brown et al. 2018d); the promotion of CA and other agricultural practices (e.g. Brown et al. 2018b); the increased likelihood of “pseudo-adoption” (Kiptot et al. 2007); and eventual negative evaluation of CA (Brown et al. 2017a).

Respondents had further reservations regarding the current informational environment and mechanisms used for informational exchange which were important not just for CA uptake, but agricultural development more generally. The majority of respondents identified that they found informational resources difficult to obtain, leading to frustration with informational exchange mechanisms and perceptions of growing inequality within communities. There were also strong assertions regarding the development of jealousy and exclusivity from both lead and non-lead farmers. Such findings confirm a growing body of evidence on the need for deeper investigation of African smallholder informational exchange mechanisms (Diagne 2009; Ngwira et al. 2014; Simtowe 2011; Wellard et al. 2013; Brown et al. 2018e). These issues transcend availability and highlighted key concerns from respondents regarding access, fairness and equality.
Importantly, lead farmers that participated in this study perceived a lack of information and training which is likely to have ramifications for their ability to convince others of the benefits of CA implementation. If lead farmers do not believe in CA (or are perceived not to due to their practice being driven by external providers and a lack of expansion), then this is likely to further impact on other farmers’ perceptions of CA as well. While such findings are a likely reflection of underfunded and overstretched agricultural extension systems alongside a fragmented NGO promotional environment (Brown et al. 2018c), there are further issues that will need to be addressed with farmer-to-farmer systems and current informational exchange mechanisms. These include addressing issues with equality of opportunity, community ownership of CA, participatory development and understanding of the role of lead farmers, which will be integral to increasing the dissemination of information on CA and increasing the number of potential adopters for new technologies (Brown et al. 2017a; Kiptot et al. 2007). This will require further dialogue, potentially as part of a farmer-driven innovation platforms approach (e.g. Schut et al. 2015) that will enable broad dialogue on community development and institutional environments to facilitate a more enabling informational environment.

5 Conclusions

Evaluating farmers in our study have had substantial time to evaluate CA, yet have not progressed their CA activities. This reflected their reservations regarding the overall benefit, feasibility and relevance of CA systems for their livelihoods, highlighting that CA in its current form may not be applicable in the African smallholder context. Noting the institutional support for CA and the likelihood of its continued promotion, there is a need to address four key issues to potentially increase CA uptake: (1) ensuring financial viability; (2) reducing stover competition; (3) promoting small-scale mechanisation; and (4) reviewing informational exchange mechanisms. This will need to be supported through the more flexible and transitional promotion of CA by its components, likely via a disaggregation of the three components of CA and stepwise progression of components over time, slowly increasing both cost of production and financial benefit. This will need to be facilitated through greater community participation in research and extension systems, which are currently perceived as inadequate and exclusive, leading to disharmony and disincentives within communities where CA has been promoted. Overall, if interest in CA is to be based on the technology itself and not perverse incentives, and if that interest is to be progressed to implementation, CA will need to be further adapted to better fit within the contextual realities of African smallholder farming systems.

Acknowledgements Thanks must primarily go to all the farmers who participated in this research. The lead author also thanks the researchers, translators and transcribers who contributed to the interview process. The fieldwork for this study was co-funded by the CIMMYT (PhD studentship) led Maize CRP, with additional support from the CSIRO (PhD studentship) and the University of Adelaide.

Compliance with ethical standards

Conflict of interest The authors declared that they have no conflict of interest.
References


Interest to implementation: progressing CA in Africa


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Chapter Seven: Perspective from Farmers Yet To Evaluate CA

Chapter 7 contains the sixth manuscript of this thesis which qualitatively explores the lack of evaluation of CA by African smallholder farmers yet to obtain information on CA. A summary of the manuscript is provided, followed by the statement of authorship and manuscript 6.

7.1 Manuscript Summary

Figure G: Graphical abstract for manuscript 6.

Context:

- Despite more than five decades of CA in Africa, informational gaps persist leading to limited utilisation of CA within African smallholder communities.

- Whilst some studies have quantified substantial information gaps, few have qualitatively explored with farmers why they exist.

- Understanding informational gaps is limited by a tendency to assume that informational exposure has occurred and non-utilisation of a practice reflects negative evaluation.
Research objective:

- To understand why substantial information gaps exist in African smallholder communities; and
- To identify leverage points to reduce agricultural information gaps.

Methods:

- Semi-structured interviews with 29 farmers who have not obtained information of CA across six countries.
- Application of the Livelihood Platforms Approach (LPA).

Findings:

- Non-exposed farmers were curious to learn about CA, but perceive issues with the access to and availability of informational resources from the community platform.
- Access mechanisms are perceived as non-functional, with frustration expressed regarding exclusivity and assertions that such mechanisms were driving inequality and conflict within communities.
- These issues were underscored by an underlying passivity for information searching and an expectation of resource provision to facilitate CA utilisation.

Implications:

- A disconnect exists between the theory and practice of farmer-to-farmer extension mechanisms in their current form.
- Farmers are yet to adapt to demand driven extension systems, meaning that there is a need for farmer education on the extension mechanisms themselves.
- Farmers are demanding more inclusive extension mechanisms, which will require greater coverage of and funding for extension service providers.
7.2 Statement of Authorship

Manuscript Details:

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<th>Title of Paper:</th>
<th>Why do information gaps persist in African smallholder agriculture? Perspective from farmers lacking exposure to conservation agriculture</th>
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<td>Contribution to paper:</td>
<td>Identification of research gap, theoretical conceptualisation, fieldwork design, fieldwork collection of data, analysis of data, interpretation of results, writing of manuscript, acted as corresponding author</td>
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Co-Author Contributions:

By signing the Statement of Authorship, each author certifies that:

i. the candidate’s stated contribution to the publication is accurate (as detailed above);

ii. permission is granted for the candidate to include the publication in the thesis; and

iii. the sum of all co-author contributions is equal to 100% less the candidate’s stated contribution.

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Why do information gaps persist in African smallholder agriculture? Perspectives from farmers lacking exposure to conservation agriculture

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ABSTRACT

Purpose: To explore why substantial agricultural information gaps persist in African smallholder farming communities and how to reduce them.

Design/methodology/approach: Using conservation agriculture (CA) as a case study, we deeply explore with 29 smallholder farmers why they are yet to obtain sufficient information to enable practice evaluation.

Findings: Respondents asserted that their lack of information on CA was not reflective of a lack of interest in obtaining it, but of the unavailability and inaccessibility of learning opportunities. A deeper analysis revealed an underlying passive approach to seeking information and culture of financial expectancy.

Practical implications: If extension systems are to catalyse broader sustainable intensification, we find the need for emphasis on (1) more inclusive extension mechanisms; (2) education of farmers about demand-driven extension; and (3) revision of direct input provision to lead farmers.

Theoretical implications: While not contesting the value of farmer-to-farmer (F2F) extension systems for those socially connected to lead farmers, we find four research questions for further exploration regarding the practical application of F2F mechanisms that may impede their broader effectiveness, namely (1) Is extension coverage sufficient? (2) Do farmers understand demand-driven extension systems? (3) Do current incentive structures complicate farmer information seeking behaviour? and (4) Do current mechanisms encourage social stratification?

Originality/Value: To date, adoption studies have largely utilised quantitative, econometric lenses that generally assume farmers are sufficiently aware of the technologies in question. Due to our in-depth qualitative analysis, we provide novel insights into how to close informational gaps that hamper efforts to increase the food and livelihood security of African smallholder farmers.

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1. Introduction

Conservation agriculture (CA) has been promoted as a technology to address productivity decline and reduce externalities in agricultural production through the simultaneous application of three sustainable intensification practices: minimum tillage, crop residue cover and legume diversification (Thiombiano and Meshack 2009). CA has been strongly embraced by many African development organisations and governments, which have invested considerable financial and institutional resources in its promotion (Giller et al. 2009). Despite this, recent evidence suggests that the promotion of CA in Africa has not translated into extensive utilisation (Arslan et al. 2014; Brown, Nuberg, and Llewellyn 2017b).

The discourse exploring CA (non-)adoption has mainly focused on agronomic and environmental outcomes (e.g. Mupangwa et al. 2017; Ndah et al. 2014; Pittelkow et al. 2015; Thierfelder et al. 2016; Thierfelder, Bunderson, and Mupangwa 2015) or the applicability of CA to the livelihoods of African smallholder farmers (e.g. Andersson and D’Souza 2014; Giller et al. 2009). There is also a tendency for (project-aligned) studies to focus on achieving ‘adoption’ as understood through exploring how to reduce farmers’ negative evaluation. This has led to conclusions that CA utilisation is hampered by low expected benefit (Hobbs, Sayre, and Gupta 2008), a lack of relevance (Lalani et al. 2016; Van Hulst and Posthumus 2016), feasibility issues including stover availability (Baudron et al. 2014) and weeding and labour (Chauhan, Singh, and Mahajan 2012; Grabowski et al. 2016), a lack of legume markets (Giller et al. 2009), financial constraints (Pedzisa et al. 2015), and institutional arrangements (Rockstrom et al. 2003).

Due to this focus, informational constraints tend to have been overlooked, particularly when exploring CA in eastern and southern Africa (Brown, Nuberg, and Llewellyn 2017b). This is problematic, as recent studies have suggested that information gaps can be a substantial contributor to a lack of CA utilisation in Africa (Brown, Nuberg, and Llewellyn 2017b; Ngwira et al. 2014). Clearly, obtaining agricultural information remains a central and ongoing problem constraining the improvement of farmer livelihoods in sub-Saharan Africa (Ferris and Robbins 2004; Ozowa 1995). As such, questions abound as to why farmers are not being sufficiently exposed to agricultural practices that have been present in African research and extension systems for decades. Where studies
have explored informational gaps in sub-Saharan Africa, they tend to do so at an econometric modelling level and with focus on input usage (e.g. Diagne and Demont 2007; Simtowe and Muange 2013) as opposed to sustained practice changes that are required for the utilisation of CA. The effectiveness of current extension mechanisms, especially farmer-to-farmer (F2F) diffusion systems that serve as the primary information diffusion mechanism in sub-Saharan Africa (Masangano and Mthinda 2012) are also yet to be fully explored (Wellard et al. 2013), and studies that do exist mainly interrogate lead farmers or those connected to extension programmes (e.g. Lukuyu et al. 2012; Mwambi, Kiptot, and Franzel 2015; Tsafack et al. 2015). Hence, there is a need to explore more broadly the functionality of extension mechanisms within the wider community (Brown, Nuberg, and Llewellyn 2017a), particularly through explorations with farmers who are not connected with project-aligned activities and themselves have informational gaps.

To address this void, we utilise a series of semi-structured interviews with non-project-aligned farmers who have not obtained sufficient information on CA to enable them to evaluate it, despite substantial long-term CA extension initiatives occurring in their communities. We explore ‘information gaps’ as the information deficit when a farmer is yet to consider themselves sufficiently aware of a technology to fully evaluate it, as defined in the Process of Agricultural Utilisation Framework (PAUF; Brown, Nuberg, and Llewellyn 2017b). Two farmer typologies are present under this categorisation: (1) farmers who are unaware of a practice (i.e. unawareness); and (2) farmers who are yet to obtain sufficient information to evaluate CA (i.e. unfamiliarity). Our purpose is not to quantify the information gaps that exist but to explore directly with non-exposed farmers two research questions: (1) what are the reasons non-exposed farmers have not obtained any (in the case of unawareness) or sufficient (in the case of unfamiliarity) information regarding CA; and (2) what can be done to close these information gaps?

Using the structured qualitative methodology based on the Livelihood Platforms Approach (LPA; Brown, Nuberg, and Llewellyn 2017a), we focus deeply on a subset of non-exposed farmers to understand the key issues from individual to household, community, and institutional levels to explain their informational situation regarding CA. This qualitative exploration affords unique insights into the functionality of extension systems via farmers’ lived experience. While small in sample size, the in-depth exploration of such experiences affords insights into potential blockages in information delivery systems that may be used to address the substantial information gaps that exist within African smallholder communities.

1.1. Contextualisation

CA was first introduced to sub-Saharan Africa through research systems in the early 1970s (Wall et al. 2014). While originally slow, there has been growing interest in CA over the last two decades, with CA being integrated into several countries’ (especially Malawi, Zimbabwe, and Zambia) national agricultural extension programmes. This has been further supported by large development partners such as the FAO and CGIAR centres which have championed CA as a key pathway towards sustainable intensification, placing CA firmly on the development agenda (Giller et al. 2009).

Despite this, the uptake of CA has remained limited on the African continent. Kassam et al. (2015) identified sub-Saharan Africa as having the lowest uptake of CA of any region.
Brown, Nuberg, and Llewellyn (2017b) quantified this pattern across five African countries and confirmed the limited uptake and utilisation of CA. When focusing on the integral component of minimum tillage, binary adoption was estimated to be extremely limited (Ethiopia: 1%; Kenya: 3%; Tanzania: 14%; Malawi: 3% and Mozambique: 21%). Importantly, a lack of information was found to be responsible for the non-use of minimum tillage for 82% of surveyed Ethiopian, 70% of surveyed Tanzanian, 49% of surveyed Kenyan, and 38% of surveyed Malawian farmers. These figures are also likely to underestimate the informational gaps for CA, given the additional two components that complete the CA package. Similarly, Ngwira et al. (2014) found that a lack of information explained 70% of non-adoption of CA in Malawi, and both Ngwira et al. (2014) and Simtowe (2011) have identified the strong presence of informational gaps for technologies other than CA in these regions.

Functional agricultural extension systems are required to address these information gaps, particularly in enabling both the development and spread of agricultural innovations broadly within communities (Wellard et al. 2013). As quantitative studies continue to point to the occurrence of information gaps (both for CA and other innovations), there are ongoing questions regarding the effectiveness and functionality of current extension mechanisms. Kiptot and Fanzel (2015) asserted this reflected multiple challenges, including limited training materials, high expectations from farmers, limited technical knowledge, transport, farmers’ resistance to change, and inadequate incentives, echoing other studies such as Lukuyu et al. (2012) and Ssemakula and Mutimba (2011). Yet, such studies tend to focus at the institutional level without understanding farmer perspectives. Elias et al. (2016) found that 45% of surveyed farmers in north-western Ethiopia were dissatisfied with extension services; yet, there continues to be only limited exploration of the perspectives of farmers not involved in extension activities. In particular, there is limited understanding within the literature of why some farmers remain unengaged with extension activities and what they feel needs to be done to address their informational gaps. This study addresses this gap.

2. Methods

The theoretical framework applied in this paper is based on the Livelihood Platforms Approach (LPA; Brown, Nuberg, and Llewellyn 2017a). This study specifically aims to understand why farmers have obtained limited informational resources regarding CA at the household level. To do this, we explore three research questions to explain each farmer’s situation:

1. At an individual level, does the farmer want to obtain information?
2. At the community level, does the farmer perceive that informational resources are available and accessible? and
3. At an institutional level, is the farmer influenced by cultural norms that affect information seeking behaviour?

2.1. Study implementation

This paper forms part of a broader investigation of the sustainable intensification of maize-legume farming systems in eastern and southern Africa through exploration of
various perspectives from subsets of African communities (e.g. Brown, Nuberg, and Llewellyn 2017a which explores negative evaluation of CA). In total, the data-set consists of 325 semi-structured interviews conducted in 85 communities across 20 case study locations in six countries (Ethiopia, Kenya, Uganda, Malawi, Zambia, and Mozambique). These interviews were collected as part of a two-stage process. Firstly, case study locations were purposively selected on the basis of (1) the importance of maize-legume systems for farmer livelihoods and subsequent high potential of CA to impact their livelihoods; and (2) the existence of current CA promotional activities in the district for a minimum of six years.

Within case studies, a strong emphasis was placed on obtaining a diversity of farmer and non-farmer perspectives, and as such, this work was not intended to provide a representative sample of communities. Instead, a snowball sampling methodology is applied (Figure 1) to access various farmer and non-farmer typologies, some of which are often overlooked or aggregated within broader classifications of adoption and non-adoption. This is particularly the case for the subject of this study (Farmer Set D – ‘Limited Exposure’). These farmers were primarily selected through referral from other farmers within their communities who identified them as not implementing CA activities due to a lack of connectedness to information sources. In some cases where no referrals were available, a random search of farmers was undertaken within a community, with farmers assessed as to the targeted typology and if applicable asked to participate as respondents.

Figure 1. The classification of respondent sets and snowball methodology employed in this study, as proposed in Brown, Nuberg, and Llewellyn (2017a).
The perspectives of these farmers tend to have had only limited investigation due to a lack of interaction with farmers outside the (often narrow) sphere of influence of development projects and a focus on achieving adoption by project participants. Indeed, these farmers tend to have more than three degrees of separation from extension officers (see arrows in Figure 1) and hence have had only limited qualitative investigation within the literature. In focussing on this subset of farmers, two typologies of farmers are explored:

The unaware farmer: A farmer who holds no knowledge of CA; and
The unfamiliar farmer: A farmer who is aware of the existence of CA but is not confident that they have obtained enough knowledge to evaluate it for their purposes.

As such, this study utilises a subset of 29 respondents from 21 villages in 13 case studies from six countries (Figure 2). All respondents had substantial farming
experience and had lived within their communities for a minimum of three years. In each of the case studies, CA had been promoted for at least six years through government extension services aligned with the CIMMYT-led Sustainable Intensification of Maize-legume Systems in Eastern and Southern Africa (SIMLESA) programme, and in the majority of cases for substantially longer through government programmes. The average length of the interviews was 40 minutes but ranged between 13 and 92 minutes. The ‘Farmer Set D’ interview subset includes 15 hours of interview. Each respondent was assigned an alphanumerical code: a letter signifying the case study and a number signifying the interview order which is used to identify them in the results section (Figure 2).

An interview schedule was developed to provide the opportunity for each respondent to explore why they lacked informational resources, encompassing their individual, household, community, and cultural situation. Written informed consent was obtained from all study participants prior to the interviews. No remuneration was made to these farmers to participate in the discussion. Interviews were conducted primarily in the preferred local language, except in cases where the respondent was comfortable in expressing themselves in English. A translator was used from a local agricultural research station, and was, in the majority of cases, unknown to the respondent. Interviews were digitally recorded and transcribed independently of the translator into English. All transcribed interviews were coded according to the various resource pillars and livelihood platforms of the LPA using Nvivo™ (version 11) content analysis software.

3. Results

There were no obvious quantitative patterns in the characteristics of farmers who were classified as non-exposed, and such exploration is beyond the scope of this qualitative study. While we acknowledge that this study analyses a small data-set and respondents may not be representative of the wider population, there were several themes that were recurrent throughout the lived experiences of respondents. This section identifies and explores these commonalities to form a deeper understanding of the context of informational non-exposure.

3.1. Does the farmer want to obtain information on CA?

Almost all respondents stated they were curious about CA and hoped to obtain information to increase their knowledge (e.g. ‘I just see that people are planting one maize per station and I ask myself why they are doing this? So if maybe we can get trained then I can also try it’ – C5). Only two respondents were not seeking to obtain information of CA due to an evaluation that it did not fit their circumstances, though neither respondent was able to identify what CA involved. These two respondents had assessed that CA was not financially viable for their situation (e.g. ‘I never approached them [lead farmers] because I know I can’t afford to buy a sprayer and herbicides for this type of farming. Even if I went to ask, it would be of no use to me’ – C6). This highlights that while some farmers may not be seeking to obtain information on CA, the majority appear to be interested and a lack of exposure to CA does not reflect individual’s removal from the extension system.
3.2. Does the farmer perceive that informational resources are available?

Responses from farmers were classified into two categories regarding the availability of informational sources in their communities: (1) their existence (or quantity) and (2) their quality.

3.2.1. Quantity of information providers

Respondents identified two key sources of information in their communities: extension officers and lead farmers, with other sources such as the radio rarely identified. Interaction with these sources was limited, with no respondent identifying regular contact with either an extension officer or lead farmer and the majority of respondents never having interacted with either information source. This partly reflected a poor appreciation of how and where to obtain information, both for government extension (e.g. ‘the extension worker comes but I haven’t had an opportunity to speak to him’ – F13) and lead farmers (e.g. ‘We thought he [the lead farmer] was doing his own activities; we didn’t know it was a new project so we didn’t bother to go and see it’ – G8). Specifically, nearly a third of respondents were unaware that lead farmers were tasked with providing information to them and their community (e.g. ‘I could have asked [the lead farmer] but I didn’t know if it was OK for me to do so’ – M7).

The lack of informational providers also reflected limited coverage of extension services, particularly in Uganda and Kenya. In Uganda, farmers identified significant changes to the National Agricultural Advisory Services (NAADS) since 2012, with respondents generally perceiving that extension officers were no longer present in their community (e.g. ‘In a very long time there have been no extension workers. They used to be there long time ago at the sub-county but now they are not there and they never come’ – J2). In Kenya, there was a general perception that while the government provided extension services, they were not active in their community (e.g. ‘They are there, but they just exist in the office and they are not practical … when I was young I could see these people from agricultural office going round giving farmers some information, but this is not the case now’ – E9).

3.2.2. Quality of information from information providers

While many respondents did acknowledge the function of lead farmers as part of the information delivery system, they tended not to perceive them as effective due to their provision of poor quality information. More than one-third of the respondents indicated they did not seek information from lead farmers because they did not feel the information was reliable (e.g. ‘you find some times you ask him some knowledge that he doesn’t have’ – J15; ‘we don’t actually know if they are doing what they were taught or not because they may not do everything right’ – C5). This reflected respondents’ preference for extension officers to provide agricultural information (e.g. lead farmers ‘may miss it unless the person teaching them could teach me’ – F13).

3.3. Does the farmer perceive that informational resources can be accessed?

Respondents identified informational exchange mechanisms as the primary constraint to their access to community informational resources. Emotive language was used by all
respondents to describe their attempts to obtain information, such as 'forgotten', 'worry', 'difficult', 'abandoned', 'hard', and 'struggle'. The primary driver of these concerns was the need for invitation to learning opportunities, which were perceived to be lacking (e.g. 'if they [lead farmers] invite me I will go but they didn't come to ask me' – J16; 'You cannot go somewhere where you are not invited' – E10). This underscored an element of passivity in obtaining information from those within their community (e.g. 'someone should come and invite me. I cannot just go and join a group just because I want to learn' – Y23) and the 'burden' of informational exchange was placed on the lead farmer, and not with the individual (e.g. 'I don't know [how to obtain invitation]. I always hear after they have gone. I am never invited' – Q22).

The majority of respondents further perceived a lack of proactive engagement from the lead farmer in their community (e.g. 'they [lead farmers] have not come out and talked to people to tell them what to do and what benefits they will reap' – E9; 'He [the lead farmer] has never trained anyone in this community and we just hear that he has his own group' – J13). Respondents also tended to perceive lead farmers as actively unwilling to engage with them (e.g. 'I have been asking [the lead farmer] about the new system but he always told us that other people would come to teach us' – G8; 'when I go to [the lead farmer], he gives the phone number to ring someone else' – Q22). Such experiences were common across respondents, suggesting more than a disgruntled minority may exist beyond the study respondents.

This perceived lack of opportunity to learn manifested as jealousy towards lead farmers and those connected to lead farmers (e.g. 'it's like a secret organization because they have their own people and what goes on in that group is done by the group members only' – J13), often because there was a perceived blockage of information reaching the community (e.g. '[the extension officer] passes through and visits the lead farmer and what happens there is not known' – Z11). Overall, there were assertions that these blockages led to a lack of functionality with F2F extension systems (e.g. 'whatever they [group members] get somebody goes there as an individual and leaves there with information as an individual and goes to use it as an individual, so how do the rest of the community benefit from it?' – E9).

The perceived lack of access to lead farmers was often related to the respondents' social connectedness and status within the community (e.g. 'it is difficult because I am not connected with those farmers up there [lead farmers]' – G5). Many of the respondents therefore identified that current approaches were contributing to disharmony within their communities (e.g. 'the projects have taken just a few people. You just help a small group of farmers, not all of us. Unless you have a friend from that group you only benefit very small from it' – E9; 'I feel anger because I see groups adding a lot of value to their lives but I don't have this chance... The problem is you people [projects] come to just a few people. If you just help only a few, then you build up inequality in the same community and you increase theft and these things and it really hurts the community... We want all to benefit and the community to grow, not just a few' – E12).

To address this, respondents clearly indicated a desire for more inclusive informational exchange mechanisms (e.g. 'I think if we all could have been trained it would be better than selecting only a few farmers' – C5). Respondents also identified that they would prefer trainings to be conducted by extension officers, not lead farmers (e.g. 'if trainers come and call farmers to one centre, to mobilise other farmers in one place for trainings, they
can easily change. Coming to specific homes the way they have done it now is not very good’ – J2).

3.4. Is the farmer influenced by cultural norms that affect information seeking behaviour?

3.4.1. Gender norms
Female respondents tended to perceive increased issues with accessing information due to a lack of female lead farmers (e.g. ‘I am not a man. I cannot ask another man. And my husband is not around’ – Y23). Female-headed households also faced access difficulties due to responsibilities that did not allow for them to engage with learning activities (e.g. ‘Sometimes, they invite me when I have not time to attend, because I am the only one at home with the cattle. So I cannot abandon that … I can’t leave’ – Q22). As such, gender tended to moderate access to informational opportunities due to gender roles that limit the opportunity to attend learning activities.

3.4.2. Financial expectancy complicating information seeking behaviour
Despite respondents holding limited informational resources, financial resources were identified by 23 of the 29 respondents as the key requirement for them to implement CA, at a higher rate than for information resources (14 of 29). Eighteen of the 29 respondents directly identified free fertiliser as required to implement CA. Due to this, informational seeking behaviour was often affected by an underlying expectancy for physical and financial resources (e.g. when one respondent was asked when they would be ready to learn about CA, their response was ‘I will when I am ready …. When I am given the inputs’ – D14). This underlying expectancy was connected to the subsidisation of lead farmers within communities (e.g. ‘It pains in a way that they [lead farmers] received free things while we have to buy with our own money’ – C6). Such an understanding of the extension system led some farmers to reduce their information search until physical and financial resources were made available to them.

4. Discussion

4.1. Summary of results

The commonalities in the lived experience of respondents highlight that the current extension services employed by government and development organisations may require further exploration. The majority of respondents in this study were interested in obtaining information regarding CA and had not removed themselves from the diffusion process. Instead, respondents expressed frustration with the availability of and access to informational sources, with the majority never interacting with informational sources. This was either because they were not aware of the lead farmer’s role, because there were limited lead farmers, or because lead farmers were perceived to provide poor quality information. There were further issues with the perceived exclusivity of informational exchange mechanisms, as well as an underlying culture of financial expectation to facilitate informational exchange and a passive approach to information seeking underscored by the burden of
Respondents are interested in learning about CA...
but lack informational resources...
because community resources are perceived to be inaccessible...
and/or have limited presence or quality...
which is further limited by:
- Gender relationships
- A passive approach to obtaining information
- Financial expectation

**Figure 3.** A visual summary of respondent understanding of their informational gaps using the LPA.

informational exchange being placed on the information provider. A visual summary of these results (using the LPA; Brown, Nuberg, and Llewellyn 2017a) is given in Figure 3.

While this study employs a small data-set and wider extrapolation may be difficult, there were common themes that emerged and are potentially representative more broadly within communities. This notion is supported by the similarities in informational resources found by Brown, Nuberg, and Llewellyn (2017a) with farmers who have negatively evaluated CA. That study found that a lack of functionality within informational exchange mechanisms was the primary determinant of their disadoption of CA, due to a perceived lack of availability of informational sources as well as assertions of an inequitable and inaccessible extension system. There were also strong negative perceptions from farmers regarding the subsidisation of lead farmers and the implications for farmer decision-making behaviour. Overall, this suggests that the themes identified in this study may be occurring more widely within farming communities, both for those obtaining and those not obtaining agricultural information.

### 4.2. Implications for F2F extension systems

The movement from Training and Visit (T&V) extension (Feder, Slade, and Sundaram 1986) to demand-driven extension has led African extension services to embrace F2F mechanisms (Masangano and Mthinda 2012). Such mechanisms are based on the underlying assumption that because farmers are known to access information and advice through local networks (Garforth 2011; Rogers 1962), locally based lead farmers can be
used to leverage existing social networks to share knowledge (Braun and Hocde 2000; Mulwafu and Krishnankutty 2012). The results of this study suggest that further investigation of the functionality of F2F mechanisms may be required. We find four key questions for further investigation regarding current extension approaches:

(1) Do the negative perceptions of unavailable and inaccessible extension systems reflect a constraint in functionality or limited coverage within communities?

Respondents clearly identified concerns regarding the availability of and access to informational sources, which was also found by Brown, Nuberg, and Llewellyn (2017a). These concerns primarily manifested in perceptions of jealousy, exclusivity, and bias, noting the lack of social connectivity between respondents and informational sources to facilitate broad dissemination of information within communities. While the theory of F2F extension is that communities learn from their lead farmers, it appears that due to greater than expected social fragmentation, informational blockages may be occurring for a subset of the population. Because of this, respondents perceived that opportunities to learn about CA were not present for them and only made available to lead farmers and their close associates.

Without disregarding the concerns of respondents, the results may imply an overall lack of coverage of extension providers (both officers and lead farmers). African extension systems are perennially underfunded (Akroyd and Smith 2007; Anderson 2007), with extension officers and lead farmers often tasked with the coverage of large, diverse, and dispersed populations, often in the thousands for extension officers and hundreds for lead farmers. Due to this, information providers are likely to limit their area of coverage and this may be perceived by respondents as exclusivity. This was somewhat acknowledged when respondents, particularly in Uganda and Kenya, identified that there was limited availability of extension staff and was further apparent with the potential for gender norms and relationships to moderate access to extension services (i.e. a lack of female lead farmers). In the case of Ethiopia, this may reflect the highly male-dominant workforce in research and extension services (ASTI 2017). As such, the theorised multiplier effect of F2F extension (Blauter and Quintanar 1997; Noordin et al. 2001) may be constrained, and the core problem may not only be the F2F mechanism itself but also the limited coverage that impedes the dissemination of information to the many and diverse range of smallholder farmers. The distinction between mechanism and adequate coverage thus requires further exploration.

(2) Are farmers excluded from extension activities, or are they yet to adapt from a passive information search to demand-driven extension?

Notwithstanding the farmer-identified constraints to information delivery, we find the subset of respondents who remain non-exposed to CA to be relatively passive in their search for information. They placed the responsibility of information delivery on the information provider, rather than themselves. It seems that they have been conditioned by the previous information delivery system of T&V, where the role of extension officers was to seek out and visit individual farmers to deliver information. Under demand-driven extension, farmers are expected to join cooperatives and request training, but our
respondents continue to assume the onus is with information providers to make contact. Some farmers have not learnt the need for, or process of, demanding information during the transition from T&V to demand-driven extension. Similar legacy farmer assumptions were also found by Simpson and Owens (2002). These assumptions also underlay respondents’ preferences for information from government extension and the perceived poor quality of information provided by lead farmers. The distinction between perceived exclusivity and understanding of the informational exchange mechanism hence requires further clarification.

(3) Do current incentive structures complicate farmer information seeking behaviour?

Current promotion of CA through the agency of the lead farmer is based on lead farmers obtaining inputs from development partners to enable them to provide demonstrations of CA in local fields, which is intended to increase awareness and catalyse practice change. However, the responses of farmers regarding the need for input provision highlight that this may affect their information seeking behaviour or at least impact on their early assumptions of the requirements for practice change more broadly. This reflects the issues of the subsidisation of demonstration farmers within resource-constrained environments, where observation of a potentially positive technology may not lead to implementation or further information seeking because it is evaluated, often with limited information, not to be feasible. Indeed, respondents observed that those who wait will be given inputs to enable practice change, and a disincentive is then formed to seek and experiment with the practice in question. In resource-constrained situations, it is thus likely that demonstration without learning will not enable practice change. This is particularly true of CA as a complex set of practice changes beyond input intensification efforts, which current extension systems are designed to promote (Douthwaite, Keatinge, and Park 2001). Such issues have also been identified by Lukuyu et al. (2012), who concluded that there is no intrinsic need to subsidise lead farmers, as the non-financial and indirect rewards should provide the enticement for lead farmers to use and demonstrate a financially relevant technology. If CA is perceived by farmers to require input subsidies beyond the very early stages to decrease farmer risk and cost burden to be widely adopted, it indicates (1) high-quality information is not reaching respondents and/or (2) CA is beyond the financial means of smallholders in its current form. Further understanding is required to understand the impact of this subsidisation on the functionality of current extension mechanisms.

(4) Do current mechanisms encourage social stratification?

The frustration of respondents with the current extension mechanisms highlights the potential creation of a division within communities between the ‘favoured’ and subsidised lead farmers and those not socially connected to them. The majority of respondents expressed frustrations that they were not afforded similar opportunities to lead farmers and did not benefit from the support provided to lead farmers, causing them to change their information seeking behaviour and wait for financial support. In resource-constrained environments, this raises the possibility of creating a social stratification of the ‘favoured few’ who are supported to implement technologies from which they benefit,
while community members unconnected to such opportunities remain in their comparatively unproductive systems and become disenfranchised within, and distrusting of, the extension system. There are also potential ethical concerns regarding how government and donor policy may disrupt community structures and cause conflict and the growth of inequality within communities. Noting the similarities between farmers in this study and those in Brown, Nuberg, and Llewellyn (2017a), further exploration is warranted.

4.3. Study limitations

The approach taken in this study is to engage with farmers who are affected by potential diffusion failure, and in doing so provide them with a voice in the academic discourse. Coupled with the limited sample size, we acknowledge that we cannot rule out that respondents are not representative of their communities or typologies, and may simply be generally disgruntled community members. However, the approach taken attempted to minimise this through a broad discussion about each respondent’s livelihood as opposed to immediately narrowing specifically on the technology or research question.

Furthermore, the continuing identification of potential diffusion failure in African smallholder communities, both for CA and other promoted innovations (e.g. Brown, Nuberg, and Llewellyn 2017b; Ngwira et al. 2014; Simtowe 2011), and the difficulty in accessing subpopulations of non-exposed farmers means that this work should be seen as a building block for further discussion of the effectiveness of current extension systems and pathways to close persistent informational gaps. The validity of such findings may be increased through the pairing of this study with Brown, Nuberg, and Llewellyn (2017a) who found substantial perceived issues with extension systems in the same communities as this study, through the lens of negatively evaluating CA farmers.

Secondly, as this study is focused on non-exposed farmers, it is also possible that the limited diffusion of CA reflects a technology-specific issue. As Kuehne et al. (2017) state, the ability to learn about the relative advantage of the practice is strongly influenced by characteristics of both the practice and the potential adopters, and hence there it is possible that CA is not providing sufficient benefits to implementing farmers and hence they are not passing on information regarding CA. This is supported by the discourse on the benefits, feasibility, and relevance of CA to African smallholder farmers (e.g. Brown, Nuberg, and Llewellyn 2017a; Giller et al 2015; Pittelkow et al. 2015). While the focus of this study did not allow a deeper exploration of the context of CA promotion by lead farmers, the issues identified by farmers tended not to be CA specific (i.e. with respondents identifying very limited interaction with extension beyond CA promotional activities). It is likely that such results point to systematic issues with extension mechanisms that may be further exacerbated by CA-specific issues that make lead farmers reluctant to promote CA. This theory is supported by multiple studies that have identified substantial informational gaps beyond CA, and hence the recommendations made in this study would apply not just to CA but wider systemic issues.

5. Conclusions

In our study, the subset of non-exposed respondents desired information about CA, yet asserted they were unable to obtain such information. They attributed this to a lack of
availability, access, and quality of informational resources beyond their household livelihood platform. We find further elements of passive information seeking behaviour and financial expectation for the provision of inputs. While this study has a limited sample size, the findings provide key insights into why information gaps exist, as well as the basis for further exploration of the functionality of current extension systems. Specifically, we identify four key research questions for further investigation: (1) Do the negative perceptions of unavailable and inaccessible extension systems reflect limitations of the mechanism or limited coverage within communities? (2) Are farmers excluded from extension activities, or are they yet to change from a passive information search to demand-driven extension? (3) Do current incentive structures complicate farmer information seeking behaviour? and (4) Do current mechanisms encourage social stratification? These issues may be been previously overlooked due to a lack of investigation of current extension mechanisms with those who are not project aligned or connected to lead farmers. While this study is not contesting the value of F2F systems for individuals socially linked to lead farmers, it does highlight the perceptions and issues of others in the broader community. These primarily relate to exclusivity, distrust and expectancies of financial support. Such perceptions confirm the need for deeper research into how to structure effective and equitable extension systems for the African context.

6. Geolocation information

This work was conducted in Ethiopia, Kenya, Uganda, Malawi, Mozambique, and Zambia. The corresponding author resided in both Ethiopia and Malawi for this research. The co-authors reside in Australia.

Acknowledgements

Thanks must primarily go to all the farmers who participated in this research. The lead author also thanks the researchers, translators and transcribers who contributed to the interview process. The fieldwork for this study was co-funded by the CIMMYT-led Maize CRP, with additional support from CSIRO and the University of Adelaide.

Disclosure statement

No potential conflict of interest was reported by the authors.

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Notes on contributors

Brendan Brown completed his PhD at the University of Adelaide, Australia. His PhD explores the sustainable intensification of smallholder agriculture across eastern and southern Africa. His research interests focus on ensuring that the fruits of agronomic research are able to be utilised by smallholder farmers.
Rick Llewellyn is a farming systems scientist and Research Group Leader with CSIRO’s Agriculture Flagship based at the Waite Campus in Adelaide. Rick’s research bridges farming systems field research, strategies for technology adoption and agricultural economics.

Ian Nhuberg identifies as a ‘generalist’ working across a range of disciplines within agriculture and natural resource management. His focus is primarily agroforestry and then agricultural extension, particularly in the context of developing countries. He is based at the University of Adelaide with extensive field experience in Nepal.

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References


Chapter Eight:
Perspective from Extension Service Providers

Chapter 8 contains the seventh manuscript of this thesis which qualitatively explores the perspectives of agricultural extension service providers on CA utilisation by smallholder farmers. A summary of the manuscript is provided, followed by the statement of authorship and manuscript 7.

8.1 Manuscript Summary

Figure H: Graphical abstract for manuscript 7.

Context:
- CA is a complex and knowledge intensive production systems, making extension services critical to enabling utilisation by smallholder farmers.
- The perspectives of those providing extension services are limited in the literature, despite their importance in facilitating utilisation.
Research objectives:

• To explore the commonalities exist across communities that culminate in limited intensity of CA activities by non-mechanised smallholder farmers across eastern and southern Africa; and

• To understand what is required to enable extension systems to facilitate wider dissemination and drive farmers towards greater intensity of utilisation of CA by smallholder farmers.

Methods:

• Semi-structured interviews with 76 extension service providers across six countries.

• Application of the Livelihood Platforms Approach (LPA).

Findings:

• The limited intensity of utilisation of CA generally reflects broader issues with the transitioning of farmers from subsistence to market oriented production systems.

• Farmers tended to have limited interaction with the community platform, yet CA requires greater reliance on community resources and enabling institutional environments.

• Many of the constraints to CA utilisation reflect a lack of participatory adaptation of CA to local contexts (especially regarding stover resources and security, functionality of input systems, financial viability and the undesirability or unavailability of labour).

• This reflects the continued use of top-down extension mechanisms that have focused on adaptation of context to technology through subsidies, which has led to a culture of financial dependency and limited effectiveness of current extension mechanisms.

Implications:

• To enable farmer intensification of CA utilisation and sustainable intensification of African smallholder systems more generally, there is a need for: 1] review of the policy context for CA to provide a mandate and funding for CA promotion (i.e. enabling environment); and 2] a more flexible and participatory approach to CA adaptation through a more pragmatic framing of CA within a systems context (i.e. flexibility).
## 8.2 Statement of Authorship

**Manuscript Details:**

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<th>Constraints to the utilisation of conservation agriculture in Africa as perceived by African agricultural extension service providers</th>
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<td>Publication Status:</td>
<td>Published</td>
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  [https://doi.org/10.1016/j.landusepol.2018.02.009](https://doi.org/10.1016/j.landusepol.2018.02.009) |

**Principle Author:**

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<th>Brendan Brown (Candidate)</th>
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<tbody>
<tr>
<td>Contribution to paper:</td>
<td>Identification of research gap, theoretical conceptualisation, fieldwork design, fieldwork to collect data, analysis of data, interpretation of results, writing of manuscript, acted as corresponding author</td>
</tr>
<tr>
<td>Overall percentage:</td>
<td>85%</td>
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<td>Signature:</td>
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**Co-Author Contributions:**

By signing the Statement of Authorship, each author certifies that:

i. the candidate’s stated contribution to the publication is accurate (as detailed above);

ii. permission is granted for the candidate in include the publication in the thesis; and

iii. the sum of all co-author contributions is equal to 100% less the candidate’s stated contribution.

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<th>Contribution to paper: Supervision, evaluation and editing of the manuscript</th>
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Constraints to the utilisation of conservation agriculture in Africa as perceived by agricultural extension service providers

Brendan Browna,b,* Ian Nuberga Rick Llewellynb
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ARTICLE INFO

Keywords: Conservation Agriculture, CA, Adoption gap, Qualitative assessment, Africa, Information gap, Farmer to farmer extension.

ABSTRACT

Conservation Agriculture (CA) is a knowledge-intensive set of practices which requires substantial access to functional agricultural extension services to enable utilisation. Despite this importance, the perspectives of those providing extension services to smallholder farmers have not been fully investigated. To address this, we qualitatively explore the perspectives of agricultural extension providers across six African countries to understand why uptake of CA has been limited, as well as the institutional changes that may be required to facilitate greater utilisation. Across the diversity of geographical, political and institutional contexts between countries, we find multiple commonalities in the constrained utilisation of CA by smallholder farmers, highlighting the difficulties non-mechanised subsistence farmers face in transitioning to market-oriented farming systems such as CA. The primary constraint relates to the economic viability of market-oriented farming where farmers remain in low input and low output systems with limited exit points. The assumed exit point used by CA programs appears to have led to a culture of financial expectation and reflects a continuation of top-down extension approaches with inadequate modification of CA to the contextual realities of subsistence farmers. If African agricultural systems are to be sustainably intensified, we find a need for greater flexibility within extension systems in the pursuit of sustainable intensification. If extension systems are to persist with CA, it will need to be promoted through more transitional pathways that disaggregate the CA package, and with that there is a need for the provision of a mandate to, and necessary funding for, more participatory extension services.

1. Introduction

Sub-Saharan Africa is the most food-insecure region of the world, with the rate of undernourishment in eastern Africa reaching 31.5% (FAO, 2016). Part of this problem relates to limited agricultural productivity growth (Steen et al., 2013). Paired with substantial population growth (Mountford and Ruparelia, 2016), African cereal demand over the next three decades is expected to more than double (van Ittersum et al., 2016) and will need to be addressed without further land degradation (Bui et al., 2009) and in a more variable climate (Jones and Thornton, 2003).

Conservation agriculture (CA) has been proposed as a diversified production system to address these issues via three principles: minimum tillage, stover cover of the soil and legume diversification (FAO, 2014). CA has been at the forefront of research efforts to increase the sustainability and productivity of African smallholder farming systems (Whitfield et al., 2015), with more than five decades of research undertaken in the African context (Wall et al., 2014). While there remains ongoing debate about the benefits and relevance of CA to African smallholder farmers (e.g. Pittelkow et al., 2015), the drive for CA promotion remains both strong and politicised (Whitfield et al., 2015). Despite this, utilisation by African smallholder farmers remains limited (Andersson and D’Souza, 2014; Brown et al., 2017; Giller et al., 2009).

To understand this limited uptake, the literature has been dominated by econometric studies that investigate the benefits accrued to farmers from agronomic, environmental and economic perspectives (e.g. Arslan et al., 2014; Bekele and Dracke, 2003; Kihanga et al., 2015; Ngoma et al., 2015; Pedrazza et al., 2015; Pittelkow et al., 2015; Wall et al., 2014). Such methods often do not identify underlying causes and mechanisms for limited adoption and tend to lack depth in the understanding of constraints (Andersson and D’Souza, 2014). They also tend to assume that non-adoption reflects negative evaluation by farmers, overlooking constraints to farmers in obtaining information (Brown et al., 2017b) and leading to only limited investigation of the functionality of informational exchange mechanisms (Wellard et al., 2013). There are limited examples of different approaches taken to explore these issues, such as Nilah et al. (2014) with the proposal of the
Qualitative expert Assessment Tool for CA adoption in Africa (QaToCA) which aimed to highlight the relevant factors influencing the potential adoption of CA. In that study, integral constraints were found at the community and institutional levels, yet the constraints identified were not further explored. Indeed, there has generally been limited exploration of African perspectives to understand the feasibility and relevance of CA within local communities (Giller et al., 2009). Exceptions to this include the exploration of farmer perspectives on CA uptake by negative evaluators (Brown et al., 2017a), positive evaluators (Brown et al., 2018a) and those unable to obtain information on CA (Brown et al., 2018b), as well as local African researchers on CA (Brown et al., 2018c). These studies found important constraints within agricultural extension systems in eastern and southern Africa, including strong perceptions of a lack of availability and access, yet these issues remain unexplored from the perspectives of those implementing extension programs. As the implementation of CA systems is knowledge-intensive (Beltrán and Rochefort, 2014), there is a clear need to explore these perspectives to understand both the reasons for limited CA uptake and more broadly the functionality of current extension mechanisms.

To address this void, this study uses CA as a case study to understand the functionality of current extension systems. This is done through deep qualitative exploration of the perspectives of extension service providers from six countries in eastern and southern Africa. Extension service providers continue to be the main conduit for agricultural information within rural African communities and their experiences and perspectives are integral to understanding the current status of CA utilisation in eastern and southern Africa. In doing so, we note that each individual community in this study has a unique context for CA utilisation, as does each individual farmer. Whilst acknowledging this, our paper aims to explore common factors that exist across communities.

Although Knowler and Bradshaw (2007) concluded that there are few if any universal variables to explain adoption, they excluded regions where non-mechanised farming was practiced and did not include any studies from eastern and southern Africa. There is therefore justification to explore commonalities within the non-mechanised smallholder systems of eastern and southern Africa. As such, we explore the research question: what commonalities exist across African smallholder

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<td>Village</td>
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<td>Village</td>
<td>Type 2</td>
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<td>Type 1</td>
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<td>Kululu (M)</td>
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<td>F2</td>
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**Fig. 1.** Location and classification of respondents (map courtesy of Google Maps, 2017).

<table>
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<tr>
<th>Type 1</th>
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<th>Type 2</th>
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communities in eastern and southern Africa that limit the utilisation of CA, as perceived by extension service providers? Due to our in-depth qualitative analysis of the perspectives of extension service providers, we provide a uniquely broad analysis of the community and institutional environments that impact on the utilisation of CA, and identify leverage points for the broader sustainable intensification of small-holder farming across eastern and southern Africa.

2. Methods

2.1. Study implementation

This paper is part of a wider investigation of the sustainable intensification of maize-legume farming systems in eastern and southern Africa, including the exploration of various farmer (see Brown et al., 2017a; 2018a; 2018b) and non-farmer (Brown et al., 2018b) perspectives. In total, 325 semi-structured interviews were conducted in 85 communities across 20 case study locations in six countries (Ethiopia, Kenya, Uganda, Malawi, Zambia and Mozambique). Case study locations were purposely selected for: 1) the dominance of maize-legume systems for farmer livelihoods; 2) the high potential for CA to create positive benefits within the community; and 3) the presence of active government activities promoting CA for at least six years. For respondent selection, the government agricultural extension supervisor responsible for the case study was first approached. Subsequently, interviewers were directed to a field officer currently tasked with implementing CA activities, other field officers not currently tasked with CA activities and any NGOs that were implementing CA activities in the case study area. In total, 76 respondents were interviewed. Each respondent was assigned an alphanumeric code: a letter signifying the case study and a number signifying the interview order (Fig. 1).

2.2. Theoretical framework

An interview schedule was developed to provide the opportunity for each respondent to explore the context of their extension activities and the limitations for constituents in their community in utilising CA. The interview schedule was based on the Livelihood Platforms Approach (LPA) proposed by Brown et al. (2017a). The LPA provides a framework for qualitative research to explore the uptake of agricultural technologies embedded within the wider community and institutional context. Livelihood selection is explored through discussion on four resource pillars (physical, financial, human and informational) that support various livelihood platforms. The LPA can be viewed as an evolution of the successions livelihood approach (Cairney, 1998), but with a hierarchical structure of platforms which build on each other, similar to Nizamendiokhodayeva (2007). As the respondents were asked to comment at the community level, the ‘individual’ platform of the LPA was not explored, and thus a slightly modified LPA was applied in this study (Fig. 2).

The semi-structured interview schedule explored the four LPA resource categories at various platforms using the following structure: Interest of farmers in new technologies generally; engagement with market-oriented farming; farmer perceptions of CA; personal perceptions of CA; issues with CA implementation; enabling environments for CA implementation; information flows and the functionality of information delivery systems; influence of government policy; institutional confusion on CA; harmonisation with other extension services; and future directions for fostering utilisation of CA.

Interviews were conducted in the preferred language of respondents with a translator from a local agricultural research station. Audio of the interviews was digitally recorded and independently transcribed into English. The average length of the interviews was 40 min, but ranged between 13 and 92 min. The interview subset for this paper includes 55 of interview. All transcribed interviews were coded according to the various elements of the LPA using Nvivo® (version 11) content analysis software.

3. Results

While respondents were generally positive regarding the agronomic benefits of CA utilisation, they tended to hold strong reservations about the likelihood of uptake of CA by farmers in their communities. Despite the geographical, political and institutional diversity of the case studies, ten themes were identified by more than half of respondents (Table 1). As many of these themes are interrelated, they are explored via the four LPA livelihood resources. Importantly, the majority of the identified themes are not specific to CA, but apply to farming systems change more generally.

3.1. Physical resources

Respondents strongly indicated that the resources required for CA implementation were not available at the community platform, especially in regards to agronomic inputs such as hybrid seeds, chemicals (particularly herbicides) and CA equipment (e.g. “Not many of the agro dealers are stocking CA equipment” – Z14). Even if inputs were available, there were often issues with quality (e.g. “They always find it difficult to get genuine agricultural chemicals...it doesn’t work on your field because there might be some counterfeiting” – G13), quantity (e.g. “The problem is the volume. They might want 2 or 3L of herbicides, but they will only sell in 20 L [at the trading centre]” – Y21) and/or reliability (e.g. “There is a lack of reliability and timely delivery. Some years the government will supply, and some years it will not, it is always intermittent... input supply, especially for herbicides, it is not very reliable” – P1). Overall, there were common assertions that inputs were not readily available (e.g. “We would be helped if herbicides were found easily here as well as new seed varieties. Farmers only see them in the demonstration plots but they can’t purchase because they are not available in the market” – U2).

Such issues were further reinforced in regards to stover resources. While there were some issues with household-level availability of stover resources (e.g. “Biomass is at a minimum. The farmers have been failing to grow enough stalks to cover the soil” – D10) and subsequent competition for crop residues (especially for livestock feed, fuel wood and tobacco production), respondents most strongly identified issues at the institutional platform, specifically with the security of stover.
Table 1
Key themes identified by more than half of respondents as constraining CA utilisation.

<table>
<thead>
<tr>
<th>#</th>
<th>Constraint identified by respondents</th>
<th>Respondents</th>
<th>Resource</th>
<th>Section</th>
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<tr>
<td>1</td>
<td>Financial expediency and handout culture</td>
<td>80%</td>
<td>Financial</td>
<td>3.2</td>
</tr>
<tr>
<td>2</td>
<td>Limited household financial resources</td>
<td>76%</td>
<td>Financial</td>
<td>3.2</td>
</tr>
<tr>
<td>3</td>
<td>Confusing and confusing informational environment</td>
<td>67%</td>
<td>Informational</td>
<td>3.4</td>
</tr>
<tr>
<td>4</td>
<td>Stover security when residue retention is practiced</td>
<td>64%</td>
<td>Physical</td>
<td>3.1</td>
</tr>
<tr>
<td>5</td>
<td>Limited information reaching farmers</td>
<td>64%</td>
<td>Informational</td>
<td>3.4</td>
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<tr>
<td>6</td>
<td>Labour resources required to implement CA</td>
<td>63%</td>
<td>Human</td>
<td>3.3</td>
</tr>
<tr>
<td>7</td>
<td>Economic viability of current farming systems</td>
<td>61%</td>
<td>Financial</td>
<td>3.2</td>
</tr>
<tr>
<td>8</td>
<td>Limited coverage of extension services</td>
<td>59%</td>
<td>Informational</td>
<td>3.4</td>
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<td>9</td>
<td>Competing uses for stover resources</td>
<td>50%</td>
<td>Physical</td>
<td>3.1</td>
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<tr>
<td>10</td>
<td>Non-functional input markets</td>
<td>50%</td>
<td>Physical</td>
<td>3.1</td>
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</tbody>
</table>

Respondents stated that there were many threats to stover security in CA fields, such as communal grazing, wildfire, rodent hunting, theft, the boredom of children in starting fires, termites and jealousy that meant that retaining stover was a risky endeavour. This led many farmers who had retained stover to become demoralised (e.g. “We find after the farmers have done the mulching, the livestock go there and do the damage by eating the crop residues. Then there is the issue of the bushfires, and then the children who hunt the mice. You will find that they have burned the whole area in which the farmer mulched, so it is very disheartening” – F10). Therefore, even if CA was a desirable practice, the community and institutional conditions required to implement CA were absent.

Respondents identified that due to the community and institutional contexts, most farmers utilising CA tended to limit (due to limited market accessibility) or modify (due to lack of stover security) their CA activities. In the case of modification, this tended to occur via either incorporation of stover (e.g. “Farmers feel it’s safer for them to incorporate their stover rather than leaving it on top. This saves it from burning and from others feeding their livestock” – C1) or periodic stover removal (e.g. “Some farmers take their stover and store it until after planting time [when there is no more communal grazing] and then bring it back, so that is their idea of keeping the stover in the field” – U7).

When asked to explore how they believe extension systems should overcome the challenges of physical resource limitations, respondents tended to focus on stover security issues rather than market functionality which they did not see as to be addressed from within extension systems. Two key pathways identified regarding stover resources: 1) Stronger integration of CA at the farm level (e.g. “Regarding the crop-residue retention, there needs to be other options to replace these residues like increased options for forage” – P1); and 2) Implementation of strong local bylaws (e.g. “Farmers complain that their local leaders don’t take a part in the system and so they won’t do CA without bylaws, which the chiefs need to make” – K14), although where such laws existed enforcement was also an issue (e.g. “We met the local leaders so they could provide some help, but we found that the local leaders are very weak. Even the people don’t accept whatever the chief is saying” – F10).

3.2. Financial resources

Respondents strongly asserted a mismatch between the financial requirements of CA and the general financial capacity of farmers in their communities, with a majority of farmers in their communities trapped in cycles of "low input, low output" production systems (e.g. "farmers don’t have money as they don’t yield enough for the market so they have no income" – Y21). Farmers were perceived to be unable to afford systems such as CA, due to an increase in input usage (e.g. "CA is the system of buying seeds and herbicides. When you talk to farmers, they mention the cost of inputs as too high" – Y9), further hampered by a lack of pathways to access and build financial capital. This problem was exacerbated by a lack of remunerative markets (e.g. “Farmers grow for market and then after doing it they don’t have a market to sell to so it discourages most of the farmers... mostly of them are very reluctant to engage [in CA] because of the market issue” – Q24), sometimes combined with unintended disincentives provided by government policies such as in Zambia (e.g. “Many farmers stopped legumes and concentrated on maize, as they are assured the government will buy maize and the government does not buy legumes” – Z14). Consequently, credit systems tended to be non-functional (e.g. “The problem is in their income level. The price of the crop, for example maize, is very low as compared to the price of the inputs. As a result, they were unable to repay the credit” – H9). There were also further issues with the provision of credit, such as high interest rates, late distribution past planting time, collateral requirements (e.g. “Credit is difficult, as the banks require high collateral, and this is not usually available for most smallholder farmers so there is no framework for credit because there is no capital and no collateral” – P1), and fear of embarrassment (e.g. “Farmers are averse to taking credit, they fear it... Collectors come and embarrass the farmer and auction their things” – Q4). There was also a tendency for credit to be politically aligned, leading to limited repayment (e.g. “Farmers knew credit was a political move to gain votes and not a loan. So a lot of people didn’t repay... The problem is it is political motivation” – N6).

While collectivism is often promoted as a pathway development, respondents often identified issues with communal trust (e.g. "If the farmers organised themselves in groups to sell collectively, it would not be difficult. But they don’t trust each other. They think ‘if they join, someone will use their money, so they will lose with the collective’ " – C1). Instead, promotional activities often provide inputs directly to farmers to enable adoption, yet respondents strongly asserted this has led to a culture of financial expectation (e.g. “They say ‘if you want us to try this new technology, we also need to be assisted’. If they are not assisted then they deny the technology and say ‘Is it only for those who receive the free inputs’ – M2; “They won’t listen to me unless I give them something”, which is the trend of dependence, that if that farmer has been chosen to do this, then he or she expects to be given an input” – D4). Such issues had several consequences for the role of agricultural extension officers in disseminating information and facilitating continued adoption of CA (Table 2).

The development of this underlying mindset was attributed to two key determinants:

1) The historical provision of inputs
   e.g. “There is a history of handouts and that spirit of getting handouts has been instilled in those farmers. If I am not doing this I will still receive from someone or the government or an NGO” (D4); and
2) The politicisation of input provision
   e.g. “The subsidy has altered the minds of the farmers... this is political equipment, so it has changed the mindset of the farmers to wait for subsidies... it’s more to win the votes, not to win the yields” (C1).
Table 3
Respondents’ identification of complications in their role due to input provision.

<table>
<thead>
<tr>
<th>Problem</th>
<th>Representative quotation</th>
</tr>
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<tbody>
<tr>
<td>Sharing of extension officers</td>
<td>“It (subsidisation) hampers the extension officers because if farmers do not receive something they will turn away from the extension officer. It creates so much trouble”</td>
</tr>
<tr>
<td></td>
<td>“These NGOs provide farmers money to attend the trainings, but as government officers we use the same farmers. They say ‘you are stealing our money, the same very activity we get something from NGOs, what about you?’ So there is tension and very antagonistic issues.”</td>
</tr>
<tr>
<td>A lack of ownership of CA</td>
<td>“If you give it free, then they don’t see their contribution... If you are not careful, they will not even maintain the trials as they say that it is not mine, it is yours”</td>
</tr>
<tr>
<td></td>
<td>“By giving the farmers inputs, they say ‘this is a project and therefore whatever done here is not mine’. So ownership and empowerment is not there”</td>
</tr>
<tr>
<td>Perceptions of excludability</td>
<td>“Farmers think that CA is only for those people who are being given the inputs”</td>
</tr>
<tr>
<td></td>
<td>“There are two levels and some distrust between lead farmers and other farmers. So lead farmers and inputs are strongly linked and it is not good”</td>
</tr>
<tr>
<td>Creation of diversity</td>
<td>“There was a lot of Jacknays, because they say the lead farmer has got all the inputs and the work suit and they would talk badly against that lead farmer”</td>
</tr>
<tr>
<td></td>
<td>“You know some farmers see the project that was supporting has gone away, they see that the support has stopped, they just go away. They were there for the inputs”</td>
</tr>
<tr>
<td>Creation of disincentive for (continued) adoption</td>
<td>“(Subsidised inputs) are a third of the agro vet price. So they will no longer buy an agro vet”</td>
</tr>
<tr>
<td></td>
<td>“You see some farmers see the project that was supporting has gone away, they see that the support has stopped, they just go away. They were there for the inputs”</td>
</tr>
<tr>
<td></td>
<td>“You can see a lot of people adopting because they have a mindset that they will receive some inputs or chemicals or sprayers to do that, but if they see they are not provided anything, then they will lag behind”</td>
</tr>
</tbody>
</table>

3.3. Labour resources

Respondents tended to identify difficulty in promoting CA systems in their communities because such systems did not align with farmer realities. For example, there was a strong perception that CA systems increased the concentration of labour activities, yet additional labour was often limited at peak times (e.g. “The labour here is diminishing at a very high rate because the young people who are capable of digging, most of them are going to be employed elsewhere running their own businesses like motorcycle taxis, so the labour is very constrained” – E4). Conversely, in cases where there was promotion of CA as a labour reducing technology, there were potential shortages of labour due to the communities’ refusal to work on CA fields (e.g. “They say, ‘if you increase the (CA) acreage, where are we going to find work’? Because if you mulch, there is no weeding, there is no piece (casual) work. It reduces the labour, so people are unhappy and set fire to their fields, so the soil is bare, the weeds will come and they can obtain work” – N6). These issues, paired with the overall undesirability of early basin preparation in the dry season (e.g. “It is very challenging to convince the farmer that this is the time... the sun is hot and the ground is hard” – Q8), stover importation (e.g. “The issue is about perception and farmers say it is tiresome to carry stalks from the field” – D12) and a preference for drought land preparation (e.g. “They will not appreciate you if you turn them back (from animal tillage) to hoes” – G14) meant that promotion of CA remained complex for extension service providers.

3.4. Informational resources

Respondents strongly identified information shortages within their communities and that extension messages were not reaching community members (e.g. “There are a lot of people, and some have the potential and ability, but they are lacking the correct extension messages” – D4). The primary reason for this was attributed to the large area of responsibility of extension officers (e.g. “Look at the staff to farmer ratio. It is not very good, it’s too big... meeting with 1600 farmers is not something that can be done easily” – N12), and this was reflected in the average number of households of responsibility per respondent, averaging 6269 households and by country: Ethiopia – 963; Zambia – 1232; Malawi – 2024; Mozambique – 3636; Eswatini – 9353; and Uganda – 72500.

In each country, there was continued identification of a general lack of funding for extension services (e.g. “The government wishes that every village should have a demonstration plot but since finances are hard, they can’t manage to train more extension staff” – U1). This had implications for the activities officers were able to provide (e.g. “The resources are not there. If the resources could increase we can have more lead farmers, more training, more communities involved, more extension workers, more tours. Then I think adoption can be there” – F16), with mobility the most commonly cited consequence (e.g. “I find the problem of reaching everybody and that is why the adoption rate of CA may be difficult because we don’t reach everybody. It means that I have a transport problem on my side” – T3). When this occurred, there were also issues with the perceived respect from farmers (e.g. “As you can see the area is very big and then within my section we have NGOs, and each of them is on a motorbike. When they see you cycling and someone is on a motorbike, even if you are speaking the same language, they look at you as a very junior person, the respect is to the motorbike man” – K19). Overall, this led to an acknowledgement that field officers were limited in the implementation of their activities (e.g. “It’s us to blame, we need to do more sensitisation” – X5) and could only reach a small proportion of their community (e.g. “At the moment the farmers we are reaching to are quite minimal” – J9).

In attempting to address this, all respondents implemented farmer-to-farmer extension approaches to facilitate greater reach (e.g. “We cannot reach each and every farmer, as it is very difficult. The lead farmer assists us to upscale the number of farmers we can reach” – D3; “We also work with clubs that have their own demonstration plots. I use the clubs because I can’t manage to visit each and every farmer” – U12). However, there was also an acknowledgement of limited coverage with these approaches (e.g. “It is possible if you have enough lead farmers, but at the moment I don’t have enough, there are very few” – R1). Only one respondent identified they had sufficient lead farmers to have a lead farmer: follow farmer ratio below 1:50, and 60% of respondents identified a ratio of above 1:170. Beyond coverage, various other constraints and unintended outcomes regarding farmer-to-farmer systems were also identified (Table 3).

Respondents also strongly asserted that a confusing informational environment existed for both them and the farmers in their communities (e.g. “We are sending all this different information to farmers and we might confuse them. Then we are complaining they are not adopting but it is because we are confusing them!” – D11). This confusion stemmed from several conflicts within and between information providers (Table 4).

Due to a lack of policy direction and clarity, respondents perceived a lack authority to promote CA (e.g. “CA is not a policy so we are not able to tell farmers to do CA, as it would be outside our mandate... If it was in policy we could talk with authority” – Q4; “If the government could incorporate CA in its policy, it would really help, because everyone will...”
Table 3
Respondents issues identified with the farmer-to-farmer extension system.

<table>
<thead>
<tr>
<th>Issue</th>
<th>Representative quotation</th>
<th>ID</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nepotism in community selection</td>
<td>“If we ask how this lead farmer was selected, you will find that it was in the hands of the local leaders who chose them. They are looking at their interest, the relationships they have and their own benefit”</td>
<td>N12</td>
</tr>
<tr>
<td>Size of trials</td>
<td>“The kind of demonstration we do just 5 m by 5 m or 10 m by 10 m and then we extrapolate the yields and other thing. The farmer doesn’t visualise it and then the others assume if it is a small plot and that is it a toy”</td>
<td>Z15</td>
</tr>
<tr>
<td>Limited lead farmer knowledge</td>
<td>“Lead farmers are only taught on part of it, they know what they are doing practically, but to a certain extent you will find they cannot use the knowledge to indicate something else on the trial… They are not able to teach others”</td>
<td>Q4</td>
</tr>
<tr>
<td>Unfair perceptions</td>
<td>“Other farmers still think that it is unfair and lead farmers just do it for a compensation of resources”</td>
<td>N34</td>
</tr>
<tr>
<td>Engagement of lead farmers</td>
<td>“Currently, the selection of farmers is biased towards one group and not good. Only model farmers are benefited mostly. It is better to create a group that comprises all and train them that way”</td>
<td>E11</td>
</tr>
<tr>
<td>Understanding of mechanisms</td>
<td>“They don’t go and train other farmers, because you tell them we are doing this because they are to train the other farmers, but they don’t go and train the other farmers”</td>
<td>H4</td>
</tr>
<tr>
<td>Community cohesion</td>
<td>“You don’t understand really what we are trying to do”</td>
<td>H5</td>
</tr>
<tr>
<td>Cost of membership</td>
<td>“If you come to a group, there is a contribution which a group collects weekly but to get money for contributing is a problem”</td>
<td>X4</td>
</tr>
</tbody>
</table>

know it. If it is against policy it can’t work” – C1).

In terms of the best messaging for CA, respondents identified a desire for a more flexible approach to CA (e.g., “CA sounds too complex. So for simplicity, take the minimum tillage as the first step and in the second season the residue cover and the rotation. Step by step works as the best strategy” – Q8; “We have the three principles. If we go for all of the principles together there is too much change and farmers struggle. So I think we need to promote CA principle by principle and gradually they can change. Start with the cover crop first, the next time we can then teach them rotation. Then the cover works with minimum tillage and rotation and manure application, these can follow. We can’t make all the change at once” – K1).

4. Discussion

While the findings of this study confirm various contributors to the CA adoption gaps found by other studies, such as limited stover availability (Baudron et al., 2014), the unsustainability of labour (Chuamen et al., 2012; Grabowski et al., 2016); a lack of legume markets (Giller et al., 2009); and financial constraints (Foster and Rosenzweig, 2010; Langvintus et al., 2010; Suri, 2011), the unique contribution of this study is in the findings of commonality across diverse countries regarding community and institutional constraints that are non-specific to CA. These are important as they will limit not only the uptake of CA, but the broader efforts to affect farming systems change.

These constraints can be broadly summarised as a lack of supportive community and institutional platforms, such that farmers continue to implement non-mechanised smallholder subsistence livelihoods with only limited application of resources from the community platform. In practice, this culminates in a cycle of low input-low output (LIIO) agriculture that perpetually restricts farmers’ output and income, as also identified by Tronqué et al. (2011) and Xiaoyan et al. (2012).

Without the generation of sufficient income to meet basic needs and invest in agricultural activities, communities have limited desire or ability to implement market oriented production systems. This lack of connectedness is visualised in Fig. 3, wherein the household is ‘floating’

Table 4
Conflicts in messaging that may confuse farmers as identified by respondents.

<table>
<thead>
<tr>
<th>Issue</th>
<th>Representative quotation</th>
<th>ID</th>
</tr>
</thead>
<tbody>
<tr>
<td>Promotion of conflicting messages</td>
<td>“I am telling this farmer and then to another farmer something different for the very same technology. It raises a lot of suspicions and questions by the farmer”</td>
<td>D4</td>
</tr>
<tr>
<td></td>
<td>“We do confuse them. We are telling them to do this, and then the next day we tell them to do a different thing. They get angry sometimes saying ‘why is this extension officer telling to do this and now telling me that?’ It confuses them”</td>
<td>D5</td>
</tr>
<tr>
<td>Conflict with government policy</td>
<td>“They know about residue retention but our government teaches farmers that ploughing again and again is good for the land… we say to plough more than 4 or 5 times is good, but CA is better, so there are two ideas in the village. These ideas confuse farmers”</td>
<td>W7</td>
</tr>
<tr>
<td></td>
<td>“It is true that it is contradicting, so it needs to be revisited… Extension policy is that all crops remain should be incorporated in the soil. It should be dug in”</td>
<td>M12</td>
</tr>
<tr>
<td>Conflict between researchers</td>
<td>“We are dealing with the researchers. So if they all talk in the same language of their research, then it will work nicely and it will avoid repetition, so different trials don’t come for each of the different research bodies. That even confuses the extension workers”</td>
<td>N14</td>
</tr>
<tr>
<td>Conflict between levels of government (in Enaya)</td>
<td>“The county has procured tractors, as they want farmers to be mechanised. But these tractors come with the disc ploughs, not ripple. Then they subsidise the rates. So when we carry out training with the rippers, we always tell them that this is so much better than tilling the land. One of the advantages we tell them is that this is cheaper. But then the subsidy comes and makes it a lair. It is disrupting the minds”</td>
<td>Q8</td>
</tr>
<tr>
<td>Historical conflicts</td>
<td>“Previously in Molawi, people were not planting on ridges, so we have told them to ridge. Then we have also then come again to say stop ridging and to go back. So people are resisting”</td>
<td>N5</td>
</tr>
<tr>
<td></td>
<td>“This is causing problems for the farmers and government because yesterday we are saying ‘no you have to plough at least 4 times’ and now we come back and tell them to plough just once”</td>
<td>H12</td>
</tr>
<tr>
<td>Conflict with tobacco companies</td>
<td>“As much as you can advise farmers not to burn, if the company advises them to burn then they have to burn. If they don’t then they won’t get fertiliser. So they are trapped with the tobacco companies”</td>
<td>Z14</td>
</tr>
<tr>
<td>Conflict between organizations</td>
<td>“There has been conflicting messages on CA from extension workers. So that one has contributed to low adoption… other organisation are here with different messages, so organisations are fighting”</td>
<td>F11</td>
</tr>
<tr>
<td></td>
<td>“There is a lot of confusion and no harmonisation… there is a lot of pulling in different directions”</td>
<td>Q8</td>
</tr>
</tbody>
</table>
on semi-transparent livelihood platforms which do not provide supplementary resources to enable a transition to market oriented production. This is in line with the findings of Ndah et al. (2014) that community and institutional limitations are the major hindering factor in the potential uptake of CA in southern Africa.

Such findings have important implications for the promotion of practices that aim to transition subsistence farmers to market oriented production, as is the case with CA. For example, CA is known to require increased interaction with the community platform for subsistence farmers, due to the need for inorganic fertilizers, improved maize and legume seed, alternative fodder seeds and herbicides (Vinianou et al., 2014), additional labour (Baudron et al., 2012) and increased knowledge (Belliotti and Rochecouste, 2014), which in turn also increases the need for financial capital. Respondents strongly indicated that these resources were rarely available and accessible to farmers in their communities.

Perhaps most importantly, the extension service providers themselves found that the extension context was highly limiting, and that the supportive institutional platform was absent. While the institutional constraints were numerous, they were primarily rooted in a lack of visible policy regarding CA. It should be noted that such findings may not reflect the actual policy situation (e.g. Malawi and Zambia have national CA policies), but the visibility and enforcement of such policy within the extension services, which was limited in all countries. Respondents strongly asserted that if there was a CA policy, they were not aware of it and this had strong implications for their role in providing information on CA to farmers. Such findings confirm those of Dougill et al. (2016) in the limited application of a coherent policy regarding CA in Malawi despite more than a decade of efforts to formulate such a policy. Fig. 4 provides a visual summary of the linkages between various institutional constraints and informational and adoption gaps, highlighting both CA-specific and extension services generic issues.

For CA-specific issues, there was a clear need for the government to define their position on CA and, if positive, ensure that all extension services worked together to harmonise their efforts and reduce confusion with both extension officers and farmers. Extension officers were seeking a mandate and authority which such a policy would bring, which would also ensure that they were provided training to develop their belief and confidence in the benefits and merits of CA. Without such a policy, CA remains confined to local project activities with limited scope and coverage and will be further limited without an adaptive approach to sustainable intensification.

For generic extension service issues, respondents asserted that while not ideal, the use of farmer-to-farmer extension systems was a direct reflection of their near impossible task to cover often many thousands of households. However, there was also an identification that often these mechanisms may have unintended consequences. While farmer-to-farmer approaches are intended to leverage existing social networks (Braun and Hoede, 2000; Muliwafu and Krishnankutty, 2012), respondents raised concerns that direct input provision combined with limited community cohesion and low coverage may be hindering the closure of information gaps. Hence, the theory behind farmer-to-farmer mechanisms creating an information multiplier effect (Blauert and Quintanaar, 1997; Noordin et al., 2001) may need further investigation in the sub-Saharan African context due to fragmented social networks and underlying cultures of distrust in other community members (Weillard et al., 2013; Brown et al., 2018).

Adding further complexity to this, respondents asserted that any policy on CA would require flexibility and adaptation of CA. Hence, there is a need not for a specific CA policy, which would reflect a top-down provision of CA to farmers, but a more flexible and adaptive approach to sustainable intensification and a mandate to provide farmers with a basket of suitable and disaggregated CA practices that best fit their situations. Addressing this would involve a rethink of the current mechanism for CA promotion, based on the subsidisation of the lead farmer. Nearly all respondents identified that these mechanisms were unlikely to enable farmer uptake, in contradiction to the underlying theory that the provision of resources to lead farmers would enable them to expand the area on which CA is practiced over time based on the benefits of utilisation, as well as to catalyse other nearby farmers to utilise CA.
According to respondents, this is unlikely to be effective over the long term, as the limited area of subsidised implementation does not break the cycle of ILO agriculture due to limited volume, insufficient biomass to address the competing uses for stover resources, inadequate area to extrapolate results and convince others of the benefits of CA, and inability to grow community interest to a level where local bylaws are demanded or stimulate community demand for CA inputs such that reliable input markets are formed. Such assertions are confirmed by various studies including Brown et al. (2018a) and Lukuyu et al. (2012) who found that provision of inputs had led to a disincentive to utilise CA, either due to financial irrelevance or a perceived likelihood that inputs will be provided if a farmer waits for them.

Overall, respondents continued put forward a traditional view of agricultural extension in which a need is perceived (i.e. sustainable intensification), research is conducted (at a research station) and the resulting technology demonstrated with lead farmers which is then observed by fellow farmers and reproduced (McDonough et al., 2014). As such, assertions of participatory innovation systems being practiced in Africa (e.g. Chowula et al., 2013; Garforth, 2011) seem only partially evident, with a continued philosophical view of ‘extending’ research-based knowledge to farmers through a ‘transfer of technology’ model to be continued. This in turn has led to a failure to adopt technologies to the diversity of socio-economic and institutional environments and other factors affecting farmers (Birner et al., 2006; Chambers and Ghilinyi, 1984), perhaps also driven by an underlying dogma regarding the inability to disaggregate CA practices (see Giller et al., 2009). In fact, we find that the conventional training and visit (T&V) model has simply moved down a level, with local lead farmers used as the trainers instead of the extension services directly to farmers. There was little evidence of functional feedback mechanisms or local adoption of CA, and it was clear from the language used by respondents that they primarily saw their role as convincing farmers to adopt, rather than adapting a basket of best fit technologies for an individual farmer’s circumstances.

It is important to note that the continued dominance of these extension mechanisms may not be due to a philosophical belief in top-down approaches, but pragmatic acceptance of the limited budgets and institutional skills of extension services. It is possible that without adequate funding to assist extension services to develop facilitation skills, to enable physical scientists to deeply and regularly interact with farmers, and to develop community structures that facilitate adaptation of new practices, it has not been possible to implement participatory systems. Likewise, issues with community trust and cohesion are likely to heavily impact on the functionality of participatory systems (Brown et al., 2018b). Hence, we do not intend these findings to be a criticism of the ongoing dominance of top-down approaches, but to further support the transition to more participatory systems within the complex institutional, societal and financial environments of the studied countries. Indeed, it was clear from respondents that they identified a strong need for more flexible and participatory systems, based on a move from the current linear adoption pathway based on incremental expansion of CA area over time to a more flexible, risk-prescriptive utilisation pathway based on modification of CA to local contexts, as previously asserted within the literature body (e.g. Andersson and D’Souza, 2014; Brown et al., 2017b; Glover et al., 2016). In a practical sense, this will require a greater acknowledgement of the role of transitional stages to complete CA utilisation, particularly with the intensification of input usage and alternative cash crops. It appears the promotion three-factor CA is inappropriate for most subsistence farmers and as such should be viewed as an ambition over the longer term, with intermediate and transitional steps required to reach it. An impact pathway that achieves full adoption through disaggregation and modification of CA components is more likely to be successful in these contexts. One such example that could achieve this is proposed by Brown et al. (2018a), in which a five staged process is proposed to ensure that CA is locally adapted to match farmers’ desires and abilities. Such pathways are reflected in the historic uptake of CA globally, in that although CA was developed in the USA in the 1930s, it was not widely adopted for at least five decades because the economic conditions were not yet present (Farooq and Siddique, 2015; Brown et al., 2017c). Noting the financial situation of smallholder farmers and an underlying input dependency culture, there may be a need to implement alternative financial mechanisms to catalyse utilisation, such as through social protection programs that can have a beneficial influence on the adoption of improved agricultural practices in Africa (Tirivayi et al., 2013).

5. Conclusions

This study finds strong commonalities across our six studied countries regarding the constraints to CA utilisation. This reflects the shared
Adaptation of Conservation Agriculture in Eastern and Southern Africa. Global Food Security (2017) 03/02/17
Garforth, C., 2011. Education, Training and Extension for Food Producers. Foroign Project on Global Food and Farming Futures, UK.


Chapter Nine:
Perspective from Community Leaders

Chapter 9 contains the eighth manuscript of this thesis which qualitatively explores the perspectives of community leaders on the utilisation of CA by smallholder farmers. A summary of the manuscript is provided, followed by the statement of authorship and manuscript 8.

9.1 Manuscript Summary

Context:

- Enabling the utilisation of improved agricultural practices will require substantial community participation to ensure the practices are beneficial, feasible and relevant.
- Current discourse on CA tends to focus on plot level biophysical benefits, yet there is a need for broader exploration of the fit of CA into the wider livelihood contexts of farmers.

Figure 1: Graphical abstract for manuscript 8.
Research objectives:
- To explore for the perspectives of community leaders to understand how CA fits within the wants, needs and capacities of smallholder farmers in their communities.

Methods:
- Semi-structured interviews with 47 community leaders across six countries.
- Application of the Livelihood Platforms Approach (LPA).

Findings:
- While there were strong perceptions of perceived benefit in implementing CA, CA was not a preferred practice because it was perceived to be neither feasible nor relevant to community members.
- There were three key themes that limited the fit of CA for potential utilisation: 1] a reluctance for farmers to engage with the community platform; 2] non-functional informational exchange mechanisms; and 3] limited participation in the adaptation of CA to local contexts.

Implications:
- If CA is to be widely utilised as part of the sustainable intensification of African smallholder systems, there is a clear need for participatory engagement with community perspectives to ensure CA is feasible and relevant.
## 9.2 Statement of Authorship

### Manuscript Details:

| Title of Paper: | Further participatory adaptation is required for community leaders to champion Conservation Agriculture in Africa |
| Publication Status: | Published |

### Principle Author:

| Principle Author: | Brendan Brown (Candidate) |
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ii. permission is granted for the candidate in include the publication in the thesis; and

iii. the sum of all co-author contributions is equal to 100% less the candidate’s stated contribution.

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| Signature: | Date: 17/08/2017 |
Further participatory adaptation is required for community leaders to champion conservation agriculture in Africa

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ABSTRACT
There is a recognized need for the participation of local communities in designing and implementing agricultural interventions for the sustainable intensification of smallholder systems. This study examines the perspectives of local community leaders towards the widely promoted, but not widely adopted, practice of Conservation Agriculture (CA) in African smallholder systems. Perceptions from 47 community leaders (both from traditional local authorities and farmer organizations) across six African countries are documented regarding how CA matches the wants, needs and capabilities of farmers in their communities. While community leaders generally perceive CA as potentially beneficial, they also indicated that CA is not currently perceived as feasible within their communities and hence has limited relevance. Three key themes were identified that limit both CA use and sustainable intensification more generally: [1] a perceived reluctance of farmers to engage with the community platform as part of a higher input, market-oriented production system; [2] informational constraints due to non-functional exchange mechanisms; and [3] a lack of local adaptation of CA underscored by the persistence of top-down, linear research and extension approaches. Through greater understanding of local perspectives, a clearer picture emerges of the need for greater participatory engagement; and local adaptation if sustainable intensification of African smallholder agricultural systems is to be achieved.

KEYWORDS
Adoption gap; qualitative assessment; Africa; participatory development; conservation agriculture; agricultural extension

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1. Introduction

Food insecurity is one of the greatest challenges facing Africa, both currently and in the future. Twenty-five percent of Africans suffered from severe food insecurity in 2014/15 (FAO, 2017), and global trends in population and consumption are expected to triple demand for cereals in Africa by 2050 (van Ittersum et al., 2016). The sustainable intensification of African smallholder agriculture is essential to meeting both current and future challenges, especially noting land pressure, soil fertility concerns, climate change and limited productivity growth (Bai, Dent, Olsson, & Schaeppman, 2008; Jones & Thornton, 2003).

Much of the focus on sustainable intensification of smallholder farming systems in Sub-Saharan Africa has been specifically on conservation agriculture (CA), a package of the three interrelated principles of minimum tillage, crop diversification and soil cover to improve soil fertility and increase yields sustainably (FAO, 2015). Despite the ongoing and nuanced debate on the benefits of CA to African smallholder farmers (Pittelkow et al., 2015), CA has been strongly embraced by governments and development organizations (Giller, Witter, Corbeels, & Tittonell, 2009). However, recent estimates highlight that the utilization of CA has been limited (Andersson & D’Souza, 2014; Giller et al., 2009; Ngwira, Johnsen, Aune, Mekuria, & Thierfelder, 2014). In a study of CA adoption across five countries in eastern and southern Africa, Brown, Nuberg, and Llewellyn (2017b) attributed this to two key issues: [1] substantial issues with the delivery of information about CA to smallholder farmers; and [2] issues in implementing CA that reflect substantial negative evaluation and modification, limited interest and low intensity of use.

There is a strong acknowledgement that many agricultural development initiatives in Africa have often been top-down oriented (Graef et al., 2014) and tend not to take into account the perceptions of smallholder farming communities (Nyaga, Johnsen, Aune, & Kalinda, 2011). Schut et al. (2016) argued that instead of attempting to alleviate biophysical and/or technological constraints at a plot level, a broader approach which seeks to understand the interplay between biophysical, technological, social–cultural, economic, institutional and political dimensions from farm to community and institutional levels will be required to catalyse agricultural change. To do this, a need for greater participation from local stakeholders in the innovation systems, both development and extension, has been identified (Mapfumo, Adjei-Nsiah, Mtambanengwe, Chikowo, & Giller, 2013; McDonough, Nuberg, & Pitchford, 2015). The need for researchers to continue to work with farming leaders after release of an innovation to further develop its local performance has also been identified (Douthwaite, Keatinge, & Park, 2001). Specific to CA, the findings of Brown, Nuberg, and Llewellyn (2018a) and Brown, Nuberg, and Llewellyn (2018b) both identified the integral role of community leadership in the promotion of CA, and the need for far greater engagement of communities, and particularly community leadership, in addressing community and institutional constraints to technological uptake.

This paper documents an exploratory study that analyses perceptions of CA within communities directly with local community leaders. It pairs semi-structured interviews with community leaders (both traditional and from farmer based organizations) with the Livelihood Platforms Approach (LPA; Brown, Nuberg, & Llewellyn, 2017a) to understand the fit of CA within their communities, across multiple scales (from individual to household, community and institutional) and a range of resource types (physical, financial, human and informational). Our research question is: how do community leaders perceive the benefit, feasibility and relevance of CA for their community? The purpose of the study is not to provide a quantitative analysis of the status of CA but to qualitatively explore the context, experiences and perspectives of local leaders of communities and farmer organizations regarding CA. These leaders are the necessary supporters and likely participants in efforts for greater local farmer input into the development, local adaptation and promotion of CA, but their appraisal of CA has been absent from the literature.

2. Methods

2.1. Theoretical framework

This paper is one in a series that investigates different perspectives of key stakeholders (both farmer and non-farmer) in the utilization of CA, the first of which investigates the negative evaluation of CA by African smallholder farmers (Brown et al., 2017a). In that paper, the Livelihood Platforms Approach (LPA) was proposed as a methodology to structure qualitative research on farmer decision making. Brown et al. (2018b) modified the LPA to focus on the institutional contexts beyond the household by removing the individual platform,
and this modified Livelihood Platforms Approach (mLPA) is applied in this study (Figure 1). By focusing on household, community and institutional platforms, the mLPA aims to facilitate a wider view of the contexts in which farming decisions are made from the perspectives of those with oversight within community. These platforms are supported by four resource pillars (physical, financial, human and informational).

2.2. Study implementation

This study forms part of a wider study of the sustainable intensification of smallholder farming systems in 85 communities across 20 case study locations in six countries (Ethiopia, Kenya, Uganda, Malawi, Zambia and Mozambique). Those communities were purposively selected for the potential for CA to positively impact on the dominant maize-based production systems and for the presence of CA promotional activities in their communities.

From the larger dataset of 325 semi-structured interviews, a subset of 47 interview transcripts are analysed in this study. These comprise of two categories:

- Traditional chiefs and community leaders (34 respondents); and
- Elected farmer union leaders (13 respondents).

It should be noted that nearly all respondents were also farmers themselves, and only three women were found in this subset. This reflects the difficulty in finding women in leadership positions, particularly traditional leadership, in the studied contexts. Each respondent was assigned an alphanumerical code: a letter signifying the case study and a number signifying the interview order (Figure 2).

An interview schedule was developed to provide the opportunity for each respondent to explore their community’s situation and the local ‘fit’ of CA. The interview schedule was based on the LPA and explored the four resource categories at various platforms as follows: general community interest in practice change; community preference towards subsistence or market orientation; community perceptions of CA; personal perceptions of CA; issues with CA implementation; enabling environments for CA implementation; information flows and the functionality of information delivery systems; influence of government policy; institutional confusion on CA; harmonization with other extension services; and future directions for fostering utilization of CA.

Interviews were conducted primarily in the preferred local language, except in cases where the respondent was comfortable in expressing themselves in English, and a translator was utilized from a local agricultural research station. Audio of the interviews was digitally recorded and transcribed independently of the translator into English. The average length of the interviews was 40 min, but ranged between 13 and 92 min. The interview subset for this paper includes analysis of 34 h of interview. All transcribed interviews were coded according to the various elements of the LPA using Nvivo™ (version 11) content analysis software.

3. Results

Community leaders tended to perceive CA as beneficial to maize yields, and particularly so in light of climate change (e.g. ‘In the beginning people did not have interest because the rain pattern was okay. Now that we have seen the changed rain pattern, we have started adopting CA at a quicker rate’ – K6) and soil fertility concerns (e.g. ‘I want other farmers to expand CA as the fertility status of the land is getting depleted from time to time’ – P3). Despite this, when respondents were asked to identify the most needed intervention to develop their community, they tended to preference other options for development, primarily: irrigated farming; micro-processing; cash cropping via non CA crops; livestock intensification; aquaculture; and agroforestry. CA was rarely identified as a pathway for community development, reflecting issues at all four resource pillars of the LPA: physical, financial, human and informational.

3.1. Physical resources

When exploring why CA was not viewed as a preferential pathway to community development, respondents identified two key physical resource constraints: stover resources and the availability of agronomic inputs.

3.1.1. Constrained and unsecured stover resources

Respondents identified strong competing uses for stover resources in their communities, especially regarding fuel-wood (e.g. ‘We could not succeed on stover retention even if we agree on its importance … stover is used for fuel wood by the farm households’ – W5) and animal feed (e.g. ‘We receive
teaching from the extension officers about its [CA] advantages. But we need the livestock to eat. Adoption will come when we have forage trees and seeds’ – S8). At the community platform, there were also concerns regarding the security of stover used in CA activities. In Ethiopia, Uganda and Kenya, this referred to communal grazing practices (e.g. ‘If crop residue decomposes on the farm land it will be converted to fertile soil. This is known by everybody. But, let alone leaving the stubble on the farmland, if you do not harvest the main crop on time, your crop will be eaten by animals’ – W5) and in Malawi, Zambia and Mozambique, this referred to fire from rodent hunting activities whereby unmonitored fields covered in stover were often burned by community members in search of rodents for consumption or sale (e.g. ‘The stalks are burnt by the mice hunters’ – X14).

![Figure 1. The modified Livelihood Platforms Approach (mLPA) framework (Brown et al., 2018b).](image)

![Figure 2. Location and classification of respondents (map courtesy of Google Maps, 2017).](image)
Table 1. Respondent identified issues with credit market functionality.

<table>
<thead>
<tr>
<th>Issue</th>
<th>Representative quotation(s):</th>
<th>ID</th>
</tr>
</thead>
<tbody>
<tr>
<td>Limited repayment</td>
<td>‘There isn’t any credit available, because if we give them credit they fail to pay it back’</td>
<td>D6</td>
</tr>
<tr>
<td>Availability</td>
<td>‘Credit supply is needed, but there is no credit’</td>
<td>W6</td>
</tr>
<tr>
<td>Repayment structure</td>
<td>‘The loan should be paid back after the season not at the end of every month’</td>
<td>F9</td>
</tr>
<tr>
<td>Crop specific</td>
<td>‘Credit is mostly for cotton’</td>
<td>F3</td>
</tr>
<tr>
<td>Cost of Loan</td>
<td>‘In this area we had that chance of getting loans but now we stopped getting credit because we were being charged with high interest rates’</td>
<td>F4</td>
</tr>
<tr>
<td>Fear impacts of default</td>
<td>‘Because of the high interest and if one fails to pay back they come to remove iron sheets from houses’</td>
<td>D8</td>
</tr>
<tr>
<td>Religious incompatibility</td>
<td>‘Because of their religion and interest paid tied with, as they are Muslim, they can’t use it’</td>
<td>S7</td>
</tr>
<tr>
<td>Amount available</td>
<td>‘When many farmers want credit, they say money is not available or not enough from the loan’</td>
<td>P8</td>
</tr>
<tr>
<td>Risk Adversity</td>
<td>‘When we talk of modern farming, it requires cost or risk taking in terms of entering into credit for the various inputs. Some farmers say I better remain in my current income status than involve myself in risky activities as they may come to my livestock or residence at the end if I am unable to pay back the loan’</td>
<td>P6</td>
</tr>
<tr>
<td>Collateral requirements</td>
<td>‘People have not been able to access credit because there is the impediment of security and no collateral, the land is family land so you have to negotiate with your wife and children and it becomes difficult securing collateral. You may use your animals but this is risky because they say it is not secure as a cow may die’</td>
<td>E13</td>
</tr>
<tr>
<td></td>
<td>‘Farmers fear to get loans from the banks because of those collaterals. The farmer doesn’t have the land title and the bank manager is requesting the land titles, so the farmer is shut out … Nobody has title. It’s a big issue’</td>
<td>J7</td>
</tr>
<tr>
<td>Political background</td>
<td>‘Farmers think the government just wants to help them, they think that loans are political that the government want to gain votes, that mentality kills all procedures to help them … During the one party era people were repaying the loans but the coming in of democracy has made people think that the government will always be there to take away their loans’</td>
<td>D6</td>
</tr>
</tbody>
</table>

3.1.2. Functionality of agronomic input markets
Community leaders asserted that despite the potential benefit of CA, it was currently not perceived as a feasible practice due to non-functional markets for the inputs they viewed as required for CA implementation (e.g. ‘We find it difficult to buy fertilizer. We can have money but there is nowhere to buy it’ – U11). While CA systems may not require input intensification in some circumstances, the perspectives of nearly all respondents was that CA implementation in their community would require increased input use by farmers. There were also issues with the quality of seed (both maize and legumes) available at markets (e.g. ‘We have a problem of poor quality seeds that when we plant it doesn’t germinate.’ – U11), timing of delivery (e.g. ‘The problem is that the inputs come very late. We are appealing to the agriculture office that the inputs should come in time’ – X9) and exclusive availability (e.g. ‘It is only available if it is from a project or the department of agriculture. Otherwise it is not possible.’ – Y19).

3.2. Financial resources
Thirty one out of 34 community leaders and 11 of 13 union leaders identified financial constraints as the major limitation to CA utilization in their communities (e.g. ‘The major problem is lack of fertilizer and seeds. It is available at the market but most farmers have no money to buy them’ – C2). Respondents highlighted that most farmers in their communities were not able to break out of their current production systems because of a cyclical inability to afford inputs, leading to limited output (e.g. ‘They plant without fertilizer and do not harvest anything and that makes them not to have money to buy fertilizer [next year]’ – K6). They were also not able to invest in agricultural activities because they required any financial resources for basic needs (e.g. ‘Financially, people are not able to take care of their families’ – T6). Hence, traditional production systems were perceived as the only feasible system (e.g. ‘The main problem to diversify a new technology is the capital problem. We can’t afford it so we have to do traditional farming’ – H5).

Community members’ limited financial resources were perceived to reflect issues at the community platform – namely an inability to create financial resources through markets or borrow through credit mechanisms. Output market opportunities were perceived to be limited (e.g. ‘The problem is marketing, the farmers are able to produce but their produce lack markets’ – E1) or providing limited return (e.g. ‘We don’t have reliable markets as a result we sell our produce to vendors who buy at a low price’ – M17). Likewise, credit systems were unavailable or not utilized for various structural reasons as well as community preferences (Table 1).

Because of a lack of financial feasibility, CA has generally been promoted with the direct provision of financial resources to users. However, more than two thirds of respondents perceived that there was now a culture
of financial expectation through a handout culture that hindered broader CA utilization (e.g. ‘People have come to understand that to go to a field day or a meeting you must to be facilitated. If they miss that the next time they will not go again. So they are not in thirst for that education, they thirst for what they will be given’ – E1). In many cases, this has led to a disincentive to invest time and other resources in CA (e.g. ‘We had 24 members, and then because they were not encouraged, some have left and more do not join. People come to take money and not knowledge and if they do not get it they will leave’ – Y6). Such input provision also leads to a disruption of community dynamics (e.g. ‘I think the problem is that it came as a club which gives other farmers free inputs which makes others jealous that’s why they don’t adopt… Farmers are just jealous that their friends are receiving inputs’ – F3).

At the institutional platform, respondents also identified that farmers were hesitant to engage more broadly with market-oriented farming because local vendors were not seen as trustworthy (e.g. ‘We sell our harvests to vendors who move around with their own scales and these scales are not trust worthy… vendors steal from us’ – M3). Likewise, there was a reluctance to join output cooperatives due to a lack of trust (e.g. ‘The market is available but most of the farmers fail to sell their produce at the cooperatives once they harvest. They just sell on their own hence they sell on low prices… they really don’t trust each other’ – D6; ‘Everybody has become so apprehensive about cooperative movements… The leaders smuggle other people’s money but they are never prosecuted and as a result the members don’t get the benefit… That’s why a group like this, you find we may not get big membership’ – E13). Hence, there was limited relevance in CA systems because farmers were perceived to be hesitant to engage with the community platform.

3.3. Human resources

Overall, leaders perceived that their communities viewed CA negatively due to the labour required in implementation, and there were often assertions that CA was more time consuming than traditional agriculture (e.g. ‘The procedures are too difficult, and there are too many rules. Farmers here, if they want to plant, they want to do it fast in one day. The traditional is fast, and the new [practices] takes too long to plant in rows. So farmers are aware of it, but they just prefer the traditional’ – Y19). This reflected three key issues regarding:

3.3.1. Stover importation

More than one third of respondents identified negative perceptions of stover importation within the community (e.g. ‘The most tiresome thing with conservation agriculture is the gathering of stalks’ – N4) and such perceptions often outweighed the benefits of CA utilization (e.g. ‘They continue saying CA is tiresome although they know they can benefit more with CA’ – D6).

3.3.2. Land preparation

The digging of semi-permanent basins (the common method of minimum tillage implementation where oxen are not available) was usually viewed as laborious (e.g. ‘Farmers say that it is time consuming and laborious because we dig only a small portion as it takes a lot of time’ – J7). These perceptions were especially strong when oxen were available for tillage activities (e.g. ‘Those who have oxen think that they can easily plough their land and soften the soil and hence, do not participate in CA’ – B3).

3.3.3. Weeding activities

CA was often perceived to increase the need for weeding activities (e.g. ‘Everything else is ok with CA but the main problem is weeding’ – Y19).

There were also concerns that where more labour was required to address these concerns, it was not able to be obtained from the community platform because labour tended to be engaged in other activities. This related to both farm activities (e.g. ‘The problem is that others are growing tobacco and they can’t join us who grow maize. They dedicate most of their time on tobacco’ – Z6) and non-farm activities (e.g. ‘The majority of the people you are seeing around here are youths who go to town to search for jobs other than farming’ – G8).

3.4. Informational resources

While CA was viewed as a more complex practice than traditional practices, more than two thirds of respondents identified issues with community members’ awareness of CA and access to CA information. The primary reason for this lack of awareness was the perceived limited learning opportunities for CA in communities (e.g. ‘Farmers are reluctant to fully accept and implement these new technologies, but this is
Table 2. Perceived issues respondents identified causing constrained information environment.

<table>
<thead>
<tr>
<th>Issue</th>
<th>Type</th>
<th>Representative Quotation(s):</th>
<th>ID</th>
</tr>
</thead>
<tbody>
<tr>
<td>Limited coverage</td>
<td>Extension Officer</td>
<td>‘They rarely visit because we are far and the extension workers are few in number, such that they can’t reach all the people. This makes us fail to receive information concerning farming’</td>
<td>T6</td>
</tr>
<tr>
<td></td>
<td>Lead Farmer</td>
<td>‘The problem is that there are so few lead farmers’</td>
<td>H6</td>
</tr>
<tr>
<td>Limited interaction</td>
<td>Extension Officer</td>
<td>‘What is needed mostly is to continue with the sensitization and also the training should be done frequently’</td>
<td>X14</td>
</tr>
<tr>
<td></td>
<td>Lead Farmer</td>
<td>‘(Lead farmers) are not doing activities widely with farmers’</td>
<td>H5</td>
</tr>
<tr>
<td>Limited skills</td>
<td>Extension Officer</td>
<td>‘The extension officers sometimes lack the knowledge, so they can’t teach us well … Sometimes the farmer thinks they don’t support them fully, so they can get upset’</td>
<td>S7</td>
</tr>
<tr>
<td></td>
<td>Lead Farmer</td>
<td>‘These lead farmers are helping but not much. This is because those farmers don’t have enough information and in fact they have lower education levels’</td>
<td>T6</td>
</tr>
<tr>
<td>Farmer understanding</td>
<td>Extension Officer</td>
<td>“Mostly it is because of literacy level is low – most farmers did not go to school so for them to be trained it’s not easy”</td>
<td>D6</td>
</tr>
<tr>
<td></td>
<td>Lead Farmer</td>
<td>‘We thought he (lead farmer) was doing his own thing: we didn’t know it was a new project so we didn’t bother to go and see’</td>
<td>G8</td>
</tr>
<tr>
<td>Confusion</td>
<td>Extension Officer</td>
<td>‘The problem is that we have multiple players … The farmers are being confused; who is right? Who is wrong? … The ministry of agriculture is the mother, so let the information flow in one voice so that the farmers cannot be confused’</td>
<td>E1</td>
</tr>
<tr>
<td>Distrust</td>
<td>Extension Officer</td>
<td>‘Organizations lie to the farmers. Like for a project, when they came they told the farmers that they will be given one bag of fertilizer but they didn’t do it’</td>
<td>N4</td>
</tr>
<tr>
<td></td>
<td>Lead Farmer</td>
<td>‘Farmers sometimes doubt the lead farmers … because when they are practicing they are alone and the other farmers just go there to see during field days so they think that maybe the lead farmer will hide some information from them’</td>
<td>F4</td>
</tr>
<tr>
<td>Hesitance to engage</td>
<td>Extension Officer</td>
<td>‘Some think because he (extension officer) has been working here he has a lot of influence and money so he will degrade us. I think that is the main problem which is making us not to move. Others will not go to training because they think they just degrade us’</td>
<td>E1</td>
</tr>
<tr>
<td></td>
<td>Lead Farmer</td>
<td>‘Those who are not part of those groups, they take it as private’</td>
<td>F4</td>
</tr>
<tr>
<td>Timing of training</td>
<td>Extension Officer</td>
<td>‘Early training is important before the farmers plough their land. Because of the late training only a few farmers attended’</td>
<td>Q23</td>
</tr>
<tr>
<td>Exclusivity</td>
<td>Extension Officer</td>
<td>‘When the department of agriculture bring seed here, they do not publish that they are coming. They just come to see us directly. They contact me and it is a bit of a secret. They just come quietly and leave’</td>
<td>W5</td>
</tr>
<tr>
<td></td>
<td>Lead Farmer</td>
<td>‘Practical demonstration and training can change if made available for all farmers. All need to be invited not just the lead farmers’</td>
<td>S8</td>
</tr>
<tr>
<td>Jealousy</td>
<td>Lead Farmer</td>
<td>‘Some say “I was not invited, I will not go there” … Some don’t go to others because of jealousy or because he was appointed a leader so I will not go there. So those who would like to go but they can’t because all those that there seem to be of the high level’</td>
<td>E1</td>
</tr>
<tr>
<td>Perception of trials</td>
<td>Lead Farmer</td>
<td>‘The only problem is that farmers can’t see how much produce has come from that field’</td>
<td>K6</td>
</tr>
<tr>
<td></td>
<td>‘Because it is a small area, they never try to see how much it will cost’</td>
<td>Y6</td>
<td></td>
</tr>
<tr>
<td>Farmer selection</td>
<td>Lead Farmer</td>
<td>‘The selection of lead farmers need to involve both the extension workers and the chiefs. Not one party. In that way we can know if the one who is chosen will be reliable’</td>
<td>D8</td>
</tr>
</tbody>
</table>

because training is not enough’ P6). However, there were further issues with the mechanisms that facilitated information delivery to community members, both with extension officers and lead farmers (Table 2). Overall, the dominant farmer-to-farmer extension mechanisms were not perceived to be functional (e.g. ‘If we continue to use the system of the lead farmers only it will not help us’ – F4; ‘Coming in specific homes the way they do it is now not very good’ – J2; ‘Farmer-to-farmer extension is not working’ – K9).

4. Discussion

The benefit of CA utilization has been a major focus of the CA literature. Numerous studies have found benefits of CA implementation, mostly focused on yield and environmental outcomes (Mupangwa, Mutenje, Thierfelder, & Nyagumbo, 2017; Ndah et al., 2014; Thierfelder, Bunderson, & Mupangwa, 2015; Thierfelder et al., 2016), but such claims are contested and nuanced (Giller et al., 2015; Kathage, Kassie, Shibwera, & Qaim, 2015; Pittelkow et al., 2015). As the scientific debate continues, the respondents in this study overwhelmingly perceived CA as agronomically beneficial and stated that a lack of yield benefit was not the primary driver of limited utilization. Despite this, CA has not been embraced and was not preferred by respondents as the most desirable development pathway for their communities. This reflected major constraints to both the feasibility and relevance of CA
in their communities. Importantly, these constraints were often generic community and institutional constraints that are likely to effect the broader sustainable intensification of African smallholder systems and not just CA utilization. This discussion places these constraints into three broad categories:

4.1. A hesitation to engage with the community platform

Respondents asserted that farmers were hesitant to engage beyond their household platform, and this restricted their use of CA and other new technologies more broadly. The perceived need for greater reliance on the community platform is related to the dominance of low input and low output subsistence orientation of farmers (Brown, Nuberg, & Llewellyn, 2018c) paired with the historical pathways in which CA has been promoted to farmers through direct incentives (Brown et al., 2018b, 2018c). Respondents also identified a third issue of an institutionalized distrust of the community platform also found in Brown, Llewellyn, and Nuberg (2018d) in relation to informational resources. This was particularly evident when discussing input markets (perceptions of poor quality agronomic inputs and unreliable delivery), output markets (lack of trust in vendors and lack of remunerative markets) and financial services (limited interest in credit services due to risk and cost as well as lack of engagement with co-operatives due to prior poor experiences). Furthermore, respondents questioned the merit of engaging with the community platform due to limited resources (especially labour and informational), poor quality (due to limited skills of information providers), non-functional relationships (that harboured distrust and resentment) and poor mechanisms (e.g. size of trials). Respondents perceived that this led farmers to prefer subsistence production systems (i.e. household platform focused) rather than market-oriented production systems (i.e. community platform focused). This has important implications for engaging African smallholder communities in market-oriented farming, because they will need to be convinced not only of the merits of new technologies, but of the broader merits of transitioning their objectives towards market-oriented farming.

4.2. The functionality of informational exchange mechanisms

The reluctance to engage with the community platform was most evident within the informational pillar. Because extension services cannot be expected to reach every household on an individual basis (i.e. supply driven extension), current extension mechanisms (and particularly farmer-to-farmer approaches) are designed to leverage existing social and trust networks through demand-driven and peer facilitated extension (Braun & Hocde, 2000; Garforth, 2011; Mulwafu & Krishnankutty, 2012; Rogers, 1962). However, respondents strongly perceived that these mechanisms were non-functional, mainly due to limited coverage and interaction provided by informational sources that led to perceived exclusivity, jealousy and distrust. Because lead farmers are generally provided with inputs, this further created perceptions of exclusivity and an underlying expectation that inputs should be provided to facilitate adoption. When this did not occur, there was a disincentive to adopt which respondents identified also had the potential to lead to disadoption. This is likely to further impact on community cohesion and the intent of farmers to engage with the community platform (Brown et al., 2017a).

These findings provide novel insights into the quantitative findings of various studies that identify significant informational gaps within African smallholder communities, but did not explore their drivers (Brown et al., 2017b; Diagne, 2009; Ferris & Robbins, 2004; Fisher, Holden, & Katengeza, 2017; Khaila, Tchuwa, Franzel, & Simpso, 2015; Simtowe, 2011). These insights warrant further investigation directly with farmers on the functionality of current extension mechanisms in effectively disseminating information. As highlighted by Wellard, Rafanomezana, Nyirenda, Okotol, and Subbey (2013), there is currently little exploration of the effectiveness of such mechanisms, particularly as the limited literature that explores this tends to do so from the perspectives of those connected to extension programmes as subsidized lead and follow farmers (e.g. Lukuyu, Place, Franzel, & Kiptot, 2012; Mwambi, Kiptot, & Franzel, 2015; Tsafack, Degrande, Franzel, & Simpson, 2015) or to overlook the importance of subsidization (e.g. Fisher et al., 2017).

4.3. A systematic lack of local adaptation within communities

Noting the limited financial status of African smallholder farmers, CA may be perceived as a higher input, market-oriented system (Brown et al., 2018c). Respondents confirmed that this means CA is not
perceived as feasible, because the enabling factors to facilitate a production-oriented system do not exist. Respondents confirmed substantial issues regarding a lack of functional input markets (Giller et al., 2009; Kaumbutho & Kienzle, 2007), limited credit availability (both presence and requirements), limited remunerative markets (Giller et al., 2009) and an overall lack of capital accumulation to sustain basic needs and invest in agronomic inputs. As such, while CA may be beneficial, it is not feasible for the average farmer in their community. The approach taken by development agencies in subsidizing inputs to lead farmers appears unlikely to break cyclical low-input and low-output production systems because there remains limited avenues to build financial capital, and hence such an approach will not build long term adoption of CA (Brown et al., 2018b). Beyond this, we confirm substantial issues with high competition for stover residues (Baudron, Jaleta, Okitoi, & Tegegn, 2014; Valbuena et al., 2012; Valbuena et al., 2015) and security of stover from loss (Brown et al., 2017a), as well as undesirable labour burden that is required for stover importation and land preparation (Giller et al., 2009).

Whilst this investigation confirms the findings of various studies, when these constraints are combined a picture emerges of a lack of adaptation of CA to local contexts. It may be argued that extension systems in the studied countries remain linear, using top-down mechanisms to promote the adoption of CA (Brown et al., 2018b; Lynam, Beintema, Roseboom, & Badiane, 2016) rather than promoting flexible adaptation of CA to fit the contextual realities of smallholder communities. The various issues that respondents identified clearly highlight a need for greater local adaptation and, noting the hesitance of farmers to engage with the community platform, the continued use of transformational adaptation pathways based on simultaneous change to three-factor CA seem unlikely to facilitate wider practice change. Instead, locally relevant transitional pathways appear a more favourable option (an example for CA is provided in Brown et al., 2018c). This would be consistent with global patterns of CA uptake that show the need for local, participatory driven adaptation of CA (Brown, Llewellyn, & Nilberg, 2017).

Such a transition will require a movement to, and capacity built for, more participatory local research and extension systems (Brown et al., 2018a, 2018b). However, this may not be easily achieved, noting that community leaders remain unconvinced of the feasibility and fit of CA in their community’s dominant farming system, farmer hesitance to engage with the community platform, and chronic underfunding of research and extension services (ASTI, 2017).

5. Conclusions

The breadth and depth of constraints to CA utilization identified by community leaders highlights a strong mismatch between CA and the contextual realities of smallholder farmers in their communities. However, many of the identified issues suggest broader community and institutional issues that will constrain many new technologies and the broader sustainable intensification of African farming systems. Particularly, we find a need to: [1] convince farmers of the merits of engaging with the community platform as part of a market oriented production system; [2] review the information delivery mechanism used in CA promotion; and [3] implement a more participatory adaptation process to ensure CA fits local contexts. While community leaders in this study generally see potential yield benefits from CA, the current feasibility and broader compatibility constraints mean that few are likely to be local champions for greater adoption in the short term. Overall, there will need to be decreased expectations on the type and rate of CA utilization that can be expected in sub-Saharan Africa, as many of the drivers limiting adoption reflect institutional issues, both formal and informal, that may take significant time and efforts to address.

Acknowledgements

Thanks must primarily go to the community leaders that generously gave their time to participate in this research. Further thanks must also go to the researchers, translators and transcribers that helped to facilitate field activities. The fieldwork for this study was co-funded by the CIMMYT-led Maize CRP and socio-economics programme, with additional support from CSIRO and the University of Adelaide.

Disclosure statement

No potential conflict of interest was reported by the authors.

Funding

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Fisher, M., Holden, S. T., & Katengeza, S. P. (2017). Adoption of CA technologies among followers of lead farmers: How strong is the influence from lead farmers?


and profitable options for smallholder farmers in different agro-ecoregions of Zimbabwe? Renewable Agriculture and Food Systems, 32, 87–103.


Chapter 10 contains the ninth manuscript of this thesis which qualitatively explores the perspectives of local researchers on the utilisation of CA by smallholder farmers. A summary of the manuscript is provided, followed by the statement of authorship and manuscript 9.

10.1 Manuscript Summary

Context:
- CA is a complex farming system requiring substantial adaptation to facilitate utilisation by African smallholder farmers.
- Limited utilisation of CA raises questions regarding the functionality of current research systems which is yet to be explored with local researchers.

Research objectives:
- To explore the capacity for local research systems in Africa to recognise constraints to smallholder utilisation of CA and adapt CA to those constraints.

Methods:
- Qualitative exploration with 28 locally-based agricultural researchers across six countries.
- Application of the Livelihood Platforms Approach (LPA).

Findings:
- Respondents identified constraints with the benefit, feasibility and relevance of CA implementation, and limited adaptation of CA to these constraints.
- This was not a reflection of ignorance to the smallholder context, but substantial limitations in the research, extension and policy institutional contexts.
- These limitations reflected the assumed adoption pathway for CA through complete three factor implementation does not recognise the importance of local modifications.
- Research systems were perceived to be top down and lacking participatory engagement with communities. This reflected limited ability to interact with farmers through current extension mechanisms that had limited trust with and coverage of local communities.
Further compounding this was issues with policies to enable CA utilisation and adaptation because researchers perceived limited mandate to promote CA.

Implications:

- While a persistent philosophical belief in top down research mechanisms cannot be discounted, we find that a lack of participatory research and extension most likely reflects limited financial, human and social capital to implement more participatory approaches. Without addressing this, successful widespread adoption of complex farming systems change appears unlikely.
### 10.2 Statement of Authorship

**Manuscript Details:**

| Title of Paper: | Research capacity for local innovation: the case of conservation agriculture in Ethiopia, Malawi and Mozambique |
| Publication Status: | Published |

**Principle Author:**

| Principle Author: | Brendan Brown (Candidate) |
| Contribution to paper: | Identification of research gap, theoretical conceptualisation, fieldwork design, fieldwork to collect data, analysis of data, interpretation of results, writing of manuscript, acted as corresponding author |
| Overall percentage: | 90% |
| Signature: | Date: 17/08/2017 |

**Co-Author Contributions:**

By signing the Statement of Authorship, each author certifies that:

i. the candidate’s stated contribution to the publication is accurate (as detailed above);

ii. permission is granted for the candidate in include the publication in the thesis; and

iii. the sum of all co-author contributions is equal to 100% less the candidate’s stated contribution.

| Name of Co-Author | Contribution to paper: Supervision, evaluation and editing of the manuscript |
| Signature: | Date: 17/08/2017 |

| Name of Co-Author | Rick Llewellyn |
| Contribution to paper: | Supervision, evaluation and editing of the manuscript |
| Signature: | Date: 17/08/2017 |
Research capacity for local innovation: the case of conservation agriculture in Ethiopia, Malawi and Mozambique

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ABSTRACT

Purpose: The limited uptake of improved agricultural practices in Africa raise questions on the functionality of current agricultural research systems. Our purpose is to explore the capacity for local innovation within the research systems of Ethiopia, Malawi and Mozambique.

Design/methodology/approach: Using Conservation Agriculture (CA) as a case study, we qualitatively explore with 26 locally based agricultural researchers the context of CA research and promotion, including their perceptions on persistent research gaps and issues in closing them.

Findings: Respondents identified that CA was not yet a finished product, with concerns regarding the benefit, feasibility and relevance of CA implementation. They asserted that while further adaptation was required, they were unable to do this due to institutional constraints within their research, extension and policy contexts.

Practical implications: We find that CA continues to be considered a donor-driven intervention in its current form and requires substantial further adaptation to local contexts before researchers will deem it ready for farmer uptake. The five research gaps identified by respondents highlight practical areas where further adaptations must occur.

Theoretical implications: Our findings suggest a lack of participatory research and extension most likely reflects limited financial, human and social capital to implement more participatory approaches. Without addressing these capacities, widespread adoption of complex farming systems change appears unlikely.

Originality/Value: Whilst many studies have identified a need for local innovation to enable CA utilisation, few have qualitatively explored directly with local researchers the capacity of such systems to do so. We address this gap in the literature.

1. Introduction

Agricultural researchers have traditionally been tasked with the development of improved agricultural practices and their dissemination to extension services and/or farmers. In
Africa, focus has been particularly placed on addressing ongoing concerns regarding the productivity, environmental impact and sustainability of African smallholder farming systems (Tilman et al. 2011). Whilst potentially beneficial technologies exist to address these issues, they tend to be under-utilised by African smallholder farmers (Glover, Sumberg, and Andersson 2016), and the limited uptake of these practices raises questions about the functionality of current research systems.

Agricultural research in Africa has traditionally functioned such that a need is perceived (i.e. sustainable intensification), research is conducted (at a research station) and the resulting technology is demonstrated with lead farmers and subsequently observed by follow farmers and reproduced (McDonough, Nuberg, and Pitchford 2014). Over the past three decades in Africa, there has been a theoretical movement away from these centralised, top-down research systems (whereby new practices are developed and provided to farmers) to more participatory research systems (whereby new practices are developed with farmers; e.g. Chow, Garforth, and Cardey 2013). However, there is a small but growing discourse that questions if these transitions have occurred in practice, noting the continued focus on developing and proving improved agricultural practices on research farms with only limited interaction with farmers (Lynam et al. 2016).

One technology that has been strongly promoted as part of the sustainable intensification of African smallholder systems is Conservation Agriculture (CA). CA is a production system based on three interrelated agronomic practices: (1) minimised soil disturbance; (2) maintenance of permanent soil cover; and (3) crop diversification (FAO 2014). CA provides an interesting case study to explore the functionality of current research systems due to the nature of its development, promotion and dissemination in Africa.

CA was developed outside of Africa as a set of practices to address productivity and sustainability issues on large commercial farms in North America and Australia. It was then adapted to smaller scale farms in South Asia and South America, and subsequently there have been attempts to adapt CA to African smallholder contexts (see review by Brown, Llewellyn, and Nuberg 2017). CA may, therefore, be seen as a technology not developed locally, but extended from outside, particularly noting the strong dogma that can be attached to CA and the lack of local adaptation that has limited its uptake (Giller et al. 2009). This is particularly problematic noting the aggregated set of practices that combine to form the CA package, which has been acknowledged as requiring context specific adaptations to enable utilisation (Andersson and D'Souza 2014; Glover, Sumberg, and Andersson 2016).

Further to this, there is ongoing debate around the appropriateness of CA for African smallholder systems. This extends not only to the nuanced agronomic benefits of CA to smallholder farmers (e.g. Giller et al. 2015; Pittelkow et al. 2015), but to its feasibility and relevance within African smallholder contexts (e.g. Giller et al. 2009; Giller et al. 2015). A growing body of research also highlights the limited uptake of CA by farmers across eastern and southern Africa (Brown, Nuberg, and Llewellyn 2017b; Arslan et al. 2014), as well as studies questioning the benefits, feasibility and relevance of CA from farmer perspectives (e.g. Brown, Nuberg, and Llewellyn 2017a; Brown, Llewellyn, and Nuberg 2018).

Despite this, CA continues to be vigorously promoted by various international organisations (see Kassam et al. 2009), with substantial enthusiasm from the Food and Agriculture Organization of the United Nations (FAO) and international research centres such as
CIMMYT, ICRISAT, CIRAD, ICARDA and ICRAF. This has culminated in the incorporation of CA into both regional (e.g. NEPAD) and national agricultural policies (including in Tanzania, Kenya, Malawi, Mozambique and Zambia; Giller et al. 2015). Whitfield et al. (2015) summarised this situation as the narratives of the pro-CA community (be they project outputs, policy, or rhetoric) driving the politicisation of CA within the broader agenda of agricultural transformation in Africa (e.g. the language used in the declaration of the 1st Africa Congress in Conservation Agriculture which notes that CA is ‘one of the best food security and profitability options for farmers’), with the establishment of the scientific evidence a secondary concern.

This creates a conundrum for research systems regarding CA in Africa. Despite contested literature on the benefits of implementation, as well as limited uptake by farmers, CA continues to be strongly promoted. The complex history of CA in Africa, therefore, raises questions as to whether local researchers are able to adapt CA in a participatory manner to ensure CA is beneficial, feasible and relevant to communities, or if the dominant CA narrative has limited its research and promotional activities to top-down mechanisms with limited input from local communities. That is, are local communities driving research in CA, or is it driven by outside interests and agendas?

This paper explores how CA is viewed by local researchers, whose voices remain absent from the literature. Through semi-structured interviews with 26 local researchers, we explore the context of CA promotion, the research questions they perceive as yet to be addressed, and the research, extension and political contexts through and in which CA is promoted. Our focus is on understanding, at national levels, what is occurring to ensure CA is adapted to local contexts, through which we build a greater understanding of the functionality of local agricultural research systems. The paper relates not only to CA, but to broader efforts in enabling sustainable intensification and the functionality of innovation systems in the studied countries (Ethiopia, Malawi and Mozambique) and beyond, though the absent viewpoints of local CA researchers themselves.

2. Methods

During 2015, qualitative, semi-structured interviews were conducted with 26 locally based agricultural researchers, working at either multi-national, national or regional level. Multi-national respondents worked within either the CIMMYT or FAO, with both organisations integral to promotion of CA in Eastern and Southern Africa. Regional institutes were selected due to the presence of ongoing activities from the CIMMYT-managed ‘Sustainable Intensification of Maize and Legume Systems in Eastern and Southern Africa (SIMLESA)’ project. National and regional respondents worked within their national Ministry of Agriculture (MoA), were nationals of the country they worked in, and lived locally within their area of responsibility. Respondents were randomly selected from within their institutes, with the objective of obtaining a diversity of perspectives from varied fields of expertise. Respondent’s fields of expertise included socioeconomics, plant physiology, agronomy, mechanisation, breeding and policy development. Table 1 provides the key for respondent identification within this study and their area of responsibility and organisation.

The methodology applied did not seek to find balance between locations or expertise’s, but to obtain a diversity of perspectives. Respondents were based in one of three countries:
Ethiopia, Malawi or Mozambique. The primary focus was placed on Ethiopia, with supplementary perspectives from Malawi and Mozambique as a way to share knowledge and experiences from diverse agro-ecological and institutional contexts. Malawi was selected for its considerable promotion of CA from both government and non-governmental organisations (see Dougill et al. 2017), in contrast with Mozambique and Ethiopia which were selected for their comparatively limited experience with, and uptake of CA despite growing promotional activities.

Interviews were structured to enable discussion of the promotional context of CA in their areas of work, and occurred in English with the lead author of this paper. All transcribed interviews were coded using Nvivo™ (version 11) content analysis software. This paper examines 15 hours of digitally recorded and transcribed interviews.

3. Results

Despite ongoing promotion with farmers, respondents nearly unanimously stressed that CA research was still ongoing (e.g. ‘we still need to do more research so we get the right details and information for the farmer … I feel it is not ready yet’ – L2), particularly in regard to the need for development of locally specific recommendations (e.g. ‘I don’t think the research phase is complete. There are some things we can import from the research of other countries, but there are also the tests that need to be locally done’ – A7). The research gaps perceived as needing to be addressed are provided in Section 3.1., while the perceived constraints in addressing these research gaps are provided in Section 3.2.

Table 1. Identification key used for interview respondents outlining their area of responsibility.

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<thead>
<tr>
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3.1. CA research gaps as perceived by respondents

The responses of respondents are summarised into five research questions, which reflected a need for more local adaptation of CA to ensure it was beneficial, feasible and relevant to farmers in the communities they worked in.

3.1.1. Do yield benefits exist through CA implementation?
Nearly all respondents raised concerns regarding the potential for CA to reduce yield, especially over in the early years of implementation (e.g. ‘The worry is it may compromise productivity and production in the short term’ – A5) or increase production risk through disease and water logging (e.g. ‘We are creating a lot of moisture and this creates an environment for fungus and diseases and pests’ – L2). Very few respondents were convinced that CA was widely beneficial in their area of responsibility without further research regarding local adaptation.

3.1.2. Are farmers likely to perceive CA as beneficial in terms of labour requirements?
Respondents were generally concerned that CA would not be perceived as a labour saving practice, both due to the requirements of CA and farmer preferences. This was particularly true when herbicides were not used (e.g. ‘Herbicides are critical for weed management, so as to balance the labour savings from tillage and high demands for weeding labour’ – i2). Respondents also identified farmer hesitance towards the changes in required labour to implement CA (e.g. ‘If they have to do that hard work, farmers will not adopt it. They will ask why they will do something that creates more work for them’ – Y8), and particularly when encouraging hand-hoe CA where animals are available for tillage activities (e.g. ‘this message to keep the cow out and go back to manual tools, it’s not manageable. It’s a step backwards down the ladder’ – i4). Where additional hired labour was required, there were also concerns regarding availability (e.g. ‘during the rainfall period, many people are busy with farming, so labour is scarce … and very expensive. That is the major issue that we have found’ – Y4).

3.1.3. Are farmers financially able to implement CA systems?
Respondents identified that many of the farmers they worked with existed in low-input, low-output (LILLO) poverty cycles and CA may not be relevant to their production systems (e.g. ‘The issues from farmers is mainly that the input and fertiliser price is too high and the output markets are too low. Thus they cannot afford the inputs. Because of this, the productivity is too low … It is circular, there is no market and there is no production’ – B13). Respondents questioned if under the current marketing systems CA would be widely embraced (e.g. ‘If they knew they could grow soybean and make money, and someone will show up in the village at the end of the season and give a reasonable price, they will do it. But they are not going to do it, so they say ‘what is this crop, I don’t like eating it, I don’t know anyone who eats this thing, and I can’t sell it. So why would I grow it?’’ – i2).

3.1.4. Are inputs available for farmers to implement CA systems?
All respondents subscribed to the need for inputs to implement CA (particularly inorganic fertilisers and herbicides), yet were concerned about how accessible these inputs were (e.g.
'When the farmer sees the next technology, they are limited in their ability to adopt… There are not any inputs for them to use. The problem is not always the farmers, it can be that the technology is not available to the farmers’ – P11). These concerns were most present for herbicides in Ethiopia (e.g. ‘It is usually the private traders who are buying in Addis and distributing to farmers, usually at very high prices, sometimes with farmers paying 3 or 4 times what they would pay in Addis’ – i1).

3.1.5. Are farmers likely to use stover resources for soil fertility purposes?
Respondents strongly identified issues with stover competition within farms, and particularly a cultural preference for feeding stover to livestock over soil fertility activities (e.g. ‘Livestock is a bank here for money – they consider it their bank despite it is in kind, it’s a big asset. They also consider livestock as a kind of expression of wealth culturally, if you have many animals, you are respected in society’ – A7). They also raised concerns that CA systems were not relevant due to a lack of stover security from various sources including: (1) Termites and disease (e.g. ‘The farmers accept CA as an idea. But practically, one problem is the residue management, the termites and diseases that come with it’ – P11); (2) Rodent hunting (e.g. ‘CA is failing to pick up because of other external forces like mice hunters and grazing and things like that… they are not yet trusting of the surrounding external forces which are pushing them back’ – L3); (3) communal grazing (e.g. ‘Stover retention is difficult because in our cultural system we have open grazing and livestock is very important. If the farmer retains residue, then livestock will just eat it… I think residue retention is too difficult in this open grazing environment’ – B13); and (4) fuel wood shortages (e.g. ‘because here, we don’t have any firewood, so the population, when the season ends, the people will remove the stover to be used for fuel’ – U5). Overall, stover retention practices were seen as unlikely to be widely adopted even if the benefit of CA systems was proven.

3.2. Constraints to addressing research gaps
After identification of the pressing research questions that researchers held, respondents were asked to assess how successfully these issues were being addressed. In nearly all cases, respondents asserted that they were unable to address these research gaps, due to the research, extension and policy contexts in which they operated.

3.2.1. Research context
Respondents strongly perceived that a lack of CA adaptation reflected the continued application of top-down and non-participatory mechanisms and a narrow focus of research activities. The majority of respondents identified that this reflected the CA development process that primarily occurred on research stations that do not have the same contextual realities confronted by farmers (e.g. ‘the problem is these demonstrations, you have all the variables under control. But when you are scaling out [with farmers], most of the variables are out of control … from inputs, to outputs, to production and markets, and processing’ – A4). This culminated in the continued application of top-down approaches (e.g. ‘The research and development modus operandi is very classical, very linear. It is really like things are cooked in the research station and unfolded at farms’ – i4), with limited farmer input (e.g. ‘In a practical way, the extension system organised by the ministry of
agriculture on the ground is not participatory. From planning to implementation, farmer views are not often listened to’ – B15).

Overall, there was a common theme that the farmer’s situation was not being addressed (e.g. ‘There is also this issue that we are looking at yield of cereals and I don’t know if we are really evaluating and developing our improved technologies based on the criteria of farmers’ – i4), and that there was a narrow focus on CA without understanding the wider farming systems (e.g. ‘We need the integrated approach with value chains because just working on one aspect of this system is not solving the problems’ – A4). This was particularly relevant for addressing stover constraints (e.g. ‘Unless we address some of the existing problems that farmers have, these technologies are really challenging, unless you come with alternative options for forage production, multipurpose legume production or reducing the number of livestock’ – i1).

3.2.2. Extension context
While respondents asserted a need for greater interaction with farmers, they identified several constraints in doing so due to the context in which extension occurs. This reflected three constraints:

3.2.2.1. Limited trust held by farmers. Respondents identified that farmers had limited trust in research and extension services, and particularly so in Ethiopia. This extended to both the government services (e.g. ‘Due to these [political] reasons the farmers don’t have trust in the development agents, because they are just looking after political issues rather than the realities of agriculture’ – B14) and lead farmers within their villages (e.g. ‘You can see that some model farmers are politically aligned. Model farmers and extension agents can play politics, so farmers are not selected for their extension merits and this can be a problem’ – P11). This was further complicated by a conflicting informational environment wherein researchers were providing information counter to prevalent extension recommendations (e.g. ‘They have all these NGOs with conflicting messages, so it seems like the government extension is seen as a liar, or he is not a true professional and knowledgeable’ – Y4), and particularly when religious organisations are involved in the promotion of alternative systems (e.g. ‘Some people who are religious, they have been told by the church it can be sinful to use chemicals. I don’t know why they say that, but it is important for the farmers who are religious’ – P11). Due to this, researchers had limited ability to meaningfully engage with farmers, particularly under short time frames set by projects and governments to achieve impact.

3.2.2.2. Capacity of extension services. Researcher interaction with farmers was generally enabled through government extension services. Yet respondents identified limited capacity within the extension services to facilitate this interaction. This reflected both human capacity (e.g. ‘The extension personnel, the old ones who have been here for a long time, they have the old messages and they cannot even understand the new package for themselves’ – Y4) and financial capacity (‘We have very few extension officers, and the coverage is not sufficient. There are farmers who you ask them if they even have interacted with an extension agent and they will say ‘no’. They don’t even know the extension worker’ – Y8). There were also concerns regarding gender (e.g. ‘Woman consist of more than 50% of farmers, but they are not exposed to trainings, not in the right
groups and not given a fair chance compared to fellow men’ – A6), leading the majority of respondents to be concerned regarding current extension services ability to facilitate interaction (e.g. ‘The [extension] system doesn’t work. There is now a huge gap in terms of information, and the correct information is not being received’ – L2).

3.2.2.3. Extension mechanisms. Respondents were also concerned regarding the functionality of promotional mechanisms used in the extension of CA to farmers and their impact on facilitating meaningful interactions with researchers. Their major concern involved the pathways in which CA was promoted as an aggregate technology, and the need for more flexible and transitional approaches (e.g. ‘adoption as a component by component [pathway] is better, doing it stepwise and not as a whole … Farmers can’t use everything, but they can select what is achievable in their system’ – Y4). The current promotion through CA as an aggregate technology and the use of incentives to enable uptake was perceived to have created problems, including a lack of ownership of CA (e.g. ‘We need to have a system where the farmers act like the work coming to them is theirs, not owned by research or extension. If you go and put a demonstration there and say to them, “we are doing this and this and then you will benefit this and this”, you will then come back in two years and nothing would happen’ – L3) and the development of jealousy within the community (e.g. ‘The aspect of jealousy most of the time comes in because of the aspect of the free inputs and handouts. Because we are giving the lead farmer everything, so most of the time, the ones who follow develop that aspect of jealousy’ – L2). There was now an engrained expectation for inputs which hinders further research interactions (e.g. ‘When you approach a farmer here, they know you are coming from an NGO or whatever, so they expect start up chemicals. They think if we are to expand, these people always come in and give us everything to expand. So why would they use their own resources? … It becomes problematic to go and visit a farmer without any other handout. They will not listen to you’ – L3).

3.2.3. Policy context
Respondents also identified a policy void that limits their mandate to implement research on CA with farmers (e.g. ‘If it is not with deliberate policy to make sure the officers take up CA in their activities, the budget to train, the budget to follow up these farmers and also to pick the demonstrations to encourage those to do CA, if that doesn’t happen, then we still have a challenge of those adopting CA’ – P10). Particularly in Ethiopia, there were also concerns on conflicting government messages that put researchers in difficult positions when liaising with farmers (e.g. ‘The areas where the government advises to plough three or four times, that will be very low adoption for minimum tillage. This is because of the importance of government extension to Ethiopian farmers’ – A1).

4. Discussion
Douthwaite, Keatinge, and Park (2001) highlighted the integral need for negotiation between researchers and farmers to ensure continued adaptation of farming practices in situ, ensuring practices are not only beneficial, but feasible and relevant to the context of end users. This is particularly crucial for the introduction of complex, multi-component technologies such as CA within resource constrained contexts such as in Sub-Saharan
Respondents in this study held views consistent with these concepts, clearly articulating the need for more local adaption of CA, yet identifying that this adaptation was not occurring.

Five key research gaps were identified by respondents to be addressed before CA will be ready for farmer implementation. All five of these persisting research questions have been previously reported in the literature, viz: uncertain agronomic benefits (e.g. Pittelkow et al. 2015), stover trade-offs (e.g. Homann-Kee et al. 2015), labour requirements (e.g. Baudron et al. 2014), limited financial means (e.g. Grabowski et al. 2016) and non-functional value chains (e.g. Giller et al. 2009). These themes are also consistent with the recent explorations of farmer perspectives on CA in eastern and southern Africa (e.g. Brown, Nuberg, and Llewellyn 2017a; Brown, Llewellyn, and Nuberg 2018), which highlight the concerns of community members about the benefits, feasibility and relevance of CA in the African smallholder context.

The importance of this study is in highlighting that respondents in this study are not ignorant of these issues, but feel unable to address them. It demonstrates that the dominant pro-CA narratives of international donor organisations, particularly that CA is ready for scaling up (e.g. Kassam et al. 2015), are not held at the local research level. CA is not viewed as a finished product, but requiring substantial further research, particularly to meet the criteria of farmers in their selection of their agricultural livelihoods. That such themes continue to be raised begs questions as to why this further research on local adaptation is yet to occur.

Respondents asserted that the lack of adaptation in each of the three countries reflected the dominance of top-down extension systems that were unable to incorporate farmer perspectives and lacked the involvement of communities in the development of CA. This was reflected in four of the five research gaps relating to a lack of compatibility between CA in its current package and the objectives (e.g. diverse uses for stover, undesirable labour) or the abilities (e.g. to intensify their input usage due to financial limitations) of farmers. Such assertions are consistent with several studies that suggest technologies promoted to African smallholders tend to be through top-down mechanisms (Lynam et al. 2016) that are unresponsive to smallholder contexts (Hall and Yoganand 2004), leading to the promotion of unsustainable, unprofitable or socially unacceptable technologies (Van Asten et al. 2009).

It is important to note that respondents had a clear philosophical preference for greater engagement with farmers, yet they perceived that their institutional situation did not enable them to implement this preference. They asserted a lack of mandate to implement CA research, as well as a lack of functional mechanisms for interaction with farmers through extension systems. Such findings add further weight to the calls for deeper explorations into the functionality of current extension mechanisms implemented in Africa (e.g. Brown, Nuberg, and Llewellyn 2017a; Wellard et al. 2013; Brown, Nuberg, and Llewellyn 2018).

Overall, the perspectives of respondents in Ethiopia, Malawi and Mozambique indicate that CA remains a donor-driven technology yet to be made beneficial, feasible or relevant to smallholder situations (as suggested by Andersson and D’Souza 2014 and Giller et al. 2009). The lack of local adaptation highlights that the dogma surrounding CA remains, as evidenced by a lack of examples of the local adaptations made to CA to increase its applicability in eastern and southern Africa. Indeed, some of the attempted local adaptations,
such as stover importation to address limited biomass production, have had negative consequences on farmer perception of CA as they have ignored farmer desires (Brown, Nuberg, and Llewellyn 2017a). The continued promotion of CA also reflects the important contribution of international donors to agricultural research and development efforts, especially in countries such as Malawi where government budgets are limited and there remains a high dependency on donors to fund government activities.

If CA is to be further adapted to enable implementation by farmers in the studied countries (and more broadly with similar issues identified more broadly with the region; ASTI 2017), respondents indicated a need for a more flexible framing of CA which would reflect the results of further testing and adaptation of CA in farmer contexts. To enable this, they identified the need to build three key capacities:

1. Social capacity: Participatory research systems require increased social capacity to enable strong collaboration with farmers, yet respondents identified their connectivity with farmers was often limited by issues with trust and social cohesion. This reflected limitations with both the trust in the accuracy of information provided by researchers and the mechanisms through which information was provided, leading to a culture of financial expectation and disincentives to invest, as well as a confusing informational environment that leads to conflict between informational providers. Such findings are consistent with the findings of Brown, Nuberg, and Llewellyn (2017a) when exploring why farmers negatively evaluate CA and Brown, Nuberg, and Llewellyn (forthcoming) when exploring the perspectives of agricultural extension service providers. If researchers are not able to effectively interact with farmers, then the ability to implement participatory research systems will be restricted. Hence, calls for more participatory research systems must be met with longer term activities to build the social capacity of communities to engage and interact with researchers.

2. Financial capacity: Participatory extension systems are more costly than top-down systems because they require increased interaction of various stakeholders to negotiate the technologies and create and test various iterations to ensure benefit, feasibility and relevance. Yet the extension systems in all three countries in this study are underfunded, noting that although the Global Forum on Agricultural Research recommends developing countries invest at least 1–1.5% of agricultural GDP in agricultural research (Lele et al. 2010), Malawi invests only 0.53%, Mozambique invests only 0.36% and Ethiopia invests only 0.24% (ASTI 2017). Increasing funding will, therefore, be required to implement more participatory research activities.

3. Human capacity: Participatory extension systems require a balance of disciplines and strong linkages to enable the negotiation of technological development. However, respondents asserted that research activities were often narrow in focus and limited in connectivity across disciplines. This is likely a reflection of the human capacity of the NARs. Firstly, the number of agricultural researchers is limited in each of the studied countries, all of which employ fewer than eight agricultural researchers (FTE) per 100,000 farmers, and fewer than four per 100,000 in Mozambique (ASTI 2017). Noting the need for multidisciplinary expertise to locally adapt agricultural practices to hugely diverse and dispersed farming communities, it appears the institutional capacity is limited. Secondly, there is often limited balance in the NARS. For example, the Malawian research system is dominated by plant breeders and geneticists (47% of researchers according to ASTI 2017). Likewise, there is also a strong focus on
physical disciplines, with the socioeconomics discipline accounting for only between 6% and 13% of researchers and researchers on extension between 0.2% and 6.3% (ASTI 2017). This may also reflect a continuation of the lack of training in participatory research methods within research institutions (Lilja and Bellon 2006). Hence, there is limited balance and potential for a lack of capacity to implement participatory research systems.

It should be noted that building the above capacities will lead not only to greater adaptation and potential uptake of CA, but to an overall strengthening of the agricultural research system more generally. It will enable greater autonomy for each of the studied countries to better set their own agricultural agendas and more strongly inform their agricultural policy directives, moving away from the current donor-funded priorities that potentially lead to promotion of inappropriate practices. This building of capacity will also enable research systems to better serve their constituents though enhancing the relevance of their output, increasing their impact and facilitating the movement towards more productive and sustainable agricultural production systems.

5. Conclusions

The limited uptake of improved agricultural practices in Africa raises questions on the functionality of current agricultural research systems. We use CA as a case study in Ethiopia, Malawi and Mozambique to explore how research systems are adapting new agricultural practices to local contexts to ensure their applicability to smallholder farmers. Local agricultural researchers in this study identified that CA was not yet a finished product, but required substantial further adaptation to ensure there was sufficient benefit, feasibility and relevance to engage smallholder farmers, contrary to the strong pro-CA narrative that CA is ready to be widely scaled out. Yet respondents also identified limited capacity to do so, with assertions that top-down research and extension mechanisms persisted within research systems that allowed only limited integration of farmer contexts. This was in part attributed to a limited ability to interact with farmers though current extension systems and limited perceived mandate. As such, CA may be viewed as a donor-driven intervention without local ownership in its current packaging. To enable greater uptake, respondents identified a need for a more flexible packaging of CA and the need to build the institutional capacity of research and extension systems, primarily in regard to social, financial and human capacity. Without this, the successful widespread uptake of complex farming systems changes required to sustainably intensify smallholder farming systems in the studies countries, and more broadly noting similar limitations in the region, appears unlikely.

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References


Section D: The ‘How’ of CA Utilisation

Building on the findings of Section B (the ‘what’ of CA) and Section C (the ‘why’ of CA), this section compares these findings with the contexts of other regions that are identified as successful implementers of CA. In doing so, it addresses the third research objective.
Chapter Eleven:
Expectations for CA Utilisation in Africa

Chapter 11 contains the tenth manuscript of this thesis which compares the utilisation of CA across several regions globally to the African context. A summary of the manuscript is provided, followed by the statement of authorship and manuscript 10.

11.1 Manuscript Summary

![Global Context and African Context Diagram]

**Figure J:** Graphical abstract for manuscript 10.

**Context:**
- There has been limited utilisation of CA by African smallholder farmers despite similar periods of introduction as other regions.

**Research objective:**
- To explore the types of CA utilisation that occur globally to re-evaluate the expectation for CA utilisation in Africa; and
- To explore the patterns for utilisation of CA globally to re-evaluate the expectation for CA utilisation in Africa.
Methods:

• Review of adoption in various regions of CA utilisation, and comparison with the African situation.

• Application of the standardised CA nomenclature with the CAAF and the LPA.

Findings:

• It is rare to have the simultaneous implementation of all three CA principles in any studied region, and hence it should not be expected to occur in the African context.

• Common requirements for the wider utilisation of CA that have occurred elsewhere but are absent in the African context were found to be: 1] strong perceptions of benefit; 2] financial stimulation of households; 3] functional resource exchange mechanisms; 4] development of social capital to enable adaptation; and 5] collaboration of farmer organisations with stakeholders to create an enabling environment.

Implications:

• To enable the sustainable intensification of African smallholder agriculture, there is a need for: 1] development of financial incentives to engage farmers in market orientation and crop intensification; 2] development of strong social capital to enable adaptation; and 3] lower expectation on types of CA and period for change to occur.
11.2 Statement of Authorship

Manuscript Details:

| Title of Paper: | Global learnings to inform the local adaptation of conservation agriculture in Eastern and Southern Africa |
| Publication Status: | Published |

Principle Author:

| Principle Author: | Brendan Brown (Candidate) |
| Contribution to paper: | Analysis of data, interpretation of results, writing of manuscript, acted as corresponding author |
| Overall percentage: | 90% |
| Signature: | Date: 17/08/2017 |

Co-Author Contributions:

By signing the Statement of Authorship, each author certifies that:

i. the candidate’s stated contribution to the publication is accurate (as detailed above);

ii. permission is granted for the candidate in include the publication in the thesis; and

iii. the sum of all co-author contributions is equal to 100% less the candidate’s stated contribution.

| Name of Co-Author | Contribution to paper: Supervision, evaluation and editing of the manuscript |
| Signature: | Date: 17/08/2017 |

| Name of Co-Author | Rick Llewellyn |
| Contribution to paper: | Supervision, evaluation and editing of the manuscript |
| Signature: | Date: 17/08/2017 |
Global learning to inform the local adaptation of conservation agriculture in Eastern and Southern Africa

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ABSTRACT

Conservation Agriculture (CA) has been widely promoted as a part of the process of sustainable agricultural intensification in several major grain producing regions but in many developing countries, such as those in sub-Saharan Africa, its uptake has been low. Through a broader view of the uptake of CA beyond binary adoption, this review addresses two research questions: (1) how has CA been modified in various regions around the world? and (2) what processes occurred to enable CA uptake? We compare global learnings with the context in Sub-Saharan Africa to assess expectations for uptake and leverage points to address limited practice change in African smallholder systems. Our findings indicate that there is limited evidence to suggest that continued use of a ‘complete’ three component version of CA has been widely implemented in any region and so should not be expected to readily occur in the African situation. Likewise, we find that there are multiple processes and developments required beyond acute erosion issues to enable CA uptake, namely: (1) strong perceptions of individual benefit; (2) economic stimulus to enable and motivate investment in CA systems; (3) functional market exchange mechanisms to supply the required resources to implement CA; (4) development of farmer driven organisations to drive local adaptation of CA; and (5) collaboration of farmer organisations with other institutions to create an enabling environment for further CA adaptation. The situation in many countries across eastern and southern Africa is without these required developments to enable CA utilisation. With this in mind, we identify three key learnings from a review of CA in the global context and the implications for Africa: (1) financial stimulation of households will be required to enable African smallholder farmers to transition to market orientation through utilisation of CA components; (2) farmer organisations require further development to enable context-specific adaptation of CA which will require strong collaboration with various stakeholders and institutions; and (3) expectations on both the type of, and period for, CA utilisation must be lowered, noting the substantial institutional change required.

1. Background

Sustainable intensification of African agriculture is urgently required to feed a rapidly expanding population (Pretty et al., 2011) through sustainable productivity increases and without land expansion (Bank, 2007). Conservation agriculture (CA) has been promoted as one major pathway to achieve this (see Giller et al., 2009) through the simultaneous implementation of minimal soil disturbance, permanent soil cover and crop diversification practices (F4AO, 2014). The various benefits accrued by farmers and the environment in implementing CA-based systems have led to substantial global uptake, with more than 157 million ha now estimated to be under CA-based production systems (Kassam et al., 2015).

The importance of CA in Africa is underpinned by the high potential for increased agronomic and environmental outcomes (Msapangwa et al., 2016; Thierfelder et al., 2016), though such benefit may be nuanced (Pittelkow et al., 2015). Despite CA entering African regions at a similar time to other regions globally, Africa has shown the least uptake of CA, both in terms of cropland area (1.2 Mha) and percentage of cropland (0.9%; Kassam et al., 2015). As such, CA remains a potentially beneficial production system that is yet to impart substantial benefit to the livelihoods of African smallholder farmers. This review aims to contextualise this limited uptake and specifically address two research themes:

1) In regions where substantial CA uptake has occurred, what are the dominant types of CA being implemented and what implications will this have on the expected types of CA in eastern and southern...
Africa? To overcome the substantial ambiguity within the literature regarding the classification of CA (and CA components), we apply the proposed standardization of CA (and CA components) definition as proposed in Brown et al. (2017c), whereby each CA component is assessed independently and then as part of a CA aggregation; and 2) In regions where substantial CA uptake has occurred, what processes enabled CA uptake to occur and what implications will this have for the expected uptake of CA in eastern and southern Africa? Whist acknowledging the important benefits and costs of CA utilisation beyond the farm level, it is not within our scope to review the societal benefits and environmental services that CA provides. Instead, we focus on the changes in farmer perception and broader processes that enabled farmers to transition to CA based farming systems.

It should be noted that such a review is complicated, particularly in the African experience, by ambiguity in what constitutes ‘CA’ and ‘CA adoption’ (see Broza et al., 2017a), as well as the dominance of gray literature on the subject, mainly in the form of project documentation. This review draws on such literature due to the close relationship that these sources tend to have with farmers and the desire to review farmer perspectives and developments. Many studies also tend to be focused at the agronomic and/or plot level, with farm and socioeconomic factors often remaining under-researched (Thierfelder et al., 2015) and focused on the technology itself rather than the process of enabling change (Baudron et al., 2015a, 2015b). These are the gaps that this review aims to highlight and address, through the opportunity to learn from the experiences of regions with substantial CA uptake and apply these learnings to the African context. In doing this, we provide a useful evaluation of the pathways and expectations for CA uptake in the African smallholder context and reveal new opportunities to leverage research and extension systems to enable wider CA uptake in eastern and southern Africa.

2. Types of CA implementation

CA is an aggregation of interrelated practices that has come to be defined by the FAO (2014) as the simultaneous implementation of:

1) Minimum soil disturbance (though a disturbed tillage area of less than 15 cm width or 24% of area); and
2) Crop residue cover of the soil (with a minimum of 30% soil cover at planting); and
3) Crop diversification (with greater than three crops in rotation).

Whilst this definition is often cited in the literature, there tends to be ambiguity around its practical application in the classification of CA adoption (Andersson and D’Souza, 2014; Brown et al., 2017b). Periodic global estimates of CA uptake are often cited as evidence of the far reaching success of CA (e.g. Derpsch et al., 2011; Friedrich et al., 2012; Kassam et al., 2015) yet are limited in addressing the adaptation of CA to local contexts, in part due to a focus on CA as a yes-or-no binary outcome (Brown et al., 2017a), the potentially biased methods used in data collection and often synonymous use of zero tillage, minimum tillage and CA (most likely due to the datasets available to make such estimates). Particularly in the North American and Australian contexts, the literature tends to specifically report on no-till, often without reference to the remaining two CA practices. Because of this definitional ambiguity, estimates of CA adoption within regions can vary greatly and make comparisons across regions difficult.

2.1. Types of CA implemented globally

In Table 1, we provide a review of the limited literature that explores the types of CA that occur across 11 countries. The 11 countries presented account for 96% of global CA area according to Kassam et al. (2015). While the definition of CA applied in studies such as Kassam et al. (2015) is often ambiguous and there are limitations in their collection of data, they provide a strong basis for understanding the proportional utilisation of CA and CA components globally which cannot be achieved through more geographically focused studies. These 11 countries are reviewed in terms of the types of CA and CA components implemented to understand what local modifications to the FAO (2014) definition have occurred globally.

2.2. Types of CA implemented in Africa

Whilst there have been some reports of substantial expansion of CA activities in Africa (e.g. Kassam et al., 2015; Mloza-Banda and Nanthambwe, 2010), multiple studies have shown that implementation of CA by African smallholder farmers tends to be in modified forms (e.g. Giller et al., 2009; Gowing and Palmer, 2005; Pannell et al., 2014). Brown et al. (2017c) studied CA utilisation across more than 6100 farmers in five countries (Ethiopia, Kenya, Tanzania, Malawi and Mozambique) in 2010 and found that 94% of CA implemented by smallholder farmers was in modified forms rather than ‘complete CA’ as defined by the FAO. Brown et al. (2017a) further extended those findings to understand the types of CA implemented by farmers, finding only 0.3% of farmer plots (n = 27,515) would meet the definition of CA specified by the FAO (2014) in the implementation of all three CA principles to adequate thresholds. Applying a wider definition of three CA components implemented together in any capacity, only 0.8% of plots were identified. Such findings are consistent with the growing body of analysis of CA utilisation identifying the substantial modification and limited total utilisation of CA that dominate across sub-Saharan Africa (e.g. Baudron et al., 2017; Bunderson et al., 2017; Pannell et al., 2014).

Fig. 1 provides the breakdown of the types of CA found by Brown et al. (2017a), highlighting the limited application of multiple components of CA, and especially minimum tillage practices by the surveyed farmers.

2.3. Implications and expectations for the types of CA implemented in Africa

The continuous application of all three CA practices as part of a ‘complete CA’ appears to be rare and the modification of CA tends to be the most likely outcome (both in the global and African context), including where principles of low soil disturbance, residue retention and crop rotation are accepted as valued objectives. Whilst farmers may find ‘complete CA’ an attractive production system, they are likely to adapt beyond the strict definition of CA to a modified system that best suits their situation. As such, we contend that enabling CA uptake in eastern and southern Africa will involve greater flexibility in CA promotion, which should be reflected in a change in focus from increasing technological ‘adoption’ to a greater focus on the adaptation as part of a wider sustainable intensification process (Brown et al., 2017c; Thierfelder et al., 2015). This is consistent with the typical path farmers have taken elsewhere, particularly for tillage activities. The framing of CA will require a refocus towards promotion as part of a flexible and pragmatic framework to guide farmers in the sustainable intensification of their production systems and not as part of a strict classification of CA systems. This is in line with the recommendations of recent literature that highlight the need for greater localised adaptation and processes oriented (rather than outcome oriented) agricultural development activities (Giller, 2012; Glöver et al., 2016; Baudron et al., 2015a, 2015b).

Hence, we conclude that there is a need for more pragmatic promotion of CA in Africa that reflects transitional pathways based on modifications (such as in other regions) whilst maintaining the longer term objective of ‘complete CA’. This will also involve a lessering of expectations for total CA utilisation as has occurred in other regions and contexts.
Table 1
A review of the types of CA and CA components implemented in the top 11 countries of CA uptake globally. Ranking and percentage of global area are based on Rasam et al. (2015).

<table>
<thead>
<tr>
<th>Country (rank)</th>
<th>% of global CA area</th>
<th>Features of CA system identified in the literature</th>
</tr>
</thead>
<tbody>
<tr>
<td>North America</td>
<td>23% USA (1st)</td>
<td>Permanent minimum tillage is applied on only 10–12% of no-tillage area (Kassam et al., 2013).</td>
</tr>
<tr>
<td></td>
<td>Guatemala (4th)</td>
<td>Limited information exists on the extent of residue retention due to a focus within the literature on reporting of no-tillage.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Limited diversification exists beyond intensive maize-soybean rotations (Balik, 2017).</td>
</tr>
<tr>
<td>South America</td>
<td>Brazil (2nd)</td>
<td>At least a third of reported CA area is periodically tilled (Rasam et al., 2015).</td>
</tr>
<tr>
<td></td>
<td>Argentina (3rd)</td>
<td>Crop residue cover between crops can be limited (Oprea and, 2014).</td>
</tr>
<tr>
<td></td>
<td>Paraguay (6th)</td>
<td>Soya mono-cropping without other diversification dominates many production systems (Kassam et al., 2015).</td>
</tr>
<tr>
<td></td>
<td>Uruguay (11th)</td>
<td>Most farmers retain flexibility in their tillage activities, and it is common for no-tillage adoption to periodically apply some cultivation (Rickard et al., 2013).</td>
</tr>
<tr>
<td></td>
<td></td>
<td>20% of no-tillage adopters continue to burn some crop residue resources and crop residues are often used within ancient crop rotation systems (Lal et al., 2012).</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Comparative profitability may limit legume diversification in some regions, particularly in cereal-based systems (Das et al., 2010).</td>
</tr>
<tr>
<td>Australia (5th)</td>
<td></td>
<td>Full adoption of CA is limited and utilization of multiple components of CA is rare (Wang et al., 2010).</td>
</tr>
<tr>
<td>China (6th)</td>
<td></td>
<td>Limited crop rotation exists beyond maize-wheat rotations, rotary tillage is used for wheat with rice-wheat systems and removal of crop residues after harvest is common (Li et al., 2014).</td>
</tr>
<tr>
<td>Russia (7th)</td>
<td></td>
<td>No information available.</td>
</tr>
<tr>
<td>Kazakhstan (8th)</td>
<td></td>
<td>Three factor CA is only applied to 20% of identified CA area (Kassam et al., 2015).</td>
</tr>
<tr>
<td>India (10th)</td>
<td></td>
<td>Continued use of tillage for rice within rice-wheat rotations is common, and limited diversification beyond rice and wheat occurs (Hartvig, 2008).</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Burning of crop residues common (Abed et al., 2015).</td>
</tr>
</tbody>
</table>

3. Communal processes to enable the wider uptake of CA

The pathways to mass uptake of CA have rarely been short or simple, but rather the culmination of multiple developments that together enable farmers to find benefit, feasibility and relevance in the implementation of CA-based production systems. While the droughts of the 1930s in midwestern USA led to the ‘great dustbowl’ and subsequent questioning of conventional production systems (e.g. Faulkner, 1943), it took until the late 1980s for substantial uptake to begin occurring on farmers’ fields (Farnoq and Siddique, 2014). This reflects that while direct drill machinery was developed in the 1940s (Friedrich et al., 2012), successfully demonstrated in the 1950s (Harrington, 2008), and extended in the early 1970s from North America to Brazil and Argentina (Friedrich et al., 2012), Australia (Barrett et al., 1972), China (Li et al., 2014) India (Hafeezur-Rehman et al., 2014) and Africa (Wall et al., 2014), the enabling environment and processes for CA uptake took more than five decades to develop. Gray (2010) highlighted that such a process involved a multitude of developments including mechanical innovation, agricultural knowledge, manufacturing scale, on-farm changes and changes in input and output market prices. We review the processes that enabled uptake to occur through two groupings: large commercially oriented farmers of North America, South America and Australia; and smallholder farmers in South America, South Asia and China.

3.1. Commercially oriented farmers in the Americas and Australia

The development of conditions for the utilisation of CA by commercial farmers in North America, South America and Australia are broadly similar (Gray, 2010), and pertain to developments from individual, household, community and institutional levels, namely:

3.1.1. Development of strong perceptions of benefit in substitution of tillage with herbicides

The relative advantage of weed control using herbicides compared to cultivation is often attributed as a primary driver of CA

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Fig. 1. Types of CA utilization across maize growing regions in Ethiopia, Senegal, Tanzania, Malawi and Mozambique in 2010 found by Brown et al. (2017a) as the plot level is = 27,045 plots. Each of the three components of CA is presented separately and then as simultaneously implemented components in part as a Venn diagram. Threshold use is classified using the Conservation Agriculture Appraisal Framework (CAAF) from Brown et al. (2017c) using established thresholds as follows: for Stover cover: 3 t dry matter ha at planting; for Minimum tillage: a maximum of one tillage event per season; and for Legume diversification: a legume diversification index of greater than 0.33.
implementation by commercial farmers (D’Emden et al., 2006). The advent of glyphosate in the 1970s (Calegari et al., 2014) alongside large fuel price increases (Calegari et al., 2014; Ward et al., 2010) in each region led farmers to substitute more expensive tillage operations with cheaper herbicide use, saving time, labour and costs in production. Benefit was further increased with the end of the relevant patents, especially in Brazil (Galindo-Jurado et al., 2020). This led to strong perceptions from farmers regarding the benefit and relevance in transitioning to CA systems.

3.1.2. Development of household financial resources through structural changes
As summarised by Derpich (2003), even though the environmental and agronomic benefits of CA have been evident since the 1940s, the main driver of mass utilisation was the change in the economic viability of farming, and cropping in particular. This produced both increased capital to invest in CA and longer term planning horizons to consider sustainability as part of the production system. In each region, an economic stimulus occurred that increased the profitability of more intensive grain production and thereby the potential benefit of CA cropping systems, viz:

- **South America**: Government policies and subsequent markets that incentivised farmers to move from livestock to soybean based livelihoods, and environments that were often conducive to double cropping (Harrington, 2006);
- **USA**: Declining tobacco prices and double cropping soybean market opportunities (Van Es and Notier, 1998);
- **Canada**: A grain price boom that increased farm-gate grain price eight-fold (Fulton, 2010);
- **Australia**: Declining wool prices that led to increased cropping intensity (Leeweldyn et al., 2012).

3.1.3. Development of community exchange mechanisms that met demand for inputs
As farmers’ perceptions of the benefit and relevance of CA grew, input value chains, especially for herbicides and minimum tillage equipment, were able to meet farmer’s demands and address feasibility constraints. Economies of scale were reached, and the cost of CA system inputs also further decreased. For example, glyphosate in Australia fell from an average of A$18.30/L in 1983 to an average of A$4.50/L in 2003 (D’Emden et al., 2006). The local adaptation and manufacture of minimum tillage equipment also decreased the cost of importation, further driving the cost of CA systems down. Such economic opportunity stimulated the growth of value chain operators, in turn continuing the economic development of the agricultural sector (Gray, 2010).

3.1.4. Development of farmer driven innovation groups that enabled local adaptation
As experience with and benefits from CA grew, local farmer innovation groups developed from within communities that enabled ownership of CA and continue CA modification to meet local contexts, particularly with machinery (Galindo-Jurado et al., 2012). Much of the success of CA is hence attributed to community driven participatory research and extension networks (Blaibro, 2003) and their close collaboration with industry, government, research centres and extension services (Buecher et al., 1998). The development of CA in Brazil was possible through public-private partnerships with farmers and their associations (Operati et al., 2015) and likewise in Australia, where farmer groups are considered instrumental in encouraging farmers to test and refine CA practices to suit local conditions (Ward and Siddique, 2015). These ‘local innovation networks’ remain crucial to the current and ongoing adaptation of CA to new challenges such as herbicide resistance and further machinery development.

3.1.5. Development of enabling institutional environments by governments
The public good aspects of both increased agricultural output and natural resource management benefits led governments to increasingly develop enabling policies for CA. According to Ward et al. (2010), this was achieved through three main mechanisms: (1) changes in economic policy to incentivise practice change; (2) changes to environmental policy to create awareness, and (3) change in fiscal policy to provide funding for conservation programs and reflect greater government interest in facilitating practice change. Tangibly, this was reflected in the funding and implementation of programs such as the National Farm Stewardship Program in Canada (Fuglie and Koscak, 2001) and the various ‘LandCare’ programs in Australia (Thomas et al., 2007). Such programs provided cost share funding for conservation initiatives as well as funding for locally relevant studies on CA implementation to raise awareness and ensure feasibility and relevance within the local context. Such programs highlighted the importance of partnership, resources, local credibility and persistence in creating enabling environments for CA utilisation.

3.2. Smallholder farmers across South America, South Asia and China
The utilisation of CA by smallholder farmers has been far more limited, with only 0.3% of area under CA on smallholder farms in 2010 (Derpich et al., 2010). While smallholder utilisation of CA has occurred, it has tended to be where farmers are able to accrue benefits in the intensification of mechanised activities; substitute tillage with herbicides; and address narrow planting windows (Baudron et al., 2015a, 2015b). While smallholder utilisation remains limited (see Table 1), there are three regions that have been identified as successful examples of smallholder CA uptake: South America, South Asia and China.

3.2.1. Smallholders in South America
During CA’s development in South America, the focus was primarily on large scale farms which had intensive use of inputs, with smallholder farmers only integrated into the development of CA since the 1990s (Calegari et al., 2014). Whilst some successful smallholder adoption has occurred (Kassam et al., 2015), constraints to extensive utilisation are also reported (Calegari et al., 2014; Ribeiro et al., 2005). However, Calegari et al. (2015) identified several key processes that have enabled smallholder utilisation of CA in South America to date:

- Benefits of CA became perceived by smallholder farmers in terms of reduced labour and costs of production through herbicide use, as well as the potential to use excess labour in high income off-farm activities;
- Integration of cover crops into CA systems to overcome farm level competition for crop residues, facilitated by favourable climatic conditions for more diverse rotations;
- Strong development of a local manufacturing industry to build light minimum tillage equipment driven by animal traction;
- Institutional reform of credit markets for smallholders, enabling investment in CA systems through improved access to financial facilities;
- Movement towards smallholder farmers employing locally based mechanised service providers for agricultural activities; and
- Development of strong farmer associations that interact in a participatory manner with public research and extension services.

3.2.2. Smallholders on the Indo-Gangetic plains of South Asia
The utilisation of CA has been limited in the South Asian experience (see Table 1), and is still in the initial phases of development despite considerable agronomic research (Bhan and Behera, 2014), with assertions by Hobbs et al. (2017) that substantial progress has been made in the last decade regarding the adaptation of CA to the South Asian context. However, where utilisation is occurring, it tends to be in
irrigated regions where rice-wheat systems dominate, and CA is yet to be tested in other major agro-ecologies such as the rain-fed semi-arid tropics (Bhan and Behera, 2014).

Despite being in the initial stages, there are similar processes evident as in the developed country context, viz:

- **Development of perceived benefit in utilisation of CA based systems**: Where farmers have utilised CA based systems, they have tended to do so for two major reasons: (1) minimum tillage systems address the timely planting of wheat following rice as part of a double cropped system. In such systems, wheat yield is reduced by 1-1.5% for every day planting is delayed after rice harvest (Hobbs and Gire, 1996); and (2) substitution of tillage for herbicides has shown substantial benefits regarding the costs of production (especially diesel, irrigation and labour), input use efficiency (especially fertiliser and herbicides), yields and profits (Hobbs et al., 2017).

- **Development of financial incentives for change**: Whilst the green revolution stimulated production through input intensification, a sharp increase in the cost of diesel in the late 1980s led farmers to experiment with technologies that reduced the cost of land preparation, providing an economic stimulus for change to CA based systems (Hobbs et al., 2017).

- **Development and increasing availability of community exchange mechanisms**: Particularly in Pakistan and India, there has been a strong emphasis on local adaptation of minimum tillage machinery since the late 1980s (Hobbs et al., 2017). Such adaptation has been driven through participatory development, culminating in the production and increasing availability of implements such as the ‘Happy Seeder’, a low priced minimum tillage seeder developed directly with farmers that is now exported to other regions (Hafeez-ur-Rehman et al., 2014).

- **Developing of enabling institutional environment**: The Rice-Wheat Consortium (RWC) was formed in the late 1980s to address the institutional resistance that existed towards CA. It is credited with linking farmers and the private sector (especially equipment manufacturers) and staging positive farmer field and station experimentation that initiated the start of accelerated adoption of CA (Hobbs et al., 2017).

Further to the above, and perhaps most importantly, the expansion of CA based production systems in the South Asian context has been driven by the development of locally based service providers to enable resource constrained smallholder farmers to implement CA systems. This development enabled smallholder farmers to access mechanised equipment without needing to purchase it themselves (Erenstein et al., 2007), whereby larger farmers have tended to purchase minimum tillage equipment that fits their existing tractors and provide seeding services to smallholders (Barrington, 2008).

### 3.2.2. Smallholders in China

Whilst CA has been shown to provide agronomic benefit to Chinese smallholder farmers since the 1970s (Hongwen et al., 2014), an ongoing adaptation process has been required to enable Chinese smallholder farmers to utilise CA. Context specific adoptions have been particularly required to address: (1) small farm sizes (averaging 0.5 ha per family) which did not match the size of minimum tillage seeders available from overseas; and (2) Minimum tillage equipment functionality in heavy crop residues (greater than 20 t of maize stover per hectare) which did not yet exist. The uptake of CA by Chinese smallholder farmers has hence been facilitated through a process of adaptation that led to seeders up to 75% lighter than imported seeders and which were compatible with existing small Chinese tractors, as well as a price reduction of more than eight times in comparison to imported seeders. These seeders were also capable of applying the relatively high rate of fertiliser that is common in Chinese systems. These seeders were then embraced due to their capacity to seed into existing stubble in double cropping systems and to increase resource use efficiency, particularly fuel and fertilisers. It should also be noted that the central government of China is credited with investments and policies that have further fostered the utilisation of CA (Li et al., 2014).

### 3.3. Summary of the enabling processes for mass CA utilisation

Whilst each region reviewed has had a different pathway to mass utilisation of CA, there are many common processes that are evident from this historical review of the process of CA uptake (Table 2).

### 3.4. Implications for the African smallholder situation

Comparisons between practice change in other contexts and African smallholder agriculture are complicated, noting that African smallholder systems tend to have several unique features. In the case of CA, this is particularly true in regards to the limited mechanisation that is present in the majority of African smallholder systems (Baudron et al., 2015a, 2015b). Likewise, only smallholder farming in China has similar average farm areas, yet Chinese systems have comparatively high agronomic inputs whilst African systems remain the lowest in terms of inorganic fertiliser application (PAD et al., 2016).

None the less, despite the introduction of CA at a similar time (in the 1970s) or the other regions reviewed in this study, mass uptake of CA is yet to occur in sub-Saharan Africa. While the awareness of soil degradation and productivity constraints that catalysed interest in cropping systems change in other regions does exist in Africa (Bai et al., 2008) this alone does not enable farmers to implement CA (D'Eendraten al., 2006). Hence, the limited uptake of CA is likely a reflection of the lack of enabling developments for CA to occur, which despite the differences between countries and regions within sub-Saharan Africa tend to be similar (Brown et al., 2017b) in terms of:

- A lack of economic stimulus to incentivise farmer intensification of their cropping activities. African smallholders tend to be trapped in cycles that maintain low input-low output production systems due
to limited output market and credit opportunities that facilitate capital accumulation and cropping intensification activities (Brown et al., 2017b; Xiaoyu et al., 2012). Furthermore, the African situation often differs from other regions due to comparatively substantial levels of livestock diversification (e.g. ruminants in Ethiopia or poultry in Malawi and Mozambique) that are favoured by farmers and promoted by development partners (Mack et al., 2007; Smith et al., 2013). Where CA systems have been more widely utilised there has tended to be a reduction in the importance of livestock, thereby reducing competition for crop residues that are a major constraint to implementation of residue retention practices by African smallholder farmers (Thielefelder et al., 2015).

- Limited functionality of agronomic input markets. Because of a lack of capital within communities, input use in sub-Saharan Africa remains low (Minot and Benson, 2009), tending to lead to limited demand and limited functionality of input markets (Giller et al., 2009).

- Limited perceived benefit in CA systems. Due to limited input use, herbicides are often viewed as increasing the costs of production due to household labour being undervalued, and as such herbicides are rarely perceived as a substitute for tillage (Brown et al., 2017b). Fuel savings are also non-evident because of a lack of mechanisation. This further extends to the limited local manufacture of machinery and local service provision which is not demanded by farmers, leading to limited market development.

- Limited farmer drives innovation groups to facilitate locally relevant participatory adaptation of CA. In each of the regions with substantial CA uptake, participatory innovation systems have emerged that have locally adapted CA, as well as collaborated with public research, extension services and private value chain operators to facilitate CA uptake. Across Sub-Saharan Africa, several studies have highlighted a lack of farmer led participation in research and extension activities, as well as an overarching distrust in extension services and a lack of connectivity and collaboration occurring between and within development and government partners (e.g. Lynam et al., 2016).

- Different climatic drivers within smallholder systems. The uptake of CA in smallholder systems has often been a reflection of timely planting benefits, particularly when there is an opportunity for multiple crops each year (Harrington, 2008). In many locations across eastern and southern Africa limited options exist for biomass production beyond maize through dual cropping and cover cropping, due to the dominant uni-modal rainfall patterns and short rainfall seasons (particularly in southern Africa), while preference for intercropping systems remains limited, particularly in areas of land constraints such as Malawi (Brown et al., 2017b). Furthermore, low use of agronomic inputs tend to mean that plant available nutrients are the primary limiting factor for productivity and not moisture, and as such planting windows tend to be wide in the African context (Magbe and Banga, 2001).

- Government enactment of favourable policies driven by the desire for positive natural resource management outcomes. While some countries (e.g. Malawi, Zimbabwe and Zambia) have enacted CA enabling policies, there is limited capacity within African research and extension systems to implement them due to chronic underfunding and limited human capacity (Anderson, 2007). Even where national task forces and lobby groups have been formed, they have often been ineffective in enabling policy and institutional change (Lynam et al., 2016).

A visual juxtaposition of the various livelihood platforms (see Brown et al., 2017b) of the African and other context reviewed are given in Fig. 2. This highlights the overall lack of processes and developments to enable CA utilisation across eastern and southern Africa.

4. Conclusions

Our review of the diverse application of CA supports the argument that CA has the potential to be agronomically adapted to any agroclimatic zone (Kassam et al., 2015). However, to enable uptake, the socioeconomic and political circumstances dictate the need for modification of CA to local conditions. An analysis of the types of CA that occur throughout the world highlights the flexibility in applications and that the simultaneous use of all three CA practices rarely occurs. The findings of this review support arguments that instead of a rigid definition of CA, a broader focus should be used in the pursuit of sustainable intensification as the transition to profitable yet sustainable farming systems (Vand et al., 2015; Giller, 2012; Hobbs et al., 2017). Such flexibility must be reflected in the adaptation of CA to local contexts through stepwise introduction of CA components over time and through a shift in focus from ‘food security’ to ‘livelihood security’ (Brown et al., 2017b; Hobbs et al., 2017).

In undertaking this change, there must be a focus on ensuring the profitability of African smallholder farmers transitioning from subsistence-oriented to market-oriented production systems. Economic opportunity was the enabling factor that took CA from a potentially beneficial technology (1940–1980s) to widely utilised and impactful practice (1990s to present). Active local adaptation through strong farmer innovation groups that collaborate with existing public research and extension services and value chain service providers is integral to both the ‘bottom up’ development of locally beneficial, feasible and relevant technologies and ‘top-down’ development of enabling institutional environments. Both of these are limited in the African context.

In this light, we conclude with three key practical implications for the facilitation of greater utilisation of CA practices and sustainable intensification more broadly in Africa:

1) Financial stimulation of households is required such that smallholder farmers are able to expand their planning horizons and consider stronger market orientation. This may take a traditional pathway through a focus on value chain developments and growth of market opportunities, but may also require integration of non-traditional pathways such as social protection programs that address the basic needs of farmers (e.g. education and housing expenses) which can lead to greater opportunity for agricultural investment and intensification (Tirpayi et al., 2015).

2) Farmer-owned institutions are required for the successful adaptation of CA practices.  A focus on development of structures to empower farmers to organise collective movements, collaborate with key stakeholders, and modify CA practices to their local situations is thus integral. Nowhere has full, three factor adoption of CA occurred, especially through top down technological deployment alone. Likewise, there must be strong collaboration with research and extension services to sustain ongoing CA utilisation through flexible adaptations to meet the contexts of farmers and emerging challenges within CA-based systems.

3) Noting the required changes at an institutional and economic level, realistic expectations should reflect both the types of CA expected and the length of time that it will take, particularly noting that whilst CA was introduced at the same time as in other regions, the institutional support has been more limited. Time and patience will be needed for enabling processes to be facilitated and institutional structures built to adapt CA to local contexts. Hence, realistic levels of success will occur over a period of decades, not years and success will not be measured by a substantial ‘adoption rate’ of CA.
but the successful local adaptation of CA to various African farming systems for the benefit of farmers and farm production.

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Conflicts of interest

None to declare

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This section provides a summary of the findings and how they address the three research themes. The implications, significance and limitations are then discussed, followed by suggestions for further research direction.
Chapter Twelve: Conclusions

12.1 Addressing of research themes:

This thesis addressed the three research themes (each composed of a research question and objective) as follows:

Theme 1: the ‘What’ of CA

Research Question 1: ‘Can we better understand and classify the uptake of CA by African smallholder farmers?’

In Chapter 2, the inadequacies of current estimates of CA adoption were reviewed and the need for, yet absence of, alternative methodologies to estimate the uptake of CA was established. Subsequently, three novel yet interrelated quantitative frameworks (a CA nomenclature, the CAAF and the PAUF) were proposed to better understand and classify the uptake of agricultural practices (using CA as a case study) by African smallholder farmers. This was further extended in Chapter 3 to specifically investigate minimum tillage uptake. The application of these three frameworks highlighted novel trends and the potential for binary estimations of adoption to overestimate uptake and contribute to misleading conclusions. As such, the proposal of the three quantitative frameworks has provided improved ways to understand and classify the uptake of agricultural practices by African smallholder farmers.

Objective 1: Quantification of the ‘what’ of CA utilisation

The PAUF and CAAF were applied in Section B to quantify the ‘what’ of utilisation. The findings indicate that CA utilisation is limited in all studied countries, in terms of intensities, types and stages of utilisation. In defining the ‘what’ of CA utilisation as constrained, two key issues were established for qualitative investigation: 1] Why are farmers not obtaining information on CA components?; and 2] Once exposed to CA, why are farmers not preferencing their resource allocation decisions towards higher intensities of CA utilisation? Whilst both of these research questions have been previously alluded to within the literature, Section B provides three frameworks and the empirical evidence that clearly quantified the status, or ‘what’, of CA utilisation in the studied countries.
**Theme 2: the ‘Why’ of CA**

**Research Question 2: ‘Can we better contextualise the realities of resource allocation decision making by African smallholder farmers?’**

In Chapter 4, the inadequacies of current investigations attempting to explain the reasons for farmers’ utilisation or non-utilisation of CA are established, mainly relating to the dominance of binary and econometric studies that link household characteristics to farmer behaviour without understanding the mechanisms for farmer decision making. To address this void the LPA was proposed as a structured qualitative framework to better understand and contextualise farmer decision making regarding CA utilisation. The application of the LPA across seven different key stakeholder subsets provided novel insights into the extent that contextual issues determine the status of CA uptake by farmers. The drivers of limited CA utilisation were often found to originate at the community and institutional platforms, highlighting the importance of seeking greater contextualisation to understand farmer behaviour and highlighting the usefulness of the LPA in increasing the understanding of farmer decision making.

**Objective 2: Qualification of the ‘why’ of CA utilisation**

The LPA was applied in Section C to seven different subsets of key stakeholders to understand the ‘why’ of limited intensity of CA utilisation across eastern and southern Africa. Chapters 4 to 7 explored farmer perspectives that highlighted despite being at different stages of CA utilisation, strong commonalities existed across farmer stages. Whilst benefit in utilisation of CA was perceived by the vast majority of respondents, there were substantial issues with the relevance to farmer livelihoods and feasibility of implementation. For relevance, whilst CA was perceived as potentially profitable and useful in adaptation to climate change, farmers were generally seeking to lower their input usage and were often driven by livelihood objectives that conflicted with CA (particularly livestock objectives). For feasibility, there were five strong themes that emerged: 1] Non-functional physical input markets; 2] Constrained and insecure stover resources; 3] Limited financial viability of commercially oriented production systems; 4] increased labour and a lack of labour availability at the community platform; and 5] non-functional informational exchange mechanisms. In Chapters 8-10, these constraints were further explored from community and institutional perspectives, confirming their existence and identifying an overall lack of capacity for research and extension systems to adapt CA to local contexts. This reflected a lack of community participation in the development and
dissemination of CA. These respondents identified key limitations in implementing more participatory research and extension systems, namely a lack of resources to implement activities, a lack of trust between research and extension providers and communities, non-functional mechanisms for interaction with communities and a limited policy mandate. Like in Section A where the quantification of CA is limited by a binary focus on ‘adoption’, so too is the ‘why’ of CA limited by a research and extension focus on facilitating ‘adoption’ of CA, instead of a broader framing of intensification of locally modified forms of CA towards the ultimate objective of total CA adoption. This was found to be the defining feature of the ‘Why’ of CA utilisation.

12.2 Implications

If the utilisation of CA is to be intensified by African smallholder farmers (and sustainable intensification is to occur more generally), the findings of this research imply a need for a change in approach to the way research and extension (R&E) systems frame the uptake of CA. Currently, the focus of R&E activities is on achieving the outcome of ‘adoption’. The findings suggest that this is too simplistic for complex technologies (such as CA) within resource constrained contexts (such as eastern and southern Africa). Instead, there is a need for a more transitional, process focussed approach. In the terminology of the PAUF, utilisation of CA should be facilitated through modified use (as opposed to semi use), with the overall objective of achieving increased intensity of utilisation. Programs considering how to increase the intensity of CA use will be assisted by the application of the CAAF.

However, the implementation of ‘modified use’ pathways will require stronger support for R&E systems to more deeply engage with communities. Current systems have been shown to maintain top down approaches with limited two way negotiation between researchers (the holders of beneficial technologies) and farmers (with their individual feasibility and relevance requirements for new technologies). This reflects the limited financial, institutional and social capital currently within R&E systems to engage meaningfully with farmers. Such capacity must be increased if R&E systems are to move from farm experimentation (i.e. development of beneficial technologies on research stations) to farmer experimentation (i.e. development of feasible and relevant technologies adapted to local farmer situations). The LPA provides a way to formally understand the benefit, feasibility and relevance of such R&E activities.
12.3 Thesis summary

The thesis narrative is visually summarized in Figure K.

Figure K: Visual summary of the thesis narrative, including the three research themes and implications for research and extension systems.

12.4 Significance

This body of research is significant because it addresses strongly identified voids in the literature. For example, Glover et al. (2016) argued that the concept of ‘adoption’ is flawed and
that there is a need to develop a more robust way of measuring agricultural uptake, citing the need for methods that encompass change as iterative, incremental and adaptive. Likewise, Andersson and D'Souza (2014) argued that a deeper investigation of farmer decision making is required beyond econometric analyses to understand broader livelihood perspectives. This is coherent with the assertions of Sumberg (2005) that there is currently a missing link in the design and development process of local adaptation of practices to meet farmers situations and that of Giller et al. (2009) that a deeper analysis of farmer decision making is required to understand the uptake of CA. Whilst it is common for the literature to identify such research voids, this significance of this study is in the use of a major in-depth farmer interview process leading to the proposal of four novel yet interrelated frameworks to address these voids. The PAUF and CAAF directly address the need to develop a broader and more robust empirical approach to measuring the uptake of agricultural practices, while the LPA when used with semi-structured interviews from various subsets of farm and non-farm stakeholders provides an increased depth of meaning that is currently absent from the literature. They are particularly unique in their approach to agricultural transformation from the farmer adaptation perspective, as opposed to an adoption perspective of implementing organisations.

Beyond the theoretical frameworks proposed, there are some significant findings that have been provided. Firstly, while there is often assertions that current estimates of CA adoption are more constrained than many have claimed (e.g. Andersson and D'Souza, 2014; Giller et al., 2009), this thesis has empirically proven this through the analysis of the types, intensities and stages of farmer CA use. Likewise, the deep qualitative exploration of the perspectives of key stakeholders alongside a global review of CA adoption has highlighted the need for the enabling institutional environment, currently absent, to enable farmers to intensify their CA activities. Specifically, such findings are significant as they highlight the intrinsic link between institutional context and limited sustainable intensification of agricultural systems and that the current approaches are unlikely to facilitate farming systems change for smallholder farmers in eastern and southern Africa. Such findings also provide important insights for the ongoing prominent debate around the place of CA within smallholder systems (e.g. Pittelkow et al., 2015), and particularly provide empirical support for many of the new approaches that recent literature propose regarding the need for the change in approach to R&E activities (e.g. Dougill et al., 2017). The findings are hence significant because of their direct usefulness in informing the emerging new approaches to farming systems change in Africa.
12.5 Limitations

12.5.1 Quantitative sampling strategy

Section B applies novel frameworks to existing datasets collected by CIMMYT. CIMMYT is heavily involved in the promotion of CA, and hence there is a potential that such datasets have been biased. However, each of the surveys were implemented with a probability proportional to size methodology and it should be noted that the actual surveys were implemented by the NARS of each partner country. The datasets applied in Chapter 2 were collected as a baseline before CIMMYT promotion activities were established and as such are unlikely to have been biased by any promotional activities. Likewise, the dataset applied in Chapter 3 was collected only three years into the project which had a limited scope of activities in only some of the surveyed communities, lessening the likely impact of such biases. Hence, it can be concluded that the datasets can be broadly representative of the communities targeted.

12.5.2 Quantitative analysis approach

Ideally, Section B would be analysed with panel data to assess changes over time, without which the work may be criticised as taking a limited temporal snapshot. However, this research is limited by the datasets currently available, and the financial and temporal limitations of this PhD research did not allow for collection of new data to undertake this analysis. Hence, Section B should be seen as the beginning of a broader investigation that will be enabled by the development of ongoing panel datasets to which the proposed frameworks can be applied. As such frameworks provide a standardised format, they can be widely applied to enable users to understand temporal change, as exemplified in Chapter 3.

12.5.3 Qualitative sampling strategy

Like the quantitative datasets applied in Section B, Section C applies novel frameworks to qualitative datasets that have been collected from within areas of ongoing CIMMYT promotional activities. This raises potential questions of bias, particularly noting the high incentivisation and its impacts as highlighted throughout Section C. However, the sampling procedure (first introduced in figure 2; pg. 55) was specifically implemented to reduce potential bias and, as stated throughout the thesis, respondents to the semi-structured interviews were purposely selected to ensure a diversity of farmer perspectives without the intention of representativeness. Each interview occurred without the presence of CIMMYT staff and, where possible, translators were not associated with ongoing promotional activities on CA. Each
Interview was preceded by an introduction highlighting that there were no consequences, either positive or negative, related to the answers provided, and the structure of the interviews was such that there was not a narrow focus on CA but on the respondents’ broader livelihoods, reducing a perception by respondents to answer in a certain way. Within each of the 20 case studies, there was an attempt to ‘pair’ a categorised farmer in a village with promotional activities with a similarly classified farmer in a village without promotional activities to gain a balanced perspective. This was not always possible so is not formally addressed within the methodologies of each manuscript. In summary, no qualitative dataset is ever able to account for heterogeneous populations and there will always remain questions of bias. However, the methodologies used were as robust as possible within the budgets, time and scope of this research as part of a PhD investigation, and the analysis still provides improved insights beyond the existing literature body and addresses the lack of in-depth analysis of the farmer perspective previously identified by other leading researchers.

12.5.4 Qualitative analysis approach

Section C is analysed from the perspectives of knowledge users and providers, based on the PAUF categorisations proposed in Section B. This novel approach was applied as something different from other attempts to understand CA uptake, in the spirit of the quotation by Einstein on page two. The usefulness of this is seen through the findings of this research. However, this approach also has limitations, particularly in growing the understanding of the resource endowments, production objectives and site specific issues across contexts. In future applications, it would be advised to apply the same methodology but within individual contexts (e.g. all sub-categories analysed within a country frame). This would allow the benefits of PAUF categorisation to be applied while allowing deeper analysis of the site specific needs of communities. This would provide a stronger evidence base for the scaling up of technologies in a site specific manner, and potentially reduce the repetition that occurred in this thesis, though it was useful in building an argument for the validity of both the methods and results.

12.5.5 Author Perspectives

There is a risk that as the researcher originates from another culture and continent to the interviews’ respondents, some of the data collected and analysis undertaken may be influenced by alternative world views. However, the author has spent a considerable proportion of his life working and travelling within Africa, and the methodologies applied through the structure of the LPA were intended to reduce the impact of potential differential in world views. Translators
were encouraged to ask questions during the interviews that they felt needed to be explored, also allowing for further investigation of areas that the author did not focus on, and enabling a wider investigation to occur.

12.5.6 Limitations to recommendations

Finally, while the proposed changes to the framing of CA to a more transitional, stepwise utilisation pathway originates with the key informants who participated in this study, it is beyond the scope of this thesis research to test such pathways with farmers.

12.6 Future work

With the provision of the frameworks within this thesis, there are many potential applications for future work. With the PAUF and CAAF, there is a need for additional temporal assessment of CA and minimum tillage uptake over the longer term. As such datasets become available, it is hoped that the opportunity may arise to further apply these frameworks and extend them to temporal assessments of agricultural change. They may also be applied more broadly to singular components (e.g. agroforestry) or an aggregate index of sustainable intensification (with multiple components). More broadly, the application of the LPA may be extended to the broader understanding of farmer decision making beyond CA. The frameworks and findings proposed in this research hence provide a skeleton for the design of improved approaches to enable farming systems change for smallholder farmers in Africa. Future work could be to build on the pathways identified and implement them through development programs and with farmers to test their effectiveness.

12.7 Bibliography


Sumberg, 2005. Constraints to the adoption of agricultural innovations - is it time for a re-think? Outlook on agriculture 34, 7-10.
This section contains additional Building on the findings of Section B (the ‘what’ of CA) and Section C (the ‘why’ of CA), this section compares these findings with the contexts of other regions that are identified as successful implementers of CA. In doing so, it addresses the third research objective.
A1. Farmer Question Schedule Used For Semi-Structured Interviews

1. **Exploring your farm**
   - **Current Farm**
     - Size, setup and crops?
     - Planting methods?
     - Stover management?
     - Participation in markets?
   - **Threats**
     - What makes farming difficult?
     - What are going to be the problems in the next few years?
     - Are you satisfied? Will you farm differently in the next few years?
     - Is there anything new you would like to try? Why?

2. **Exploring Conservation Agriculture**
   - **What is your personal experience with Conservation agriculture?**
     - What is Conservation Agriculture?
     - Why is CA good?
     - Why is CA bad?
   - **Why do you utilise CA the way that you do?**
     - Are you confident in implementing CA?
     - Does CA match your resources?
     - Can you access the required inputs?
     - Can you protect stover from others?
     - Does CA take too much labour?
     - Are the markets for CA outputs an incentive?

3. **Broker Interactions**
   - **How do you learn about new technologies?**
     - What’s the best way to learn about CA?
     - Has the lead farmer been helpful in learning about Conservation Agriculture?
   - **Who is here in the community supporting you with resources to do agriculture?**
   - **Who is here in the community supporting you to learn?**
     - Do they all say the same thing? Or is it confusing?
   - **What does the government say is the best agricultural practices?**
     - Do you interact much with the Government extension?
   - **What do the leaders say is the best agricultural system?**
     - Is there anything the leaders can do to support CA? By-laws?
   - **What does the community think is the best agricultural practices?**
     - Is CA proven here?
     - Does CA fit with community practices?
       - Mice hunting?
       - Communal grazing?
     - If you do CA, would you be seen as a crazy person? Why?
     - Are there any historic problems with CA?
   - **If you became the big man (president/chief/minister of agriculture) what would you change to help the community?**
     - Why has the community not taken CA?

4. **Anything else?**
A2. Non-Farmer Question Schedule Used For Semi-Structured Interviews

1. **Household Platform**
   - What are the major challenges facing farmers in this community?
     - What is going to make life and farming more difficult in the future?
   - How are farmers responding to these challenges?
     - What are farmers searching for?
   - Are farmers satisfied with their current livelihoods?
   - Are farmers engaging in markets?

2. **Community Platform**
   - Is information on new technologies reaching farmers?
   - Why do farmers tend to favour traditional technologies?
   - What is the common definition of CA in this community?
   - Is CA a proven technology in this community?
     - Is CA attractive in terms of benefits?
     - What problems does CA have in this community?
   - Do farmers want CA?
   - Why do farmers not take the next step in implementation?
     - Compatible with current stover strategies?
     - Is it too labour intensive?
   - Can CA be afforded by a normal farmer?
     - Are the required implements available?
     - Is there a dependency on handouts?
   - Are markets for sale available?

3. **Governance Platform**
   - How does it fit with normal practices in the community?
     - Communal grazing?
     - Mice hunting?
     - Socially acceptable?
   - Is the lead farmer system compatible with how communities operate? (Jealousy?)
   - Are the leaders of the community doing enough to support CA farmers?
     - Are By-Laws needed?
   - In what ways does government policy influence farmer decisions?
     - Policies?
     - Subsidies?
   - Does government extension facilitate CA or confuse the farmer?
     - Is there clear CA policy direction?
     - Does it contradict other messages?
   - Is there cohesion in messaging from all players on CA?
     - Is there confusion on CA?
   - If there were no “brokers” could CA be done?
     - Is the usage of CA restricted to just subsidised farmers?
   - Are brokers working together?
     - Is there confusing messaging?

4. **Future directions:**
   - What are the most important things that need to change to help more farmers take CA?
     - If you were the president or minister of agriculture?
     - If you were the chief?
   - How do you see the community growing in the future with CA?

5. **Is there anything else?**
Adoption vs Utilisation:  
Broadening our understanding of the uptake of Conservation Agriculture

Brendan Brown a, b, Ian Nuberg a, Rick Llewellyn b  

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b CSIRO Agriculture and Food, Adelaide, Australia

Adoption of CA

If we apply a simple binary classification of adoption

<table>
<thead>
<tr>
<th>Non Adopter</th>
<th>Adopter</th>
</tr>
</thead>
<tbody>
<tr>
<td>Is any CA component used in any way?</td>
<td></td>
</tr>
</tbody>
</table>

Binary adoption rate (2010)

<table>
<thead>
<tr>
<th>Country</th>
<th>Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ethiopia</td>
<td>57%</td>
</tr>
<tr>
<td>Kenya</td>
<td>89%</td>
</tr>
<tr>
<td>Tanzania</td>
<td>94%</td>
</tr>
<tr>
<td>Malawi</td>
<td>94%</td>
</tr>
<tr>
<td>Mozambique</td>
<td>98%</td>
</tr>
<tr>
<td>Aggregate</td>
<td>79%</td>
</tr>
</tbody>
</table>

We might conclude that there is substantial adoption of Conservation Agriculture (CA) in eastern and southern Africa.

But what threshold best constitutes ‘adoption of CA’?

Can more be learned by going beyond a binary classification of CA adoption?

Methods: We applied three novel non-binary frameworks to large household survey datasets from Ethiopia, Kenya, Tanzania, Malawi and Mozambique (from data.cimmyt.org) to gain a greater depth of understanding regarding:

Types of CA Utilisation

<table>
<thead>
<tr>
<th>Combinations of CA components (% of plots)</th>
</tr>
</thead>
</table>

Intensity of CA Utilisation

<table>
<thead>
<tr>
<th>Country</th>
<th>10^1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ethiopia</td>
<td></td>
</tr>
<tr>
<td>Kenya</td>
<td></td>
</tr>
<tr>
<td>Tanzania</td>
<td></td>
</tr>
<tr>
<td>Malawi</td>
<td></td>
</tr>
<tr>
<td>Mozambique</td>
<td></td>
</tr>
</tbody>
</table>

Stages of CA Utilisation

<table>
<thead>
<tr>
<th>Country</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ethiopia</td>
</tr>
<tr>
<td>Kenya</td>
</tr>
<tr>
<td>Tanzania</td>
</tr>
<tr>
<td>Malawi</td>
</tr>
<tr>
<td>Mozambique</td>
</tr>
</tbody>
</table>
No CA components are practiced on the majority of plots, and CA is rarely utilized in 'complete' three factor form.

The intensity of CA use is low, and significant differences exist between countries.

Implications for reporting adoption:
- Binary classification of adoption may lead to incomplete and/or misleading conclusions.
- Analysis of the types, intensity and stages of utilization provides greater depth of understanding.
- Standardised frameworks provide an opportunity for future comparisons.

Implications for promotion of CA:
- While adoption may be considerable, utilization of CA is limited.
- Extension efforts must shift focus from complete CA adoption to utilization pathways via modifications of CA.
- Two key research questions require further investigation:
  1. Why are many farmers not obtaining information on CA?; and
  2. How can positive evaluation and intensity of utilization be increased?

For further information: Brendan Brown (Brendan.brown@outlook.com)

Acknowledgements: Thanks is given to the CGIAR Program on Maize, the CINMYET Socioeconomics Program, the CSIRO and the University of Adelaide for their financial support.
Why are many African smallholder farmers yet to obtain information on Conservation Agriculture?

Brendan Brown a b, Ian Nuberg a, Rick Llewellyn b
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b CSIRO Agriculture and Food, Adelaide, Australia

Background:
1) To implement Conservation Agriculture (CA), smallholder farmers require substantial information.
2) Many African smallholder farmers are not obtaining information on CA.
3) A lack of information represents a major blockage to increasing the utilization of CA in Africa.

Methods:
- 325 key informant interviews (farmer and other stakeholders) across 20 case studies in Ethiopia, Kenya, Uganda, Malawi, Zambia and Mozambique.
- Qualitative exploration of perspectives on the informational environment for CA and agricultural livelihood selection more generally.

In theory:

<table>
<thead>
<tr>
<th>Low Interest</th>
<th>New systems are too expensive</th>
<th>I'm jealous of the lead farmer</th>
<th>I'm waiting for someone to give me inputs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low Access</td>
<td>There are no female farmers</td>
<td>The lead farmer won't help me</td>
<td>I'm never invited by the lead farmer</td>
</tr>
<tr>
<td>Low Availability</td>
<td>There is nowhere to learn</td>
<td>There training wasn't long enough</td>
<td>There was no follow-up training</td>
</tr>
</tbody>
</table>

In practice:
Jeffery – Distrust – Frustration – Disharmony
and limited information reaching many farmers

Conclusions:
- While farmer-to-farmer mechanisms may work for some, they potentially may not work for all.
- Ethical dilemmas are raised when some feel they are unable to benefit from extension efforts.
- Limited social cohesion restricts the expected information multiplier effect.
- Such issues may have been overlooked due to a research focus on project-aligned farmers.

Implications:
If more information on CA is to reach African smallholder farmers, there is a need for:
1. Adequate funding to facilitate wider coverage and mobility of extension services;
2. Extension activities that are more inclusive for farmers outside the social networks of lead farmers;
3. Education of farmers on farmer-to-farmer roles and responsibilities and demand driven extension; and
4. Alternative incentive structures for lead farmers that are less likely to be perceived as exclusive.

For further information: Brendan Brown (Brendan.brown@outlook.com)

Acknowledgements: Thanks is given to the CGIAR Program on Maize, the CIMMYT Socioeconomics Program, the CSIRO and the University of Adelaide for their financial support.
# Pragmatic principles and pathways to achieve impact from Conservation Agriculture in Africa

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b CSIRO Agriculture and Food, Adelaide, Australia

## Background:
1. Conservation Agriculture (CA) can benefit African smallholder farmers.
2. These benefits are yet to widely impact on the livelihoods of most African smallholder farmers.

## Methods:
- 325 key informant interviews (farmer and other stakeholders) across 20 case studies in Ethiopia, Kenya, Uganda, Malawi, Zambia and Mozambique.
- Qualitative exploration of perspectives on agricultural livelihoods and CA utilisation.

## Assumed impact pathway:
- CA is framed as a singular practice without possibility of modification.
- There is a complete transformation of the existing farming system.
- Focus is placed on plot expansion with limited consideration of the farm, community and institutional contexts.
- Economic viability is addressed through subsidisation.

## Findings:
- Despite diversity within and between case studies, five common constraints were found to restrict CA utilisation.
- These issues interrupt the assumed impact pathway as they originate at farm, community and/or institutional levels.

## Results:
Results indicate a need for more flexible and pragmatic impact pathways.
**Broad principles**

- **Strategic Tillage (ST)**
  Are tillage events minimised to only necessary, strategic events?

- **Soil Protection (SP)**
  Do practices conserve soil moisture and limit erosion?

- **Crop Diversification (CD)**
  Are rotations economically and agronomically diverse?

- **Input Management (IM)**
  Are inputs used to maximise benefits of the farming system?

**Proposed impact pathways:**

- CA is framed within four broad and disaggregated principles.
- There is a transition of the existing farming system through periodic intensification of the proposed principles over time.
- Focus is placed on farm-level economic viability and adaptation to the broader community and institutional contexts.
- Pathways occur through participatory adaptation of CA to individual farmer contexts, which limits the need for subsidisation.

**Transitional pathways**

Stage 1: Starting Point

- The starting point of CA implementation for the majority of African smallholder farmers

- CD: Diversification
- IM: Intensification
- SP: Protection
- ST: Multiple tillage events

Stage 2: Agricultural intensification

- Financial resources from capital building invested in input intensification

- CD: Intensified crop diversification
- IM: Intensified input use
- SP: Increased soil protection
- ST: Multiple tillage events

Stage 3: Soil Protection

- Increased biomass (input intensification) and diversification (soil protection and feedback) are investments in soil moisture and fertility

- CD: Intensified crop diversification
- IM: Intensified input use
- SP: Increased soil protection
- ST: Multiple tillage events

Stage 4: Strategic Tillage

- Increased output and capital formation invested in strategic tillage equipment

- CD: Stratacrop diversification
- IM: Intensified input use
- SP: Increased soil protection
- ST: Multiple tillage events

Stage 5: CA intensification

- Continued capital accumulation and intensification of all four principles

- CD: Stratacrop diversification
- IM: Intensified input use
- SP: Increased soil protection
- ST: Multiple tillage events

**Implications:**

- CA is not a ‘finished’ product, but requires further participatory adaptation with smallholder farmers to make it feasible and relevant.
- Transitional pathways provide an opportunity for this process to occur, but will require:
  1. Greater financial investment in research and extension services; and
  2. Upskilling of research and extension officers in participatory methods.

For further information: Brendan Brown (Brendan.brown@outlook.com)

Acknowledgements: Thanks is given to the CGIAR Program on Maize, the CIMMYT Socioeconomics Program, the CSIRO and the University of Adelaide for their financial support.
Catalysing Sustainable Agricultural Intensification in Eastern and Southern Africa

Brendan Brown a, b, Rick Llewellyn b, Ian Nuber g a
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b CSIRO Agriculture and Food, Adelaide, Australia

Problem Statement:
- Africa needs greater agricultural production.
- This needs to be achieved more sustainably.
- The pathways to achieve this remain unclear.

Research Methodology:
- Mixed methods (11,836 household surveys and 325 in-depth interviews).
- Conservation Agriculture (CA) is used as a case study technology.
- Multi-country exploration (Ethiopia, Kenya, Uganda, Tanzania, Malawi, Zambia and Mozambique).

Quantitative analysis identified two key themes:

1] Informational constraints limit intensification
   - More than 50% of surveyed farmers in each country held insufficient information to assess the technology.

2] Information is not leading to implementation (yet)
   - Once information was gained, farmers tended to:
     1] not progress to implementation; or
     2] progress at low intensity.

Qualitative analysis explored these themes:
Pathways to catalyse sustainable intensification:

1) Development efforts must be refocused on: A] the farmer, not the technology; and B] utilisation pathways, not outcomes.

2) Greater resources are required to engage the wider community, thereby increasing access to information and providing the mechanism for greater participatory development of technologies to match community wants, needs and abilities.

3) Institutional changes are required to transform African smallholder systems, which require longer time frames to achieve change.

Further Reading:


For further information: Brendan Brown (Brendan.brown@outlook.com)

Acknowledgements: Thanks is given to the CGIAR Program on Maize, the CIMMYT Socioeconomics Program, the CSIRO and the University of Adelaide for their financial support.

The What, How and Why of Agricultural Adoption in Africa.

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¹ School of Agriculture, Food and Wine, the University of Adelaide, Australia
² CSIRO Agriculture, Adelaide, Australia

Despite scientific breakthroughs that have tripled yields in Asia and Latin America, African cereal yields remain almost stagnant over the same period. A series of agricultural initiatives have been promoted under the banner of sustainable intensification, yet their use has been extremely low. Our understanding of the reasons for this is hampered by ambiguity in classification and weak methodologies.

To address this, our research proposes a redirection of the discussion around agricultural adoption through the proposal of 3 new frameworks that define agricultural adoption in terms of what, how and why. Our novel methods unambiguously define measurable thresholds that can be applied in practice (the WHAT), as well as disaggregate the adoption process to 10 distinct stages (the HOW). We also propose a new theory of change framework that integrates resource and influence drivers to explain farmer decision making (the WHY). These frameworks were applied to extensive qualitative and quantitative data sets to examine the what, how and why of the adoption of 5 sustainable intensification technologies promoted in 7 eastern and southern African countries.

The results indicate that adoption is far more constrained than the literature body has suggested, and identified several new thematic areas for research. Particular constraints were identified in the effectiveness of current extension mechanisms (where farmers have been unable to obtain information) as well as the feasibility and attractiveness of the promoted technologies (where exposure has generally led to disinterest, disadoption and extensive modification). This suggests that despite the assertion of decades of participatory research in Africa, there is an overall disconnect between research, extension, policy and the African smallholder farmer. To foster adoption of new technologies (and subsequent productivity increases), greater research emphasis is required to tailor both the technologies and information delivery mechanism to fit the local contexts that farmers operate within.
Brown, Brendan; Nuberg, Ian; and Llewellyn, Rick

ESTIMATING ADOPTION OF PRODUCTIVITY INCREASING INNOVATIONS IN AFRICA

Session 1C: Thursday 8:30 am – 10.10 am

Ambiguity in the methodologies used to classify adoption of agricultural technologies have made comparisons across studies difficult. This is further compounded but weak methodological frameworks that limit our understanding by framing adoption as a binary outcome. We propose a new standard for the quantification of the 'how' of adoption via the 'Process of Agricultural Utilisation Framework (PAUF)' and the 'what' of adoption via the 'Conservation Agriculture Based Sustainable Intensification Nomenclature (CABSIN)'. We apply this to 27,627 plots cultivated by 6,205 farmers in 5 African countries to compare the adoption of 5 sustainable intensification technologies. Overall, adoption was found to be more limited than published estimates and whilst we find different levels of adoption across countries, common trends were evident, particularly with issues of exposure of farmers to new technologies and the relevance of the technologies to the farmer’s contexts. Whilst applying these frameworks has provided novel findings, deeper qualitative researches is now required to understand them.
Adoption vs. utilisation: broadening our understanding of the uptake of Conservation Agriculture in Eastern and Southern Africa

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Background:
Conservation agriculture (CA) has been the focus of nearly three decades of efforts to sustainably intensify African smallholder agriculture. With this focus has come studies that attempt to quantify the uptake of CA. Most of these studies do this through the application of ‘adoption’ as a binary outcome, either positive (adoption) or negative (non-adoption). This has two major limitations:

1] Uptake isn’t a binary outcome, it’s a process: Farmers first build awareness, then familiarity. This will either generate disinterest or further interest and experimentation. After assessment, a farmer may disadopt or chose various forms of utilisation (i.e. modification, partial or total use). Such a process is ongoing and may occur at varying intensities making it difficult to classify under a binary framework, particularly noting the importance of incentivised CA adoption in the African context.

2] CA isn’t practically framed within a binary classification: In theory, CA is the simultaneous application of three interrelated and strictly defined principles: minimum soil disturbance (disturbed area of less than 25%); stover cover (30% at planting) and crop diversification (>3 crops in rotation; see http://www.fao.org/ag/ca/6c.html). Yet in practice, there is ambiguity on what constitutes CA adoption in the African context (Andersson and D'Souza, 2014) and various definitions applied (e.g. many studies use minimum tillage, zero tillage and conservation agriculture synonymously). Adoption studies are often unclear on how they classify modified use and the intensity of implementation of CA due to their application of binary frameworks.

Application and implications for CA:
Because of the ambiguity over what constitutes ‘CA adoption’, currently available estimates of adoption provide limited insight into the practical utilisation by farmers. Comparisons between studies are difficult and substantial variation can lead to questions regarding the validity of CA adoption estimates (Andersson and D'Souza, 2014).

**Experimental Approach:**

Instead of ‘adoption’ with its binary connotations, we propose framing uptake within a process of ‘utilisation’. In this context, ‘utilisation’ is defined as the process of learning of, evaluating, experimenting with and making various utilisation decisions in implementing an agricultural practice. By doing so, it is possible to obtain a deeper and more granular understanding of the uptake of agricultural practices, particularly multi-component and complex practices such as CA.

To do this, we apply two frameworks: the Process of Agricultural Utilisation Framework (PAUF; Figure 1) defines a farmer’s status of utilisation via ten stages; and the Conservation Agriculture Appraisal Framework (CAAF) provides a structured nomenclature for CA and quantifies the intensity of CA use through plot and farm level intensity indexes. Detailed information on the conceptualisation of the frameworks can be found in Brown et al. (2017). These frameworks are applied to large household surveys implemented by CIMMYT and local NARS across five African countries (Ethiopia, Kenya, Tanzania, Malawi and Mozambique) and two time periods (2010 and 2013).

*Figure 1: The Process of Agricultural Utilisation Framework (PAUF) proposed in Brown et al. (2017)*
Results and Discussion:

Conservation Agriculture in 2010:

Under a binary classification where any use of any component at any intensity constitutes adoption, CA was adopted at the following rates: 57% (Ethiopia); 89% (Kenya); 94% (Tanzania); 94% (Malawi); and 98% (Mozambique).

An analysis of utilisation provides an alternate perspective. At plot level, only 0.3% of plots had all three CA components used to threshold levels (see Brown et al., 2017) and 63% had no CA components used to threshold levels. Only 0.8% of plots had three components of CA used (in any intensity) and 52% of plots have no principles of CA used at any intensity. This was reflected in farm level analysis, where modified use represented between 95% and 100% of farmer use of CA. As such, the majority of farmers scored below 10% intensity measured by the CAAF farm index (Figure 2).

Minimum tillage in 2013:

Binary adoption of minimum tillage in 2013 was estimated as follows: 3.3% (Ethiopia); 15.4% (Kenya); 27.0% (Tanzania); 4.9% (Malawi); and 9.0% (Mozambique), but a deeper analysis of utilisation provides a more granular understanding of this status. In understanding the types of utilisation, four key themes emerged (Figure 3): 1] substantial constraints to farmers obtaining information on minimum tillage; 2] negative evaluation is common after obtaining information on minimum tillage; 3] issues with advancing farmer interest in minimum tillage through to implementation; and 4] when used, a tendency for minimum tillage to be in highly modified or semi-spatial forms.
Figure 3: Classification of utilisation types for minimum tillage in 2013 using the PAUF.

Conclusions:

Utilisation of CA is potentially beneficial to the livelihoods of African smallholder farmers, but adoption is only an early step towards this. Our findings highlight the need to move beyond binary analysis of adoption and towards a more nuanced analysis of the process of utilisation in order to generate a deeper understanding of the status of agricultural practices. We find binary estimates are likely to overestimate the impact of CA, noting the complex multi-component nature of CA and the subsequent dominance of modified utilisation by farmers. By considering in more detail the intensity of implementation and the types of use and non-use, deeper meaning can be found in the status and contributors to low levels of utilisation. Our analysis indicates that to foster the utilisation of CA in the African smallholder context, two key themes will need to be addressed: 1] the benefit, feasibility and relevance of CA to local contexts; and 2] the functionality of informational exchange and extension systems.

Funding institutions:

Thanks must go to the CIMMYT for the provision of the datasets on their data repository (data.cimmyt.org). Additionally the Maize CRP managed by the CIMMYT, the CSIRO and the University of Adelaide are acknowledged for provision of funding for the authors broader investigation into the sustainable intensification of African smallholder systems.

References:
