Cecilia Nyrongo has been practicing conservation farming for many years. She manages 10ha cultivated by tractor ripping.
Photo credit: CFU

Midline Evaluation Report

Climate Smart Agriculture Zambia Impact Evaluation

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Acronyms

AKTC	Zambian-German Agricultural Knowledge and Training Centre
ADP	Animal Draught Power
CA	Conservation Agriculture
CASU	Conservation Agriculture Scaling Up Project
CEO	Camp Extension Officer
CF	Conservation Farming
CFU	Conservation Farming Unit
CSAZ	Climate Smart Agriculture Zambia Programme
DID	Difference-in-Difference
DFID	UK's Department for International Development
FANTA	Food and Nutrition Technical Assistance
FC	Farmer Coordinator
FGD	Focus Group Discussion
GEFA	Global Evaluation Framework Agreement
GoZ	Government of Zambia
Ha	Hectare
HH	Household
IAPRI	Indaba Agricultural Policy Research Institute
KII	Key Informant Interview
MDES	Minimum Detectable Effect Size
MoA	Ministry of Agriculture
MT	Minimum Tillage
PPI	Progress out of Poverty Index
SD	Standard Deviation
ZIAMIS	Zambia Integrated Agriculture Management Information System
ZMW	Zambian Kwacha

Executive Summary

Evaluation Objectives

The Climate Smart Agriculture in Zambia (CSAZ) programme will utilise up to £25 million of UK International Climate Fund resources between 2016 and 2021. The CSAZ is implemented by the Conservation Farming Unit (CFU). This evaluation will assess the CSAZ programme to determine its impact on resilience, increased income, food security and social benefits at household level. The evaluation will be implemented by a WYG-led consortium contracted through the DFID Global Evaluation Framework Agreement (GEFA). The consortium consists of the UK-based LTSI International (LTSI), the Zambian Indaba Agricultural Policy Research Institute (IAPRI), and the US-based Cloudburst Consulting Group.

The evaluation has a dual accountability and learning purpose. The majority of the evaluation team's effort will be directed to learning about the programme's impacts, with additional evaluation questions helping to contextualise the findings and to generate lessons learned for future implementation design. The headline evaluation questions are as follows:

1. Was the design of CSAZ relevant given its objectives?
2. How efficient and effective is the CFU's implementation of the Climate Smart Agriculture programme?
3. Do CFU activities improve the incomes, food and nutrition security of smallholder farmers through the promotion of conservation tillage and conservation farming?
4. To what extent is support for CSA from CFU and the private sector institutionally sustainable?

The Terms of Reference are available in Annex 1 and the Evaluation Matrix agreed as part of the inception report is in Annex 2.

Overview of CSAZ

CSAZ is expected to improve the productivity and climate resilience of Zambian smallholder farmers in order to sustainably improve their well-being and livelihoods. This will be achieved through activities which promote the adoption of conservation farming practices and through the creation of private sector networks of rural input suppliers and tillage service providers to serve the needs of adopting farmers.

Midline Activities Conducted

This report describes the results of the Midline Assessment which relates to the production year of the 2018/9 agricultural season. A household survey was conducted across 169 villages, interviewing 2,292 farming households, with minimal attrition between baseline and midline. This survey sample allows results to be disaggregated across male and female headed households who use animal draught and hoe power for cultivation and for 'like with like' comparisons to be made across these tillage types. We also collected data to produce a case study of households using tractor tillage. However, we experienced more significant attrition amongst this group and we were only able to re-survey 126 of the originally surveyed 222 households. Much of the attrition was from the comparison group using tractor ploughing. Qualitative data was also collected from 258 participants in focus group discussions and 51 participants in key informant interviews. These were selected from Choma, Chobomboko, Itezi-tezhi, Kabwe, Lundazi, Luampa, Monze and Sinda and included national level stakeholders from Government, Development Partners and the Private Sector. The report presents midline findings for all outcome indicators and explores findings in relation to relevance, efficiency, effectiveness and sustainability.

Limitations to the quasi-experimental design

Since inception, we have identified a number of challenges to the quasi-experimental design. These include the fact that the "baseline" survey was commissioned after the CF training had been initiated, the fact that we needed to capture a sample of adopters that would be large enough to measure impacts and allow for disaggregation by sub-groups and therefore we selected our treatment group based on their adoption of CSA rather than as a random sample. As a consequence, this group is not as comparable to the control group as expected, making the parallel trend assumption less credible. At midline, we also found that around 20% of control households had received the treatment due to farmers in areas identified as control sites receiving training from CFU. Instead, it will focus on comparing those who used minimum tillage compared to those that did not, regardless of original treatment or control assignment status. It will also focus on the first field of each household to improve comparability. Thus, this analysis will not focus on causal inference and will instead provide an ordinary least squares regression using observable information.

Midline Findings

The baseline results for the programmes' core impact indicators are presented in the tables below. Disaggregated data for female headed households, animal draught and hoe farmers are found within the full report.

Results for Hoe and Animal Draught Power Farmers

Outcome Indicator (Units)	Baseline Treatment	Midline Treatment	Baseline Comparison	Midline Comparison
Maize Yield (Kg per Ha)	1582	1403	1258	993
Groundnut Yield (Kg per Ha)	689	427	493	379
Soya Bean Yield (Kg per Ha)	795	842	753	619
% of households who sold or plans to sell crops	73%	54%	62%	41%
Crop income (ZMW)	n/a	4009	n/a	1928
Mean number of person-days per ha spent on land prep, planting, weeding, and harvesting	56	96	59	72
Dietary Diversity Score (Score from 0-12; higher scores are more diverse diets)	7.14	7.6	6.35	6.8
Mean number of months the household experienced hunger	2.49	2.8	2.63	2.8
Proportion of households with low hunger intensity (0-1 on the household hunger scale)	90%	93%	90%	87%
Mean asset value (ZMW)	4,345	7,080	3,673	4,283
% engaged in non-weather dependent livelihoods	18%	72%	12%	69%
Likelihood the household falls below 200% of the poverty line	87%	62%	91%	66%

Source: Household Survey of ADP and Hoe users. Note: productivity by hectare is calculated by plot and compares all conservation and conventional tillage plots regardless of the treatment/control group in which the household sits.

Results for Tractor Farmers

Indicator	Ripping Baseline N = 151	Ripping Midline N=111	Ploughing Baseline N = 71	Ploughing Midline N=15
Maize (Kg per Ha)	3,062 (sd=2807)	2455 SD=2535	3,139 (sd=3,139)	3733 SD=1950

Indicator	Ripping Baseline N = 151	Ripping Midline N=111	Ploughing Baseline N = 71	Ploughing Midline N=15
Number of person-days per plot on land prep, planting, weeding, and harvesting	40.7 (sd=54.4)	54 (sd=101)	29.6 (sd=41.3)	68 (sd=15)
Amount of money per plot spent hiring labour on land prep, planting, weeding, and harvesting, first field	315.4 (sd=335.8)	254 (sd=479)	394.5 (sd=486.3)	463 (sd=445)
Crop Income (ZMW)	n/a	13,216 (sd=19,991)	n/a	23,781 (sd=21,935)
Dietary Diversity Score	10.3 (sd=2.6)	9.8 (sd=2.8)	9.6 (sd=2.7)	9.4 (sd=2.1)
Total Asset Value (ZMW)	19,231 (sd=15,602)	43,333 (sd=69,565)	18,061 (sd=22,958)	42,260 (sd=73,684)
One or More Investments in Non-weather Dependent Livelihoods	16% (N=24)	83% (92)	11% (N=8)	60% (9)
Percent Likelihood the household falls below 200% of the poverty line	62%	51%	53%	46%

Source: Household Survey of Tractor Users

Regression Analysis to investigate the effect of minimum tillage on yields

Both minimum tillage and fertilizer use are associated with large increases in maize yield and these two are 23% correlated with each other. Minimum tillage is associated with an increase of 245-420 kgs per hectare depending on the model. Fertilizer is associated with an even larger increase of 400-684 kgs per hectare, depending on the model. These results are promising but cannot completely account for self-selection bias. It may be that the households most likely to be successful based on characteristics we do not observe are strategically using fertilizer and minimum tillage. However, other variables are not statistically associated with higher yields.

Key Findings

The mid-line evaluation identified 28 findings under the evaluation criteria of relevance, efficiency, effectiveness and sustainability. These are summarised below:

Relevance

1. CSAZ's approach remains relevant to smallholder farmers. Adoption of CSA practices are consistently mentioned as an important change to farming in the area.
2. CSAZ has increased its focus on financial literacy and farm budgeting since baseline but this is not implemented everywhere.
3. CFU launched a Gender Strategy in 2018 and continues to report against its gender action plan. However, there are still large barriers related to land ownership and intra-household dynamics that limit women's ability to benefit from the programme.
4. CFU have effectively raised awareness of the importance of including people with disabilities in training activities. People with disabilities are being trained but cannot always adopt conservation farming practices nor access other sources of support.
5. CFU remains the largest training provider on CA topics and has attracted high profile Government support towards CA. It is frequently reported as influencing the approaches of other development partners.

Efficiency

6. Farmer Coordinators note that they frequently re-train the same farmers over several years. Whilst prolonged training is not necessary for adoption in all cases – FCs do note that it helps to correct problems and deepen understanding on details of the approach. The cost-efficiency of this approach can be further investigated.
7. The majority of farmers trained by CFU generally report the training as very useful
8. In all Focus Groups, participants appreciated the contents and quality of the training but in several groups noted they also placed value on the opportunity to eat together and to socialise with other farmers.
9. Agro-dealers and Ripping Providers greatly appreciated the marketing opportunities provided by CFU-organised field days. Farmers participating in field days also unanimously found the opportunity to attend field days useful but made suggestions for improvements in location and content.
10. Women are more likely to experience challenges in attending or actively participating in the training. Women in married households also lack access to land and decision-making power which limits their ability to act on the training and to experience the benefits from conservation farming.
11. Respondents in focus groups reported post-harvest losses of 0-25% of stored maize due to moisture or pest damage, often this was despite insecticide application. Only a small number had changed practices in response to training by CFU and this topic was less frequently covered in CFU trainings.
12. Focus group feedback noted topics of interest that are not currently covered by the CFU training. Participants also raised similar logistical issues as those mentioned at the baseline.

Effectiveness

13. Households in the treatment group use minimum tillage on almost half of their fields. 44% of households report a desire to expand the area under conservation tillage in future. Consistent with the baseline, the most commonly used minimum tillage method is ripping with oxen.
14. Surveyed households report that moisture retention is the most important benefit they experienced following adoption of minimum tillage. This is consistent with answers to the same question at baseline. Soil quality improvements are the second most important benefit reported.
15. Intercropping and crop rotation are also important components of CSA. There was no difference between rates of intercropping between fields under minimum tillage and those not. In terms of crop rotation, 40% of households in the original treatment group switched from maize to legumes on their first fields between baseline and midline compared to only 33% in the control group.
16. Residues were retained on 35% of fields in which minimum tillage was used.
17. Adopting households report challenges with conservation farming at similar percentages to the baseline. There are no large differences in the proportions of new adopters reporting challenges compared to those who had adopted previously. Labour constraints are the main challenge reported by disadopters. Results from the survey are consistent with challenges described in focus groups.

18. As noted in the baseline, adopting minimum tillage is associated with the adoption of other good agricultural practices. Since CFU targets 'serious farmers', the causal relationship is likely multi-directional, particularly for fertiliser. Herbicide is more likely to be adopted for the first time after starting minimum tillage. Most farmers secure inputs from FISP but 22% of farmers in the treatment group report being linked to input sellers by CFU.
19. At midline around 40% of households report receiving training on farming as a business and 85% of those households received this training from CFU.
20. CSA adoption influences food security and incomes through an increase in production of food and cash crops.
21. Access to cash for inputs and to profitable markets with timely payment terms remains a constraint to farmers despite CFU's ongoing efforts to promote bulk marketing. The factors influencing maize markets in Zambia, including the state involvement are not within the scope of this study.

Sustainability

22. There was a 12% disadoption rate across all tillage types between baseline and midline. Disadoption rates were slightly higher for hoe farmers than those using ADP. Disadopters are older and are less likely to have secondary education than those sustaining adoption.
23. Maize yields are highest for continuous CF adopters and lowest for households who never adopted CF. Yields for disadopters are slightly higher than those who never adopted but lower than those for adopters. Because of differences between farmers in each group, we cannot conclude these differences are entirely caused by conservation farming.
24. During the programme design, CFU and agro-dealers considered working with community agro-dealers (CADs) as a possible long-term model to sustain training on climate smart agriculture topics and improving last mile access to CSA equipment and inputs. However, relatively few Farmer Coordinators appear to operate as or with CADs and some agro-dealers reported that they have stopped working with CADs.
25. CFU relationships with private sector companies have mostly deepened since baseline, with all companies advertising in CFU brochures and increased levels of investment in training on conservation farming and the establishment of demonstration plots.
26. Key informants noted that CFU could improve the sustainability of its activities by addressing constraints along the whole value chain and by deepening collaborations with other organisations. However, this may not be within the scope of the current DFID-funded programme.
27. Government of Zambia remains supportive of CFU's approach and is keen for private sector providers to engage in extension. Despite field officers reporting involvement of Camp Extension Officers and District officials in many activities, at national level GoZ recommends greater involvement of camp extension officers and more joint planning with district and provincial staff.
28. As number of advocacy opportunities were identified by stakeholders, highlighting that CFU does not currently have a targeted strategy to influence Government of Zambia and other development partners to adopt its approach.

Lessons Learned and Recommendations for CSAZ

At the midline stage, six key lessons and related recommendations were prioritised for the CFU and DFID to consider in the future implementation of the programme. These are:

Lesson 1: There is an opportunity to consider how to improve the value for money of conservation farming promotion in Zambia through avoiding repeat training and using modern communication tools to promote the practice. The CFU Strategy describes a focus on social media messaging but there may be other low tech solutions such as voice recognition interactive messages, SMS messages and radio programmes that could be effective in transmitting CFU extension messages.
Recommendation 1: CFU to explore opportunities to experiment with the degree to which Farmer Coordinators allow repeat training of the same farmers and to alter training approaches to identify the approach offering optimal value for money.

Lesson 2: CFU's gender strategy has resulted in increased efforts to include women in conservation farming training. However, their ability to benefit from conservation farming is significantly constrained by their ability to access land or make farming decisions.
Recommendation 2: CFU to explore options to integrate household methodologies[1] or other behaviour change techniques into its extension packages or to partner with other organisations which have this capability.

Lesson 3: Cash flow remains a significant constraint to input purchase and there is insufficient evidence of the impact of CFU's efforts to promote last mile input and output sales. Efforts to promote input sales via Farmer Coordinators need further investigation to assess progress in a more systematic manner. However, as per the findings at baseline it is clear that efforts to promote input sales must take place in tandem with measure to ease farmers' cash flow constraints and to promote 'farming as a business' if they are to be successful.

Recommendation 3: CFU to sustain efforts to roll-out financial literacy training and to partner with other organisations able to promote savings and credit or 'pay as you go' technologies for input sales, as they began doing in late 2019. LTS to identify better approaches to measuring the effectiveness of the community agro-dealer approach at endline.

Lesson 4: Post harvest losses are resulting in farmers losing out on productivity gains achieved through adoption of climate smart agriculture. Evidence from focus groups suggested losses of up to 25% are being experienced by some farmers. Whilst we did not collect data from a larger group on this topic through the household survey, the responses in the focus groups are not surprising given other literature on this topic and farmers did not report any behaviour changes as a result of CFU training on post-harvest management suggesting that it may be an area requiring further attention.

Recommendation 4: CFU to investigate opportunities to strengthen support on post-harvest management as part of its training package. LTS to incorporate more analysis of this area in the endline survey.

Lesson 5: There are a range of other programmes promoting conservation farming, including large World Bank and EU programmes. Whilst CFU has influenced numerous programmes (See Finding 5), it could achieve a yet wider impact through investing in advocacy to encourage new programmes to use CFU best practices. Our evaluation focuses on the impacts of CFU's activities on the farmers with whom they work. However, wider considerations of value for money and sustainability also bring into question the extent to which impacts could be achieved via influencing and leveraging the impacts of other development investments in the promotion of conservation farming. Currently CFU has limited engagement with the Government of Zambia CA National Task Force and has not resourced sustained discussions with other large CF programmes such as the World Bank Eastern Province programme.

[1] You can read more about household methodologies here https://www.ifad.org/en/web/knowledge/publication/asset/40253899. A recent study of the approach from Malawi is available here: https://www.sciencedirect.com/science/article/pii/S014019631730191X

Recommendation 5: CFU and DFID to investigate opportunities to shift investment to advocacy and influencing work with a focus on promoting the use of CFU materials and training approaches in other programmes.

Lesson 6: Given challenges associated with maize production in the changing Zambian climate and the potential profitability of other legume crops, some farmers have expressed an interest for CFU to organise a greater number of field days focused on crops other than maize. Farmers have also noted concerns about the accuracy of information provided by seed sales personnel at these field days.

Recommendation 6: CFU to explore whether it is feasible to increase the proportion of field days which focus on crops other than maize and whether these days can be organised with offtakers for legumes or other crops. CFU to also provide some oversight and quality control of the claims made by companies at field days and to flag to their head offices if benefits are being presented without an appropriate evidence base.

Lessons Learned and Recommendations for the Impact Evaluation

Given the change in CFU Strategy and the challenges associated with the difference-in-difference design, it is suggested that the design of the endline assessment is re-visited to ensure maximum usefulness for CFU and for DFID. Some recommendations for further discussion include:

- Maintaining our plot-level assessment of yields to continue to build the evidence base on CSA impact on yields under different weather conditions. Explore the opportunity to integrate controls for field type and weather conditions into the regression analysis;

- Invest greater resources into surveying farmer coordinators, community agro-dealers and ADP or tractor tillage providers to explore the support they need to become self-sufficient business entities able to take forward CFU's new strategy;

- Invest in a cost benefit analysis of the CFU model with significant sensitivity assessment to allow an exploration of the drivers of benefits and the opportunities to reduce costs;

- Explore the opportunity to include research topics that have particular policy-relevance or are live questions for CFU. A process to re-visit the evaluation questions will be initiated after the delivery of a cost-benefit analysis, evidence synthesis report and during discussion with CFU at the planning phase of the endline.

- Further explore interesting details identified in our research to date with the goal of academic publication to add to the global evidence base on CSA. This could include investigation into the relationship between market prices and yields; further exploration of the impacts of crop rotation on yields, or greater investigation onto the drivers of household crop income or food security changes.

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Tables and Figures

1 Introduction

1.1 Climate Smart Agriculture in Zambia Programme

The Climate Smart Agriculture in Zambia (CSAZ) programme will utilise up to £25 million of UK International Climate Fund resources between 2016 and 2021. The bulk of the resources are spent via a grant to the Conservation Farming Unit (CFU). CFU is a not for profit Zambian organisation established to promote climate smart agricultural practices and policies.

CSAZ is expected to improve the productivity and climate resilience of Zambian smallholder farmers in order to sustainably improve their well-being and livelihoods. This will be achieved through activities which promote the adoption of conservation farming practices and through the creation of private sector networks of rural input suppliers and tillage service providers to serve the needs of adopting farmers. Finally, the programme will aim to strengthen the evidence base on Climate Smart Agriculture both to improve its own implementation and to influence wider public policy and practice. A detailed description of the intervention is available in the Impact Evaluation Inception Report.

1.2 Impact Evaluation Contract and Baseline Scope

The impact evaluation is implemented by LTS International, Cloudburst Consulting and the Zambian Indaba Agricultural Policy Research Institute (IAPRI) under a WYG-led consortium via the DFID Global Evaluation Framework Agreement (GEFA). This evaluation will assess the Climate Smart Agriculture Zambia (CSAZ) programme to determine its impact on resilience, increased income, food security and social benefits at household (HH) level. This objective is outlined in the assignment Terms of Reference available in Annex 1.

There is a dual accountability and learning purpose for this evaluation. The primary goal of the evaluation is learning about the impacts which can be attributed to the programme. The evaluation is also expected to be able to investigate the role of implementation quality and the overarching theory of change. This baseline report lays the foundation for assessing programme impacts and provides preliminary responses to evaluation questions related to relevance, efficiency, effectiveness and sustainability. The Evaluation Matrix detailing high level evaluation questions and sub-questions to be addressed by the evaluation is available in Annex 2.

DFID's support to CSAZ builds on previous support provided by the Norwegian Government for the CFU's Zambia operations between 1996 and 2015. Whilst DFID funding to CFU began in 2016, the impact evaluation was not contracted until late 2017. Survey implementation for the baseline assessment was then delayed until after the harvest of the 2017/8 agricultural season. The baseline year is therefore the production season of 2017/8. This Midline Evaluation reviews performance in the production season of 2018/9 and will be supplemented by an Endline Evaluation report which will review performance in the 2020/21 production season.

1.3 Structure of Report

This report is designed to be read by those already familiar with the inception and baseline reports for the programme. In Section 2, it describes the methodology used for the study including the limitations to the original design and how our approach has adapted to respond to challenges faced. In section 3, the report provides descriptive statistics that contextualise our report and sets out the results from the household survey against the outcome indicators for the programme. The results of our regression analysis on the relationship between minimum tillage adoption and yield increases are also reported. Section 4 describes the findings against the evaluation questions. Section 5 discusses the implications of these results for the programme theory of change and Section 6 summarises the lessons learned and recommendations arising from the study.

2 Methodology

2.1 Impact Evaluation

2.1.1 Evaluation Questions

The impact assessment is designed to respond to four headline evaluation questions:

i Was the design of CSAZ relevant given its objectives?

ii How efficient and effective is the CFU's implementation of the CSA programme?

iii Do CFU activities improve the incomes, food and nutrition security of smallholder farmers through the promotion of conservation tillage and conservation farming?

iv To what extent is the support for CSA sustainable?

This report provides insights in response to evaluation questions focused on relevance, efficiency and sustainability and reviews evidence of impact against the baseline. This is available in Section 3.

2.1.2 Mixed Methods Theory-based Impact Assessment

The impact assessment for CSAZ has been designed to follow a mixed methods and theory-based approach. In line with White (2009),[2] the inception report described our approach and associated methods in detail. Theory based impact assessment requires a close analysis of the theory of change for the programme, a deep understanding of the context in which it operates and of the factors which drive differences in results. The theory of change analysis was used to design both qualitative and quantitative data collection methods that gather evidence of beneficiary behaviour and outcomes at each stage of the causal chain and can therefore be used to explain the programme impacts. Finally, our impact assessment design included the identification of a credible counterfactual group. This group helps to understand what might have happened without the effects of the programme. The theory of change used in the design of the impact assessment is available in Annex 3.

2.1.3 Measuring Impact at Household Level

The evaluation design accepted by DFID during the inception phase was a quasi-experimental difference-in-difference (DID) method to measure the impacts of the CSAZ programme at household level. Under a quasi-experimental approach, programme impacts are determined by drawing on outcome information across a group of beneficiaries who received the programme intervention, or treatment (in this case, households who adopted conservation farming after receiving a training programme by CFU), and the same set of outcome information collected from a group of comparable households that did not receive the treatment (i.e., the control group, in this case farmers that have not received the CFU training, and engage in primarily traditional tillage methods). Unfortunately, based on the results at midline we do not find it credible to utilise this design to attribute impact to the programme. The reasons for this are described in Section 2.2.2.

Despite this, there are still non-experimental approaches that can be used to explore impacts and our reliance on theory-based analysis helps to understand the extent to which observed changes can be considered related to the programme activities. Since a major goal of the study was to quantify the impact of adopting conservation farming on yields and our survey provides extensive plot-level data, we used data on households' main fields to estimate the relationship between variables that may have a causal effect on maize yield including minimum tillage and use of

[2] White, H. (2009). Theory-based impact evaluation: principles and practice. *Journal of development effectiveness*, *1*(3), 271-284.

fertiliser. A linear regression models the 'line-of-best-fit' to reflect relationship between data points and as much as possible, minimise deviation from the actual observed data (calculated using Least Square Method).The function is represented as: Y= a + bx + e, where b is the slope of the line, a is the intercept and e accounts for error. Ultimately, the equation is meant to represent the data as best as possible so that it may be used to predict given changes in maize yield (y) with x variables (e.g. minimum tillage or fertiliser use).[3] This allows us to estimate the extent to which maize yield increases can be associated with particular practices. The results are presented in section 3.2.

Since maize yield was not the only outcome of interest, we also use the presentation of before and after data disaggregated for those households adopting conservation tillage practices and those who do not. This is combined with descriptive statistics and qualitative data analysing the evidence available to support the steps in the theory of change that relate to these outcomes. This is does not allow causal claims to be made with the same confidence as the originally proposed design but we believe this analysis remains useful in responding to the evaluation questions set out in the inception report.

2.1.4 Sub Group Analysis

The study has also been designed to examine impacts for specific subgroups. These are:

1. Female-headed vs households consisting of a married couple
2. Farmers practicing different tillage types (hoe vs. animal draught power vs tractor)

It is important to note that the treatment effects for households that use tractor power are examined through a case study approach, with a smaller sample size. This is due to the lower density of tractor farmers across programme areas.

2.1.5 Assessing Relevance

This assessment draws on feedback from farmers and development stakeholders in relation to the scope and scale of the programme, the technologies promoted, and partnerships established. Quantitative data from the survey provides farmer feedback on the usefulness of CFU training whereas qualitative data from focus groups and stakeholder interviews provides stakeholder views on areas for improvement.

2.1.6 Assessing Efficiency

This report provides insights from the survey and focus groups, mainly focusing on farmer feedback on the CFU training and field days. This helps us to understand if the training covers the topics in the CFU materials, if it is delivered in a manner that is accessible and useful to farmers and if the field days and work with input suppliers reach farmers in the desired way.

2.1.7 Assessing Effectiveness

Our study was not designed to explore adoption in detail since CFU also conducts an annual adoption survey of trained participants. However, qualitative methods are also used to explore reasons for adoption, the challenges faced in adopting and practicing conservation farming techniques. This study also explores the relationship between the adoption of conservation farming, the use of agricultural inputs and the adoption of other good agricultural practices. Since the programme assumes that adoption of a combination of good agricultural practices is important in maximising impacts.

2.1.8 Assessing Sustainability

This has been assessed at two levels. At farm level we investigated the proportion of farmers who stopped using minimum tillage between baseline and midline ("disadoption"). We also assessed

[3] Olive, D. J. (2017) Linear regression, Linear Regression. doi: 10.1007/978-3-319-55252-1.

the extent to which private sector institutions have altered their behaviour to support the CFU. Key informant interviews with Government of Zambia personnel and other development partners also provide insights into the extent to which CFU influenced other development activities in the country.

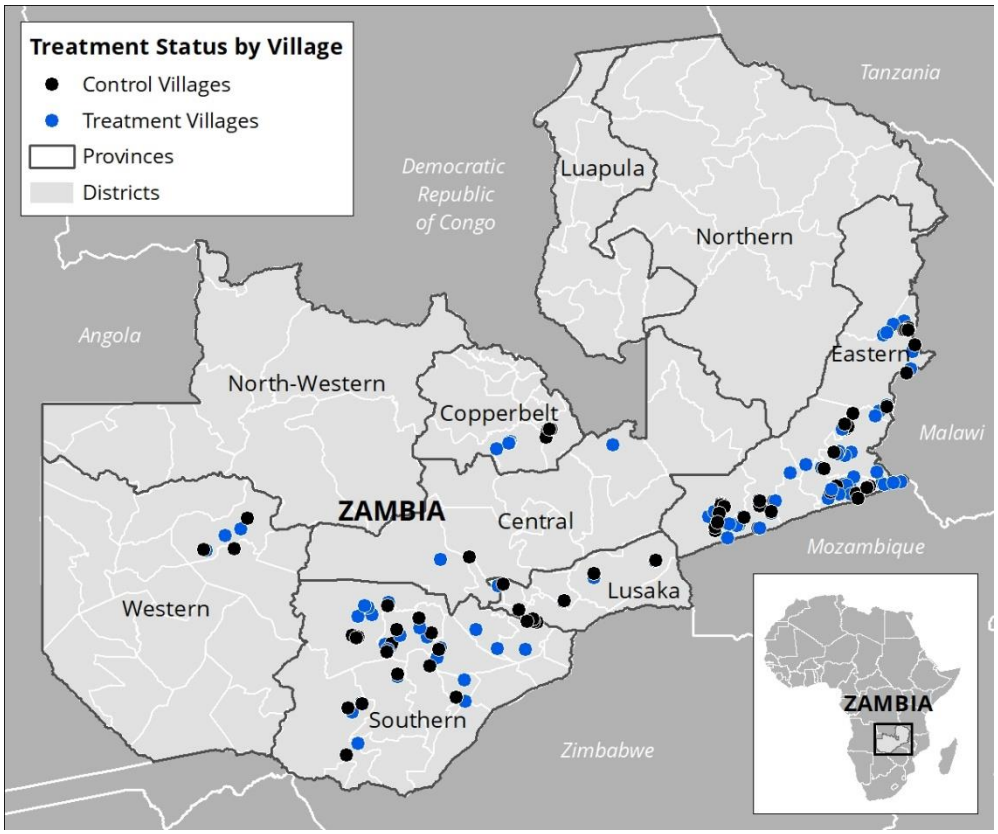
2.2 Quantitative Data Collection

2.2.1 Sampling

During the inception phase, we used three different sampling protocols to produce a sample of villages, households, and tractor users. Each protocol is described below, as well as the challenges and limitations of each sample. The intention of the design was to conduct a panel assessment, meaning that the same sample has been maintained between baseline and midline.

Village Sampling
At the village level, we utilised a two-level clustered sampling approach. 84 farmer coordinators were randomly selected from all farmer coordinators recruited in 2017 across 35 districts. These were the treatment villages, and they were chosen in advance of baseline data collection. Without clear information about where all other conservation farming programmes were working, it was not possible to select control villages in advance. Instead, once in the field, team supervisors worked with CFU Field Officers and GoZ Camp Officers to identify a suitable control village for each sampled village using maps showing the location of other CFU FCs and CASU operational areas. In total, 169 villages across 29 districts were included in the study; 84 treatment and 85 control. A map of where villages are located is show below in Figure 1.

Figure 1 Location of Treatment and Control villages



Household Sampling
The midline survey sampled the same households that were interviewed at baseline. Only 2 households from baseline were not able to be re-interviewed. It is worth noting that the proportion of households who exclusively used hoe tillage decreased from baseline to midline. The original

sampling plan called for 25% of the household to be include ADP households, under the assumption hoe tillage would be the most common method. Instead we've found that most households (82%, N=1,722) used ADP on at least one field. As a result, when presenting descriptive statistics by subgroup we present them for hoe farmers as opposed to ADP households as originally anticipated.

Table 1 Household Survey Sample

Surveyed Group	Treatment		Control		Total	
	Baseline	Midline	Baseline	Midline	Baseline	Midline
Households	1,128 (50%)	1,127 (50%)	1,165 (50%)	1,165 (50%)	2,293	2,292
Female-headed households	308 (27%)	259 (23%)	297 (26%)	261 (22%)	605 (26%)	520 (23%)
Hoe farmers	207 (18%)	128 (11%)	376 (33%)	231 (20%)	577 (25%)	359 (16%)

Tractor Case Study Sampling

Of our original sample of 222 households using tractors to till some or all of their fields, we re-surveyed 126 as shown in Table 2. This high attrition rate is attributed to the additional time and cost required to survey TSP households, who are spread thinly across a district rather than clustered in two villages as the household survey respondents are. The survey teams faced the most difficulty in surveying the tractor-using households that plough. Therefore, only 12% (N=15) of our sample use traditional ploughing methods, with seven percent of farmers (N=9) using both.

Table 2 Tractor Case Study Survey Sample

	Overall	Rip	Plough	Both
Mazabuka (Central)	51 (40%)	46 (90%)	0 (0%)	5 (10%)
Mpongwe (Southern)	6 (5%)	4 (66%)	1 (17%)	1 (17%)
Chipata (Eastern)	69 (55%)	52 (75%)	14 (20%)	3 (4%)
Total	126 (100%)	102 (81%)	15 (12%)	9 (7%)

2.2.2 Control Group Contamination and Design Limitations

As discussed above, our original impact assessment design was guided by the Terms of Reference (Annex 1) and focused on a difference-in-difference design where we intended to compare outcomes for adopting farmers in villages in which CFU had provided training with outcomes for farmers in villages which had not been offered training by CFU. At the inception phase and in the baseline report, we have consistently identified a number of challenges with the original design which include:

- The "baseline" survey was commissioned after the CF training had been initiated, making the true extent of changes in yield before and after training impossible to determine. Any improvements in yield seen might be underestimated compared to the true improvement in yield, because yield was most likely lower prior to implementing the training.

- Due to the need to focus on adoption impacts, the treatment group households were selected based on their participation in training, rather than by providing a random sample of households. This group is not as comparable to the control group as a random sample would be, as the characteristics of people who adopt CF are different than those who choose not to adopt (see the baseline report).
- Although every effort was made to select control villages that were similar to treatment villages, they were still unbalanced on a number of important characteristics (see Baseline Report) further reducing comparability of treatment and control groups. Control villages were more remote and poorer, making improvements in yields in the treatment observed possibly over-estimated, since we would expect few.
- The treatment is quite a complex intervention where there are a mix of factors which contribute to increased yields (the outcome of most interest). These include adoption of minimal tillage, fertilizer application, and crop rotation. The study was not designed to measure the impact of these separately.
- Crop rotation and changes in weather conditions limits our ability to compare the performance of single fields across seasons and under different conditions. For example, at baseline, 95% grew maize on their first field, with only around half of those continuing to produce maize on that field at midline. Comparisons across first and second fields risk being confounded by the different characteristics of these fields which are explored in more detail in Section 3.1 below.

At midline, we identified another significant constraint to the original design. We found that around 20% of control households received the treatment, detailed in Annex 5. Whilst, this can be considered good news for Zambian farming, this problem makes it difficult to match at the household level between treatment and control groups. There are unobservable reasons why some control households did not "comply" with their assigned status as members of the control village.[4]

As a result of these considerations, it is difficult to cleanly find comparable treatment and control households. Not only are they different on observable characteristics (as seen in the balance test table in Annex 4), they are also likely different on unobservable characteristics, such as the reasons why some people chose to receive treatment (in both treatment and control) and why some chose to rotate crops.

As a result, this analysis will not focus on comparing treatment and control groups to consider maize yield changes, the main outcome of interest. Instead, it will focus on comparing those who used minimum tillage compared to those that did not, regardless of original treatment or control assignment status. It will also focus on the first field of each household to improve comparability. Thus, this analysis will not focus on causal inference and will instead provide an ordinary least squares regression using observable information. Groundnut and soybean yields are not compared due to smaller sample sizes.

This analysis will provide comparability on observable characteristics by including regression covariates (controls) with key information from the village and household level. These are variables posited in the literature to affect the choice of conservation farming. These include:

- the population density of the village – the number of households over the village area – which was a selection criterion for villages to receive the trainings. (It was also highly correlated with field size, which was therefore excluded);
- village distance to the nearest road and distance to the nearest market, which might affect any financial gains from increased yields;

[4] In these cases, we would normally conduct an Intent-to-Treat (ITT) analysis assuming heterogeneous potential outcomes (Angrist 1990) since there are "non-compliers" who do the treatment (conservation farming) despite not being assigned to the treatment. This analysis estimates the Local Average Treatment Effect (LATE) of being assigned to treatment. The extent of the non-compliers in the control though, is large enough to make this analysis potentially problematic. Angrist, J. (1990). Lifetime Earnings and the Vietnam Era Draft Lottery: Evidence from Social Security Administrative Records. The American Economic Review, 80(3), 313-336. Retrieved from http://www.jstor.org/stable/2006669

- the size of the household (large households have more labour available);
- age of the household head, and
- education of household head as determinants of the likelihood of it being both easier to do conservation farming and the household head being more likely to adopt new techniques.
- Use of fertilizer, as a component of increased yields apart from minimum tillage. Note that fertilizer use at baseline is minimally correlated with fertilizer use at midline.

See Section 3.2 for these results.

2.2.3 Survey Implementation

Data Quality
The CSAZ baseline data collection effort utilized the following quality control measures: supervisor visits, spot-checks and daily high frequency checks by the team's Data Quality Associate. The supervisors randomly sat with each of their team members for at least two surveys per week to ensure adherence to survey protocols and to give tips and suggestions on how to improve. Supervisor feedback was continuously used to improve enumerator performance and discourage data falsification.

The most thorough checks were back-checks conducted by the Data Quality Associate. These checks were conducted on all household surveys using SurveyCTO, and results were compiled and shared with the survey firm daily for the first two weeks, then weekly in the remaining weeks. The back-checks compared data for each enumerator to search for patterns indicating data falsification or systematic errors that should be corrected, including short survey times, missing responses, a low average number of "other, specify" responses or multiple selections, or a low average number of rows completed on each roster.

The Data Quality Associate also scrutinized 10% of all surveys, reading each survey from beginning to end and checking for inconsistencies and other errors that are difficult to see through automation. Mistakes were then taken back to the enumerators for comment and corrections were made before the survey was approved.

Diagnostics
Our Midline diagnostic efforts focus on an analysis of the core indicators used for the quantitative impact estimates, including a discussion of balance problems, power issues and matching. The study outcome measures and core indicators and are detailed in Table 3. The results against these indicators are available in Section 3.

Table 3 Indicators Used in Impact Assessment

Outcome	Primary Indicators
Crop Yields	KG of maize per hectare harvested KG of legumes per hectare harvested
Household Income	Household sold any crops, except cassava and garden vegetables and fruits
Food and Nutrition Security	Diet Diversity score – A simple index from 0-14 that captures the different types of foods households consumed in the past 24 hours
Labour requirement and time savings	Total money spent on cultivating, planting, weeding, and harvesting Total person-days spent on cultivating, planting, weeding, and harvesting
Climate Resilience	Total value of household assets Household engaged in at least one non-weather dependent livelihood activity

Social Benefits at Household Level	Likelihood of household being under the national poverty line[5]

2.3 Qualitative Data Collection

Two teams of two qualitative data collectors (one man and one woman in each team) visited a total of eight sites across CFU's operational area to conduct focus group discussions and key informant interviews. Semi-structured interview checklists were provided to qualitative researchers along with a 2-day training held at IAPRI's office and a practice test of tools supervised by an IAPRI researcher. Qualitative data collection then took place in Choma, Chobomboko, Itezi-tezhi, Kabwe, Lundazi, Luampa, Monze and Sinda. Finally, national-level key informants were identified from Government, Private Sector and Development Partners. Four private sector partners were interviewed using a scoring rubric designed during the inception phase to provide an indication of progress in private sector commitment to conservation farming. A total of 258 respondents participated in focus groups with 51 respondents being engaged via key informant interviews. Details of the participants in each category are available in Table 4 and Table 5 below.

Table 4 Participants in Focus Group Discussions

Type of FGD	Female participants	Male Participants	Total
Adopters	78	69	147
Trained non-adopters	27	40	67
Disadopters	21	23	44
Total participants	**126**	**132**	**258**

Table 5 Participants in Key Informant Interviews

Key informant type	Female participants	Male Participants	Total
Farmer coordinators	2	6	8
TSPs and agro-dealers	-	14	14
CFU staff	1	7	8
Government staff	4	4	8
Private sector representatives	1	5	6
Partner Organizations	0	3	3

[5] To assess this, we use the Poverty Probability Index which is a simple and reliable method to assess household wealth status. The answers to 10 questions about a household's characteristics and asset ownership are scored to compute the likelihood that the household is living below a range of different poverty lines.

Key informant type	Female participants	Male Participants	Total
Development partner representatives	1	3	4
Total participants	**9**	**42**	**51**

2.4 Limitations

As discussed above, the most significant limitation to this study has been the infeasibility of the initially proposed difference-in-difference design. At inception and baseline, we had highlighted significant threats to the feasibility of the design including the implementation of the programme prior to the commissioning of the baseline survey, the absence of comparable areas where no conservation farming activities had taken place and the relative heterogeneity of the sample. As described above, further analysis at midline suggested that this design would no longer be credible as an experimental design based on statistical good practice. This is due to the contamination of the comparison group and the structural differences between households who adopt and don't adopt minimum tillage. However, the design of this evaluation to focus on theory-based analysis and a response to performance questions means that whilst we have downgraded the extent to which we can quantify a causal relationship with appropriate levels of statistical power, the study can still fulfil the objectives set out in the inception report.

However, given one of the key aspects of the design is no longer possible, it will be important to reallocate resources at endline to ensure that we can fulfil key evaluation objectives, including:

a) Provide an independent assessment of the programme for accountability and learning purposes;

b) Communicate policy relevant findings to key stakeholders of interest – especially DFID and other donors interested in funding conservation farming in Zambia and elsewhere.

With this in mind, there is scope to re-allocate resources at endline to focus on newer aspects of the CFU model such as engagement with private sector and development of a community agro-dealer model, as well as continuing to build the evidence base on the performance of CF fields under different weather conditions.

3 Midline for Impact Evaluation

The following sections provide an overview of sample characteristics and analysis of the indicators for each of the six outcomes specified in the Inception Report and the programme logframe. This also provides an overview of impact indicators for the case study of households who use tractors to till all or part of their fields. In the analysis, we disaggregate the results by gender of the household head and by tillage type. In the case of disaggregation by tillage type, we only compare "like with like", meaning we will compare conventional and conservation hoe farming and animal draught ripping with animal draught ploughing.

3.1 Sample Characteristics

Household Characteristics

The demographic characteristics of our sample have not changed significantly since the baseline. For this report, we have introduced descriptive statistics for household practicing CSA and those who do not, irrespective of the initial categorisation by 'treatment' and 'control' group. This is in response to the fact that CFU have delivered training in many of the original control villages. Table 6 below shows that those households practicing CSA are slightly older and more educated than those not adopting. Unsurprisingly the proportion of households with a disabled family member is similar to baseline but the proportion of households with a disabled family member is higher amongst those not using minimum tillage. They are also more likely to use animal draught power for cultivation. Whilst female headed households would typically have lower levels of education, there are similar proportions of female headed households in both adopting and non-adopting groups. This indicates that, all other things being equal, female headed households are slightly more likely to adopt CSA than male-headed households.

Table 6 Demographics by adopters and non-adopters

Midline	Households using minimum tillage	Households not using minimum tillage
Head age	47.9 (sd=13.5)	44.9 (sd=14.7)
Households with at least one member over 12 years old with disability	12.5%	14.6%
Head – no education	11%, (108)	17%, (76)
Head – some primary (up to grade 7)	53%, (533)	60%, (631)
Head – some secondary/tertiary ed	35% (350)	22%, (236)
Number of adults (13+)	4.08 (sd=2.0)	3.45 (sd=1.8)
FHH	23% (259)	22% (261)
Average field size in HA	1.06 (sd=1.08)	1.0 (sd=1.1)
ADP tillage	85% (998)	80% (1,058)
Hoe tillage	15% (145)	20% (211)

Midline	Households using minimum tillage	Households not using minimum tillage
Distance nearest market in km	27 (sd= 27)	33 (sd=28)

Source: Household Survey

Field Characteristics

As discussed above, in order to measure the impact of CSA adoption on yields, we have produced a field-level comparison between fields where CSA is used and those where it is not used. It is therefore important to understand more about the fields cultivated by different groups in our sample. The median number of fields for all households surveyed is three. During analysis, we focus on the first, second and third fields which are distributed across households as shown in Table 7[6]. Since fewer households have more than three fields, it is less relevant to analyse the yields from additional fields because they frequently represent outliers both in terms of the farming approaches used and the household farming them. The analysis of fields indicates that first fields tend to be the largest, be the most likely to farmed with minimum tillage, and more likely to have inputs like fertilizer applied. Focusing on the first three fields, and in some cases, only on the first field, allow us to draw clearer comparisons between fields.

Table 7 Number of fields per household surveyed

	All households (2082)	Treat Households (1036)	Control Households (1046)	CSA Adopters (998)	Non-CSA Adopters (1059)
1 field or more	99.9% (2081)	100% (1036)	99.9% (1045)	100% (998)	99.9% (1058)
2 fields or more	93% (1935)	96% (990)	90% (946)	96% (956)	90% (957)
3 fields or more	74% (1547)	80% (824)	69% (723)	78% (780)	70% (749)

Source: Household Survey

The average field size for all fields is 1.1 ha. The field size by first, second, and third field is shown in Table 8. Overall, first fields are the largest, and fields under CSA are larger than fields under traditional tillage.

Table 8 Field Size for Adopters and Non-Adopters

Field Size	All fields	CSA	Non-CSA
First field	1.38 ha (sd=1.46)	1.46 ha (sd=1.39)	1.33 ha (sd=1.50)
Second field	.85 ha (sd=.80)	1.0 ha (sd=.88)	.79 (sd=.76)
Third field	.78 (sd=.75)	.97 (sd=.97)	.72 (sd=.72)

Source: Household Survey

Use of Agricultural Inputs

[6] Farmers are asked about each of their fields in the order of size, so the first field is the largest, followed by the second, third, etc.

In the baseline report, we noted the difficulty of isolating yield changes which could be attributed to the adoption of conservation tillage due to the increased use of fertiliser and inputs on CA fields. The rates at which other inputs are used on CSA plots are shown in Table 9. As expected, fertiliser is the most common agricultural input, used by over half of households practicing CSA, and a third of households using conventional tillage. As shown in Tables 10 and 11, Basal and Urea fertilizer adoption decreases from first to second field and from second to third field for both fields under minimum tillage and those under conventional tillage. Insecticide and herbicide use are also more common by households practicing CSA, though each are much less common than fertilizer. Applying lime is rarely reported by any households.

Table 9 Agricultural inputs and investment on first field

	CSA	No CSA
Uses basal fertilizer	54% (385)	32% (433)
Uses top dressing (urea) fertilizer	57% (403)	33% (448)
Used insecticide on plot	17% (166)	12% (125)
Used herbicide on plot	28% (284)	11% (119)
Applied lime on plot	1% (12)	1% (15)

Table 10 Basal Fertilizer Adoption by Field, by tillage type

Basal Fertilizer on main crop	Minimum tillage	Conventional tillage
First field	54% (385)	32% (433)
Second field	55% (246)	23% (277)
Third field	42% (99)	17% (126)

Table 11 Urea Fertilizer Adoption, by tillage type

Urea Fertilizer on main crop	Minimum tillage	Conventional tillage
First field	57% (403)	33% (448)
Second field	57% (255)	25% (295)
Third field	47% (110)	20% (147)

Source: Household Survey

3.2 Regression Results for First Field Yields

There are three regression models using plot-level data on HH's main field are presented in Table 12. The first provides an overall comparison of maize yields by the two main CSA techniques of interest – minimum tillage and fertilizer. The second considers the original control group only. Although the sample size is small and so it is not possible to draw strong conclusions from this model, it is the most representative of what we might expect from villages after CF training, since it includes a random sample of villagers. The third model includes village fixed effects – in other

words, instead of providing the average response across all households, it instead looks at the average within each household (and then averages across those results). This model accounts for similarities within villages. Annex 4, Balance Tables, shows the summary statistics for variables used in the regression. In Table 12, P-values (or probability value) indicate the significance level of the results from the regression model by describing the probability that we could achieve the same results by random chance. The number of asterisks marks the significance level where, *** =p<0.01, ** = p<0.05, * = p<0.1. If the p-value of the results was less than or equal to 0.01, this indicates about 99% confidence that the results did not occur by chance with the given sample size denoted by, 'N' below.

There are three major findings related to this analysis.

1. Both minimum tillage and fertilizer use are associated with large increases in maize yield and these two are 23% correlated with each other. Minimum tillage is associated with an increase of 245-420 kgs per hectare depending on the model. Fertilizer is associated with an even larger increase of 400-684 kgs per hectare, depending on the model. Fertilizer use at baseline is also associated with higher yield, although to a lesser degree and by a smaller increase (30-210 metric tons/hectare depending on the model, ranging from not significant to p<.001). Results are extremely similar with basal fertilizer, which is highly correlated with top fertilizer. These results are promising but cannot completely account for self-selection bias. It may be that the households most likely to be successful based on characteristics we do not observe are strategically using fertilizer and minimum tillage.

2.There is a positive relationship between yield at baseline and yield at midline. Results below show that high maize yields at baseline are associated across all three models with higher yields at midline. In the model that looks at the overall comparison amongst HHs, one extra metric ton per hectare at baseline is associated with an increase of 0.15 metric ton per hectare at midline (p<.001). This may be because the plots where the HH chose to continue growing maize on productive fields and switched to groundnuts or soybeans on less productive fields.

3. Other variables are, for the most part, not statistically associated with higher yields. Some noteworthy trends are that higher yields are associated with increased education, younger household heads (HHs) and having a female household head (FHH) at baseline. Initially, age was positively correlated with higher yields (i.e. older farmers had higher yields) but controlling for other factors this correlation switched. This better accords with our expectation that younger household heads are more willing to try new techniques. Note that hoe tillage at baseline is associated with higher yields across villages, but not within villages. This may reflect that, although we saw in the descriptive statistics above that fewer households used hoe tillage at midline overall, the change is likely not even across villages. If in some villages more than others hoe tillage use decreased, then those are likely to have higher yields due to animal drought power at midline.

The table also shows r-squared values. These describe the percentage (about 18%) of the total variation in maize yield that can be explained by the use of fertiliser and minimum tillage practices and by the other variables listed in Table 12.

Table 12 Regression results measuring maize yield (metric ton/hectare) on field 1 at midline comparing two main CSA techniques of interest – minimum tillage and use of fertiliser (with standard errors in parentheses)

Variables	Overall N=979	Control group only N=506	Including village fixed effects N=979
Maize yield at baseline	0.150*** (0.0257)	0.168*** (0.0277)	0.128*** (0.0251)

Variables	Overall N=979	Control group only N=506	Including village fixed effects N=979
Minimum tillage at midline	420.1***	373.3***	245.7**
	(86.90)	(114.1)	(101.0)
Top fertilizer at midline	684.0***	616.5***	405.6***
	(100.5)	(117.4)	(109.7)
Top fertilizer at baseline	210.1**	341.9***	30.68
	(102.1)	(122.7)	(111.1)
PPI at baseline	0.731	-2.738	3.766
	(3.694)	(4.278)	(3.650)
Hoe tillage at baseline	46.08	126.8	-83.18
	(97.16)	(108.3)	(112.0)
FHH at baseline	11.62	76.22	4.129
	(97.25)	(115.3)	(94.97)
Education HH	18.00	11.20	47.61***
at baseline	(12.34)	(14.51)	(13.03)
Age HH	-4.568	-4.893	-0.574
at baseline	(3.048)	(3.592)	(3.069)
Village density at baseline	-29.86	-33.17	
	(21.26)	(25.37)	
Time to market at baseline	7.514	37.87***	-103.8
	(10.35)	(11.84)	(684.8)
Distance from nearest road (km)		-0.121	-3.576
		(5.093)	(5.842)
Constant	396.7*	341.4	960.6
	(216.0)	(240.0)	(4,187)
R^2	0.179	0.237	0.098
Note: *** =p<0.01, ** = p<0.05, * = p<0.1 Standard deviation = 974.01233			

To supplement the regression analysis, we use descriptive statistics that compare CSA adopters to non-CSA adopters for the six primary outcomes identified in the design report. It is important to note that the claims about the causal relationships between CSA adoption and these results is less robust than was initially envisaged but these descriptive statistics are still of great value in understanding programme results, especially when combined with the regression analysis above, our understanding of the programme theory presented in Section 4.

3.3 Results Against Outcome Indicators

3.3.1 Outcome 1: Crop Yield

The primary outcome of interest is crop yields for maize, groundnuts, and soy. In the following tables, we examine maize yields, groundnut yields, and soybean yields. To best isolate the impact

of minimum tillage, we compare each crop grown on the first field at baseline to the same crop grown on the same field at endline.

Maize is the most common crop, grown on 61% percent of first fields (N=1258) and 43% (N=707) percent of second fields at midline. We consider maize yields on the first and second fields. Groundnuts and then soybeans are some of the most common crops grown apart from maize (sunflower, cowpeas, and seed cotton are also widely grown). Their yields will be compared in cases where they are the main crop on a field and are planted on that field by 10% of households or more (so there are enough fields to be meaningfully compared).

Maize Yields

Maize yields on the first field decreased by 15.4% between baseline and endline, from 1,383 kg per ha to 1,170 kg per ha (Table 13), though there is considerable spread with a long tail of households achieving higher yield (Figure 2). This is consistent with overall agriculture trends in Zambia, which nationwide saw maize yields fall by 16% as much of the country was impacted by drought and erratic rains.[7]

Table 13 Maize Yields at Baseline (2017/8) and Midline (2019/20)

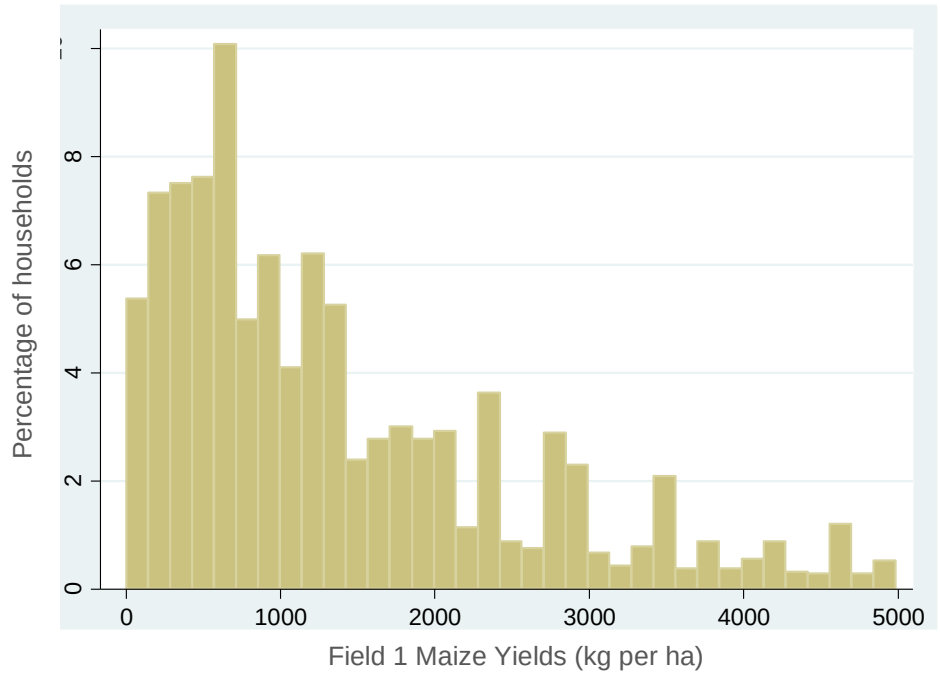
Maize Plot 1	Conventional Tillage	Minimum tillage	Difference[8]
Baseline	1258 kg per ha N=1,263 Stdev 1012	1582 kg per ha N=794 1077.024	324kg per ha
Midline	993 kg per ha N=621 Stdev 958.52	1403 kg per ha N=473 Stdev 1219.189	410 kg per ha
Maize Plot 2	**Conventional Tillage**	**Minimum tillage**	**Difference**
Midline	1,479 (sd=1212)	1,799 (sd=1207)	320 kg per ha

Source: Household Survey

[7] https://www.reuters.com/article/zambia-maize/zambias-2019-maize-output-seen-16-percent-down-at-2-million-tonnes-idUSJ8N219014

[8] Please note due to methodological limitations noted above, this table does not present conclusive evidence that the difference can be explained by the adoption of minimum tillage alone.

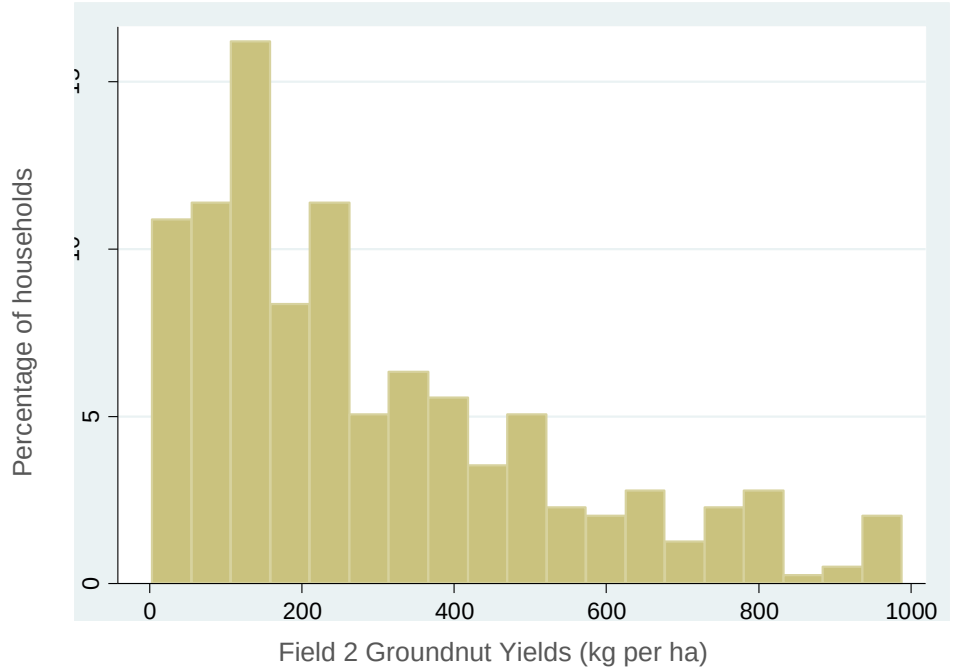
Figure 2 Distribution of Maize Yields at Midline



Groundnut Yields

We investigated groundnut yields focused on Field 2 for each household since that was most likely to be planted with legumes. Table 14 shows that average groundnut yield on Field 2 is 292 metric tonnes per ha, a 24% decrease from midline that can likely be attributed to drought conditions. As Figure 3 shows, there is a long tail of groundnut production, with some households having yields well above the average.

Figure 3 Distribution of Groundnut Yields at Midline



Source: Household Survey

On both Field 2 and Field 3, groundnut yields are higher for FHH and ADP households than for households on average at both baseline and endline (Table 15). The relatively small number of households, particularly on Field 3, make it difficult to draw too firm a conclusion about why female-headed households have higher yields than male-headed households, but it is an interesting finding nonetheless, as it is contrary to the findings for maize and soybean yields.

As was the case for maize yields, households who practice minimum tillage on their fields have higher yields than those who did not, both at baseline and at midline. The only exception is for groundnuts on field 3 at baseline. For example, at midline on field 2, households who use minimum tillage have groundnut yields that are 13% higher, on average, than households who do not use minimum tillage. These figures are presented in Table 14.

Table 14 Groundnut Yields at Baseline (2017/8) and Midline (2019/20)

Groundnut Yields	Overall - kg per hectare	FHH	ADP
Field 2			
Baseline	381 SD=234 N=767	468 SD=379 N=259	527 SD=434 N=682
Midline	292 SD=233 N=395	348 SD=361 N=100	378 SD=395 N=373
Field 3			
Baseline	497 SD=263 N=292	761 SD=571 N=90	745 SD=513 N=344
Midline	353 SD=280 N=129	732 SD=739 N=18	622 SD=584 N=145

Source: Household Survey

Table 15 Groundnut Yields by CSA Adoption

Groundnut Yield-metric tons per hectare	Conventional Tillage	Minimum Tillage	Difference [9]
Field 2			
Baseline	493 kg per ha SD=416 N=789	689 kg per ha SD=520 N=84	+196kg per ha
Midline	379 kg per ha SD=407 N=381	427 kg per ha SD=435 N=46	+48kg per ha
Field 3			
Baseline	774 kg per ha SD=525 N=335	705 kg per ha SD=514 N=69	-69kg per ha
Midline	624 kg per ha SD=598 N=124	705 kg per ha SD=694 N=43	+81 kg per ha

Source: Household Survey

[9] Please note due to methodological limitations, this table does not present conclusive evidence that differences can be explained by the adoption of minimum tillage alone.

Soybean Yields

Soybean yields follow the same trends as maize and groundnut yields (Tables 16 and 17). From baseline to midline, soybean yields dropped by 13%, from 720 metric tonnes per ha to 662 metric tonnes. Female-headed households have yields that are below the overall average, and ADP households have yields that are higher than the average. Like other crops, fields with minimum tillage have higher yields than households that use conventional tillage. On Field 2 at midline, yields are 36% higher on fields farmed with minimum tillage than on fields farmed with conventional tillage. Conversely Field 3 yields are lower than those on Field 2.

Table 16 Soybean Yields by Subgroup

Soybean Yields	Overall - metric ton per hectare	FHH	ADP
Field 2			
Baseline	760 SD=521 N=172	622 SD=433 N=33	789 SD=533 N=134
Midline	662 SD=546 N=109	621 SD=477 N=23	694 SD=579 N=93
Field 3			
Baseline	693 SD=516 N=181	696 SD=576 N=41	700 SD=521 N=148
Midline	666 SD=523 N=96	NA - too few observations	666 SD=495 N=83

Source: Household Survey

Table 17. Soybean Yields by CSA Adoption

Soybean Yield-metric tons per hectare	Conventional Tillage	Minimum Tillage	Difference [10]
Field 2			
Baseline	753 kg per ha SD=536 N=141	795 kg per ha SD=457 N=31	+42 Kg per Ha
Midline	619 kg per ha SD=535 N=88	842 kg per ha SD=564 N=21	+223 kg per Ha
Field 3			
Baseline	694 kg per ha SD=518 N=141	689 kg per ha SD=514 N=40	-5kg per Ha
Midline	712 kg per ha SD=568 N=67	560 kg per ha SD=410 N=29	-152kg per Ha

Source: Household Survey

3.3.2 Outcome 2: Household Crop Income

The primary indicator for the household income outcome is whether or not a household sold any of their crops, excluding cassava or fruits and vegetables. The proportion of households selling crops has fallen from baseline. which we assume is due to the poor rainfall performance and lower yields overall but may also relate to the maize price cap introduced. In 2017/8, 73% of the treatment group planned to sell crops whereas only 54% reported selling/planning to sell crops in 2018/9.

[10] Please note due to methodological limitations noted above, this table does not present conclusive evidence that the difference can be explained by the adoption of minimum tillage alone.

Table 18 shows the proportion of households planning to sell their crops as well as the income earned. Table 19 shows the proportion of households planning to sell each crop indicating that soybean is the crop most frequently grown for sale – 90% of those producing soybeans intend to sell them. For maize, the likelihood of sale is lowest with only 27% of households intending to sell their maize and for groundnuts, 52% of households intend to sell them.

The secondary indicator is the amount of money households earned from crop sales. The method used to calculate crop income has changed from baseline and has resulted in a more conservative and realistic estimate of crop incomes, namely that households adopting CSA who sold crops earned ZMK 5,806 (~£295), whereas conventional farmers earned ZMK 3521 (~£175). As expected, female-headed households and hoe farmers earn less than the sample overall, but hoe farmers using minimum tillage are much closer to the sample mean than those hoe farmers using conventional methods.

Households who practiced CSA at midline are wealthier than those who did not. This is true for female-headed households and hoe-tillage households as well as the sample overall. However, it is not possible to say if households were wealthier because they adopted CSA, or if wealthier households were more likely to adopt CSA in the first place.

Table 18 Crop Sales for the 2018/9 Season

	Household sold or plans to sell their crops (%)			Income earned from selling their crops for households who sold crops (ZMK)		
	Overall	**CSA adopters**	**Conventional Farmers**	**Overall**	**CSA adopters**	**Conventional Farmers**
Overall	**47.1%** N=2057	**53.6%** N=998	**41.1%** N=1050	4760 (sd=7262)	5806 (sd=8386)	3521 (sd=5590)
Female-headed households	**39.5%** N=508	**47.3%** N=239	**32.7%** N=272	3064 (sd=5075)	3926 (sd=6270)	2046 (sd=2831)
Tillage – Hoe	**35.0%** N=352	**34.5%** N=145	**35.7%** N=207	3543 (sd=8909)	5290 (sd=13430)	2434 (sd=3633)

Source: Household Survey

Table 19 Crop Sales by crop for 2018/9 Season

Crops on Fields 1-3 (midline)	Proportion of HH that grew this crop that either sold or plan to sell
Maize	**27%** N=1262
Soy Beans	**90%** N=271
Ground Nuts	**52%** N=338
Any Crop	**47%** N=2057

3.3.3 Outcome 3: Food and Nutrition Security

The primary indicator for 'Food and Nutrition Security' is the average dietary diversity score, disaggregated by tillage type and gender of the household head. The dietary diversity score is an average of the number of 15 types of food a household consumed in the past 24 hours. In addition to the primary indicator, we also consider the mean number of months a household experienced hunger, as well as their score on the FANTA II Household Hunger scale, a six-point scale based on various food security questions where a lower score indicates less hunger. The descriptive statistics for each of these indicators and sub-groups of interest can be found in Table 20.

The mean dietary diversity score increased slightly from baseline from 6.8 to 7.2 for all households overall. Female-headed households and hoe tillage households also saw their dietary diversity scores rise since baseline, though their scores remain lower than the household average. Dispute the increase in dietary diversity from baseline, households are experiencing greater hunger than in the past year. The mean number of months a household experienced hunger rose slightly from. 2.6 to 2.8 (sd=1.7) for the overall sample, and the percent of households with a high hunger score, while still very low, doubled from 1% to 2% (N=40).

CSA households overall have higher dietary diversity scores, fewer months of hunger, and lower hunger scores. This finding is particularly true for the groups most vulnerable to food insecurity, female-headed households and hoe farmers. Female-headed households who practiced CSA at midline have a mean dietary diversity score that is nearly a full point (.9) higher than female-headed households who practice conventional tillage. Female-headed household who practiced CSA at midline also experienced .4 fewer months of hunger and are 4% less likely to have a high hunger score. Hoe farmers show similar differences. CSA hoe farmers experience .2 fewer months of hunger than non-CSA hoe farmers and are 5% less likely to have a high hunger score. These significant differences in food security outcomes between CSA and non-CSA households maybe partially due to the increased yields from CSA but may also be a product of structural differences between households that were present prior to adoption of CSA.

Table 20 Food and Nutrition Security

Baseline	Mean Dietary Diversity Score (Higher score = more diverse diet)	Mean number of months household experienced hunger	Low Hunger score (0-1)	Medium Hunger score (2-3)	High hunger score (4-6)
Overall Sample – Midline	7.2 (sd=2.6)	2.8 (sd=1.7)	90% (N=1886)	8% (N=159)	2% (N=40)
Overall Sample – Baseline	6.8 (sd=2.5)	2.6 (sd=1.5)	90% (N=2258)	9% (N=220)	1% (N=34)
CSA					
Baseline 'treatment' overall	7.14 (sd=2.6)	2.49 (sd=1.46)	90% (N=1046)	9% (N=97)	1% (N=16)
Midline CSA overall	7.6 (sd=2.5)	2.8 (sd=1.7)	93% (N=933)	6% (N=55)	1% (N=9)
Midline Female-headed households	7.2 (sd=2.6)	2.8 (sd=1.7)	88% (N=210)	11% (N=25)	1% (N=3)
Midline Hoe farmer	6.7 (sd=2.4)	3.2 (sd=2.2)	88% (N=127)	9% (N=13)	3% (N=5)
No CSA					
Baseline 'control' overall	6.35 (sd=2.4)	2.63 (sd=1.51)	90% (N=1212)	9% (N=123)	1% (N=18)
Midline No CSA overall	6.8 (sd=2.6)	2.8 (sd=1.7)	87% (N=926)	10% (N=102)	3% (N=31)

Midline Female-headed households	6.3 (2.5)	3.1 (sd=1.9)	83% (N=232)	12% (N=33)	5% (N=13)
Midline Hoe farmer	6.7 (sd=2.9)	3.0 (sd=2.0)	81% (N=170)	11% (N=24)	8% (N=17)

Source: Household Survey

3.3.4 Midline for Outcome 4: Farm labour

One of the debates in conservation farming relates to its labour intensiveness. Some studies have claimed that hoe/basin farming is more labour-intensive than conventional farming whereas a key part of this programme theory of change is that households will progress from hoe/basin tillage to ADP ripping and that will therefore be labour saving. The programme theory of change assumes that households may be able to use this labour to engage in other livelihood activities.

To answer questions about how the adoption of CSA changes the amount of agricultural labour required on a field. We calculate the mean number of person-days per ha households spent on four different agricultural activities: Land preparation, planting, weeding, and harvesting. We also calculated the amount of money spent on hired labour for each of these activities. We then compared the results, both in aggregate and by activity, for first fields[11] farmed with minimum tillage and first fields farmed with traditional tillage. The results are presented in Table 21.

When we look only at the first field (Table 21), we find that CSA does require both more person-days of household labour and greater expenditures on hired labour. This is true across all agricultural activities, but is most true for land preparation, as is to be expected. Surprisingly, household labour for weeding does not decrease for fields under minimum tillage. However, it is again important to note that there are systemic differences between households who adopt CSA and those who do not, and it may be those differences, not the adoption of CSA, that lead to the increased labour expenditures.

Table 21 Midline Labour Usage on Farming (days per Hectare)

Midline	Mean number of person-days per ha spent on land prep, planting, weeding, and harvesting			Mean amount of money per ha spent hiring labour on land prep, planting, weeding, and harvesting (in ZMW)		
	Overall	CSA	No CSA	Overall	CSA	No CSA
First Field	105 (sd=130)	125 (sd=176)	94 (sd=96)	70 (sd=333)	92 (sd=508)	59 (sd=186)
Female-headed households	112 (sd=138)	133 (sd=182)	100 (sd=104)	71 (sd=498)	106 (sd=801)	50 (sd=164)
Hoe farmers	179 (sd=176)	224 (sd=224)	149 (sd=126)	102 (sd=671)	182 (sd=1030)	48 (sd=176)
ADP farmers	88 (sd=112)	100 (sd=152)	84 (sd=86)	63 (sd=200)	69 (sd=229)	61 (sd=187)

Source: Household Survey

We also examine four secondary indicators that examine the mean number of person days per ha for each of the four farming activities: land preparation, planting, weeding, and harvesting. For

[11] At baseline, we examined this indicator for all fields. At midline, we believe it is more accurate to compare only the first fields for reasons explained in the methods section.

each activity, we compare the values for plots farmed using minimum tillage with plots farmed using conventional tillage to understand how labour is distributed throughout the farming season. There is limited change since baseline on these variables with a slightly increase in time reported for weeding on both minimum tillage and conventionally farmed fields.

Table 22 Comparison between reported time use at baseline and midline for minimum tillage and conventional fields

	Mean number of person-days per ha spent on land prep, planting, weeding, and harvesting (Baseline)	Mean number of person-days per ha spent on land prep, planting, weeding, and harvesting (Midline)		
Activity	**Minimum Tillage**	**Conventional tillage**	**Minimum Tillage**	**Conventional tillage**
Land preparation	35 (sd=59)	33 (sd=65)	36 (sd=92)	14 (sd=37)
Planting	12 (sd=19)	14 (sd=19)	17 (sd=24)	13 (sd=20)
Weeding	34 (sd=49)	34 (sd=47)	42 (sd=61)	41 (sd=47)
Harvesting	20 (sd=28)	21 (sd=34)	30 (sd=41)	25 (sd=32)

The final set of secondary indicators examine how labour is distributed between household members. Respondents were asked what proportion of the labour for land preparation, planting, weeding, and harvesting was done by men, women, and children for a variety of crops[12]. Table 23 shows the distribution of labour for maize over the past agricultural season for households that do minimal tillage and those who do conventional tillage. Overall, men do the majority of land preparation and planting labour (62% for each activity), with women contributing 30% of the total labour. Children contribute 6% of the labour for land preparation and planting. Women play a more substantial role in weeding and harvesting, and contribute 46% of the labour for each activity, and children contribute between 9 and 10 percent of all labour. Men's labour accounts for 43% of the overall weeding labour, and 37% of the harvesting labour. There are no significant differences between minimum tillage and conventional tillage households.

Table 23 Distribution of Labour across Tasks and Household Members for Maize (out of a total of 15, standard deviation in brackets)

Midline	Minimum tillage			Conventional		
	Men	**Women**	**Children**	**Men**	**Women**	**Children**
Land preparation	9.5 (sd=5) 63%	4.0 (sd=4) 27%	1.2 (sd=2.4) 8%	10.3 (sd=5.4) 69%	2.8 (sd=3.9) 19%	.75 (sd=2.2) 5%
Planting	5.0 (sd=3.6)	8.4 (sd=3.8)	1.6 (sd=2.6)	4.7 (sd=3.9) 31%	8.8 (sd=4.1)	1.3 (sd=2.5) 26%

[12] Respondents were asked to divide 15 buttons into piles that represented the proportion of labour done by men, women, and children. During analysis, we converted their answers from a 15 point scale to a 100 percentage point scale, and show both the original proportion and the percentage in Table 4.3.

	33%	56%	11%		59%	
Weeding	6.8 (sd=4.0) 45%	6.4 (sd=3.7) 43%	1.6 (sd=2.5) 11%	6.3 (sd=3.8) 42%	7.2 (sd=3.6) 48%	1.3 (2.4) 9%
Harvesting	5.4 (3.4) 36%	7.1 (sd=3.7) 47%	1.6 (sd=2.5) 11%	5.4 (sd=3.7) 36%	7.0 (sd=3.9) 47%	1.3 (sd=2.3) 9%

Source: Household Survey

3.3.5 Midline for Outcome 5: Climate Resilience

The primary Climate Resilience indicators are the value of household assets, and household investment in non-weather dependent livelihoods. In addition to these primary indicators, we also examine whether households were impacted by climate shocks, and their subjective perception of their ability to respond. As in all outcomes, we disaggregate the data by tillage type and gender of the household head. Assets included in the total include both agricultural and household assets; the value of each asset was estimated by the respondent.

Table 24 shows the increase in asset values from baseline to midline for all households. This can be partly attributed to inflation which sat at around 10% per year during 2019 but also shows the extent to which farming families are interested to invest in durable assets and in livestock businesses which can help to grow household asset bases. Whilst it is not possible to make a direct comparison between baseline 'treatment' groups and 'CSA adopters' at midline – it is clear that asset values have increased more substantially for CSA adopters and that this tend is consistent across hoe farmers and female headed households.

Table 24 Baseline Values for Climate Resilience Indicators

	Mean Asset Value (ZMW) Baseline			Mean Asset Value (ZMW) Midline		
	Overall	**Treatment**	**Control**	**Overall**	**CSA**	**No CSA**
Full sample	4005 (sd=13305)	4345 (sd=9346)	3673 (sd=16297)	5082 (sd=15585)	7080 (sd=17861)	4283 (sd=14645)
Tillage – Hoe	1448 (10060)	1337 (sd=2022)	1512 (sd=12407)	2499 (sd=8480)	3369 (sd=11399)	1768 (sd=4675)
Female-headed households	1893 (sd=11650)	2066 (sd=8840)	1720 (sd=14010)	2459 (sd=8505)	3742 (sd=12629)	1598 (sd=3463)

Source: Household Survey

Under this outcome, we also measure the number of households engaged in non-weather dependent livelihoods (Table 25), which include trading of non-agricultural products and livestock, selling services such as tailoring or barbering, and formal employment. This indicator excludes income from natural resources or agriculture. The programme theory of change assumes that households with at least one source of income that is not weather-dependent are better able to cope with climate shocks such as droughts, erratic rains, and deforestation, and that income gains from CSA adoption could be invested into these activities. At midline, nearly two-thirds of all households had at least one source of non-climate depend livelihood (64%, N=1459). This is a

much higher percentage than at baseline, where only 15% of the sample engaged in such livelihoods. The most common non-crop livelihoods engaged in are livestock trading (24%, N=554), crop services (13%, N=305), and marketer/hawker/vender (13%, 292). The drastic change since baseline suggests a measurement change and this will be investigated further at endline.

Table 25 Midline Values for Climate Resilience Indicators

	Midline: % Engaging in non-weather depending livelihoods			**Baseline**: % Engaging in non-weather depending livelihoods		
	Overall	**CSA**	**No CSA**	**Overall**	**Treatment**	**Control**
Full sample	64% (1459)	72% (723)	69% (731)	15% (N=336)	18% (N=199)	12% (N=137)
Female-headed households	64% (333)	66% (158)	62% (175)	15% (N=92)	17% (N=52)	14% (N=40)
Hoe farmers	63% (225)	72% (105)	56% (118)	8% (N=49)	11% (N=22)	7% (N=27)

Compared to baseline, slightly fewer households report being impacted by a drought or erratic rains in the past year. Only 65% of households (N=1351) report being impacted by a drought last agricultural season, compared to 85% of households at baseline. Similarly, while last year 74% of households were impacted by erratic rains, this year only 69% of households (N=1429) claim to have been affected. This is surprising given the poor performance of the season this year compared to the performance in the baseline year. Of those households who were affected by drought at midline, fewer report being able to cope well or very well compared by midline – 15% vs. 18%. The same holds true for households impacted by erratic rains – only 18% of households (N=260) report being able to cope well or very well at midline, compared to 21% at baseline.

Households who adopted CSA are 2% less likely to report being impacted by drought than households who did not adopt CSA, and are 6% more likely to say they coped well with the drought. Households who adopted CSA are also 6% more likely to say they coped well with erratic rains than households who did not adopt CSA, perhaps because of CSA's emphasis on early land preparation. Overall, it appears that adopting CSA helps households to cope with changes in weather patterns.

Table 26 Midline Values Subjective Assessment of "ability to cope"

Midline	**Overall**	**CSA**	**No CSA**
Impacted by a drought	65% (1351)	64% (646)	66% (698)
Percent who said they coped well or very well with the drought	15% (201)	18% (111)	12% (89)
Impacted by erratic rains	69% (1429)	70% (696)	68% (725)
Percent who said they coped well or very well with erratic rains	18% (260)	20% (146)	15% (113)

Source: Household Survey

3.3.6 Midline for Outcome 5: Social benefits at the household level

Initially, this indicator was measured using the Poverty Probability Index, but at midline there were measurement issues with several questions and the results were not considered reliable. We selected secondary indicators to show social benefits in two areas where, after food, poor households are more likely to invest additional income – clothing and education. As shown in Table 27, the number of households where all members between the ages of 6 and 12 are enrolled in school increased from 60% at baseline to 65% at midline (N=1053), but the percent of households where all household members had at least one pair of shoes fell slightly from 88% to 85% (N=1750). As previously households adopting minimum tillage show slightly improved performance on these indicators.

Table 27 Change in key poverty index variables

	Baseline	Midline - overall	Midline -CSA	Midline - No CSA
All members have shoes	88% (N=2,021)	85% (1750)	88% (877)	82% (869)
All members between ages 6-12 in school	60% (N=976)	65% (1053)	69% (549)	62% (495)

3.3.7 Midline Data: Tractor Case Study

Each of the nine primary indicators captured in Outcomes 1-6 are shown for TSP households in Table 28. TSP households who both rip and plough are included in the "ripping" category. We would expect that households with means and the land size to hire a tractor service provider would be wealthier than the household sample overall, and we find that across all of the study indicators, TSP households appear to be better off. TSP households have higher income from crop sales, higher asset values, higher dietary diversity, experience fewer months of hunger, and are less likely to be below 200% of the national poverty line.

On agriculture indicators, TSP households have higher maize yields per ha. There are not enough TSP households growing groundnuts and soybeans to provide information about yields for those crops. TSP households also spend fewer person-days of labour on all agricultural activities, as we would expect to see from their mechanized land preparation. TSP households do have higher expenditures on agricultural labour, which again is not surprising, given the higher household wealth and the implied cost of hiring a tractor that is associated with being sampled as a TSP household

The small number of TSP households using tractors for ploughing make it difficult to make any conjectures about differences in outcomes for farmers that rip rather than plough.

Table 28 Midline Results for the Tractor Case Study

Outcome	Indicator	Overall (N=126)	Ripping (N=111)	Ploughing (N=15)
Crop Yield	Maize Yield on first field (metric tonne per Ha)	2559 SD=1500 N=49	2455 SD=2535 N=45	3733 SD=1950 N=4
Labour Requirements and Time Savings	Number of person-days per plot on land prep, planting, weeding, and harvesting, first field	56 (sd=98)	54 (sd=101)	68 (sd=15)

Outcome	Indicator	Overall (N=126)	Ripping (N=111)	Ploughing (N=15)
Labour Requirements and Time Savings	Amount of money per plot spent hiring labour on land prep, planting, weeding, and harvesting, first field	279 (sd=479)	254 (sd=479)	463 (sd=445)
Household Income	Total income from crop sales	14,537 (sd=20,450)	13,216 (sd=19,991)	23,781 (sd=21,935)
Food/Nutrition Security	Dietary Diversity Score	9.8 (sd=2.7)	9.8 (sd=2.8)	9.4 (sd=2.1)
Food/Nutrition Security	Months experiencing hunger	1.0 (sd=2.2)	1.1 (sd=2.3)	.33 (sd=.8)
Climate Resilience	One or More Investments in Non-weather Dependent Livelihoods	80% (101)	83% (92)	60% (9)
Climate Resilience	Total asset value	43,211 (sd=69,733)	43,333 (sd=69,565)	42,260 (sd=73,684)

4 Midline Findings

4.1 Relevance

Finding 1 CSAZ's approach remains relevant to smallholder farmers. Adoption of CSA practices are consistently mentioned as an important change by farmers in focus group discussions.

CFU promotes the adoption of conservation farming by recruiting a network of Farmer Coordinators (FCs) which offer training to a group of up to 90 farmers per FC each year. CFU also facilitates training for tillage service providers, including linking potential ripping service providers to banks for loans to purchase tractors and other equipment. The focus of the CSAZ programme is on Conservation Farming, which is based on three key principles: (i) minimal soil disturbance through minimum tillage, (ii) protecting the top soil with organic soil cover/crop residues, and (iii) crop rotation with legumes. The CFU training also covers a wide range of other good agricultural practices which can be applied in both minimum and conventional tillage farms – including planting across the slope to reduce soil erosion, correct spacing and depth for planting, correct timing for planting, use of lime, precision use of fertiliser, herbicides and pesticides. As an opener to all focus group discussions, we asked farmers to tell us about changes that have affected their farms in the last three years. No specific reference to conservation farming was made by the facilitators of the discussions at this point but as can be seen from Table 29, respondents routinely comment on technologies promoted by CFU as amongst the most important changes that have affected them. Key labour-saving techniques of ripping and herbicide use top the list of most frequently mentioned responses, with other CSA techniques such as crop rotation and residue maintenance also frequently mentioned.

Table 29 Most important changes impacting agriculture in the last three years

Theme	No. times mentioned as change over 3 years	No. times mentioned as important specifically for women	No. times mentioned as important specifically for men
Herbicide use	31	9	7
MT-Ripping	30	8	15
MT-Hoe Basins	18	11	4
Integrated Farming	14	3	1
Use of compost and/or manure	12	1	1
Crop rotation	12	2	-
Residue maintenance & incorporation	11	-	-
Started gardening (vegetables)	8	1	1
Practicing soil fertility maintenance	8	2	1

Source: Focus group discussions

Finding 2 Feedback from stakeholders at baseline highlighted that CFU could consider how it could invest more into helping farmers use business skills. Few changes were reported in the approach to CFU's training package between baseline and midline but some respondents reported an increased emphasis on financial literacy and farm budgeting.

Given CFU's theory of change anticipates that increased crop production would result in increased incomes, there is an assumption that farmers will sell surplus crops for a profit. However, CFU's intervention does not support farmers to access new markets nor to increase the prices they receive for their crops. This has been identified as a potential gap in the theory of change since the inception phase. It appears that in some locations, training in farm budgeting has been included into the CFU model. However, this was not unanimously reported and there was not increase in the percentage of respondents reporting being trained in 'farming as a business' between baseline and midline in the household survey. This is possibly due to a partnership between CFU and GIZ to train Farmer Coordinators as financial literacy trainers. This year key informants noted other types of CSA intervention that could also strengthen the CFU approach – including the development of irrigation schemes in areas with potential and the provision of weather information. Currently these are not in the programme scope, but it is possible that CFU's extension network could disseminate weather forecast information and its implications to farmers.

Finding 3 CFU launched a Gender Strategy in 2018. Several Farmer Coordinators noted they had made fresh efforts to include women in training in the 2018/9 season. However, there are still large barriers related to land ownership and intra-household dynamics that limit women's ability to benefit from the programme.

Five out of the eight CFU field officers interviewed for the midline reported that CFU's approach to promoting women's involvement and empowerment over the last year (2018/2019 Agricultural season) has changed. Field Officers explained that CFU started hosting CFU training and demonstrations on the farms of female headed households. The unit also worked with Zambia Rural Partnership (ZaRP), an organization that empowers women with start-up funds for gardening and aimed to target women who practice conservation farming with training on gardening. Other field officers encourage more women to attend their meetings, trainings by choosing more female farmer coordinators. CFU has also taken up the issue of land tenure rights and has worked with traditional leaders to identify vulnerable female headed households and to ensure they retain access to land. CFU reached its own targets for female training attendance but given the prevailing social and cultural norms, women still face greater barriers in attending CFU training and in benefitting from the training. See Finding 8 for more details.

Finding 4 CFU have effectively raised awareness of the importance of including people with disabilities in training activities. People with disabilities are being trained but cannot always adopt conservation farming practices nor access other sources of support.

Both Field Officers and Farmer Coordinators noted that CFU has made it a requirement to include persons with disabilities in training. This is largely focused on people with physical disabilities, so it is unclear if it is feasible for CFU to include those with visual, hearing or learning difficulties in their training and our survey did not collect disaggregated data on the nature of farmer disabilities. Farmer Coordinators also note that people with disabilities lack resources to invest in farming and are not all capable of the physical work involved. CFU staff and Farmer Coordinators also lack information about other sources of services and support to assist people with disabilities and do not have a referral pathway for people with disabilities who are unable to farm. Whilst there are limited resources available via the Zambia Association of People with Disabilities and the Department of Social Welfare to help people with disabilities overcome these constraints and CFU has communicated advocacy messages on the potential of people with disabilities via its recent case study communications, it is important to DFID that CFU continue to explore the most effective way to support people with disabilities to become more productive.

Finding 5 CFU remains the largest training provider on CA topics and has attracted high profile Government support towards CA. It is frequently reported as influencing the approaches of other development partners.

Development partners who were involved in key informant interviews frequently commented that CFU's approach had been influential in the design of a number of national initiatives, including the EC-funded, FAO-implemented Conservation Agriculture Scaling Up programme, the Zambia Sustainable Agriculture Intensification Programme and the GCF-funded Climate Smart Agriculture programme. CFU was also notably coordinating with WFP and SNV to host training and field days Further collaboration between CFU and these initiatives is requested by partners, for example sharing lessons learned on mechanisation with FAO, developing a national extension approach which draws on the best of the lead farmer and farmer field school approaches.

4.2 Efficiency

This section reports on 'efficiency' as defined in the methods section and the Inception Report. This approach acknowledges that the majority of programme performance issues are reported by CFU in routine programme reporting to DFID.

Finding 6 Farmer Coordinators note that they frequently re-train the same farmers over several years. The cost-efficiency of this approach can be further investigated.

Key informant interviews with farmer coordinators requested further information on the overlap in farmers trained from year to year. The results are presented in table 30, showing that in 6 of 8 locations, the majority of trainees are people who have already been trained in previous years. There are mixed views on this approach. CFU note that repeat training is important in increasing adoption rates. Farmer Coordinators note that many farmers adopt after the first training but re-attend in order to correct mistakes and learn more on the details of the practices – such as around herbicide use or planting. Other stakeholders commented that CFU should remain active in an area for multiple years given mindset change takes time. However, there are also a number of key informants who commented that 'scaling up' and 'reaching more' farmers should be a key objective for CFU, which when combined with Finding 8 might suggest that prioritising farmers who have not previously been trained would offer greater value for money. The examples from this small number of farmer coordinators is supported by evidence from the much larger household survey. Table 31 overleaf compares the proportion of our sample who were trained in 2017/8 with those trained in 2018/9.

Table 30 Farmer Coordinators' reports on percentage of farmers repeatedly trained

District in which Farmer Coordinators were interviewed	Reported % of trained farmers who were the same in 2018/9 as in 2017/8	Reported % of trained farmers who were the different in 2018/9 as in 2017/8
Sinda	60%	40%
Chongwe	30%	70%
Kabwe	45%	55%
Chipata	25%	75%
Kaoma	95%	5%
Mumbwa	60%	40 %
Pemba	75%	25%
Kalomo	50%	50%

Source: Key informant interviews with 8 farmer coordinators

Finding 7 The majority of farmers trained by CFU generally report the training as very useful

Table 31 indicates the proportion of farmers who were trained on topics covered by CFU's training materials at baseline and midline, as well as the percentages of households finding training on this topic provided by CFU as very useful. As per baseline, the proportion of households finding the CFU training very useful was over 85% for all topics.

Table 31 Training provision for household survey respondents

Training Topic	% trained in 2017/8 (n)	% trained on this topic in 2018/9 (n)	Most recent training provided by CFU (of those trained in 2018/9) % (n)	CFU provided training is very useful (as reported by those trained by CFU) % (n)
Ripping with oxen	92% (1043)	62% (604)	88% (533)	90% (1211)
Digging basins to a sufficient soil depth	91% (1,039)	64% (622)	89% (448)	88% (1209)
Keeping basins in the same place year after year	89% (1,017)	89% (907)	89% (447)	89% (1215)
Fertilizer application	84% (959)	62% (604)	88% (531)	90% (1210)
Correct spacing for planting key crops	83% (945)	61% (595)	89% (460)	92% (1199)
Adding organic matter to basins	82% (934)	57% (554)	87% (484)	90% (1110)
Maintaining crop residue in the field after harvest	81% (921)	60% (585)	89% (519)	92% (1173)
Digging basins in rows across the slope	81% (917)	59% (568)	93% (441)	89% (1115)
Digging basins on soil with lower permeability	56% (634)	44% (424)	91% (386)	87% (844)
Planting leguminous trees	51% (759)	46% (442)	85% (375)	90% (900)
Farming as a business	46% (529)	42% (407)	86% (350)	91% (840)
Protecting crop residue from livestock	46% (522)	35% (335)	92% (308)	89% (686)
Improving post-harvest storage	40% (457)	32% (312)	84% (261)	90% (678)
Need to protect existing trees	37% (419)	37% (360)	87% (313)	90% (737)
Applying lime	32% (365)	49% (471)	91% (427)	87% (899)

Source: Household survey

Finding 8 In all Focus Groups, participants appreciated the contents and quality of the training but in several groups noted they also placed value on the opportunity to eat together and to socialise with other farmers.

Across all focus groups, the majority of participants commented that the training was of high quality and provided sufficient information to allow a household to adopt the practices covered in that session. The reasons for a lack of adoption were reported to relate to cash, labour or ripper availability as well as disagreements within a household about the most effective approach for farming. When asked if the training content is the most important reason for attendance, focus group participants confirmed that content of the training was the most important factor in 13 out of 28 groups. For example, one farmer remarked "*The content of the training is more important than anything else, that's why we attend the training in the first place".* In 12 groups, respondents found the content of the training to be equally important as the other benefits of the session – for example one individual remarked "*The food that we are given is equally important"* and another commented

that "*meeting different NGOs that give incentives is equally important.*" In 3 groups, respondents commented that the 'other benefits' were more important than the contents of the training. For example, one respondent remarked "*Socializing and eating is more important than the actual training because we enjoy interacting and sharing knowledge with our fellow farmers".*

Finding 9 Agro-dealers and Ripping Providers greatly appreciated the marketing opportunities provided by CFU-organised field days. Farmers participating in field days also unanimously found the opportunity to attend field days useful but made suggestions for improvements in location and content.

CFU reports organising over 6000 field days in 2019. All of the eleven tractor and animal draught ripping providers that we interviewed noted the value of the CFU-organised field days in attracting new business. Some also mentioned that these days offered a valuable opportunity to seek feedback from customers. For example, one ADP provider commented "*The business increased a lot and was well advertised.*" A tractor provider noted that "t*he results from the field day were positive and encouraging – I learned about the mistakes I had been making and a lot of people got to know about me and my business."* Agro-dealers were also involved in field days and several noted that continuing to link agro-dealers to field days would be an important activity for CFU in promoting the uptake of CA in their communities. Field Days were also cited by other development partners as an important opportunity to collaborate with CFU and private sector input and machinery suppliers such as MRI Syngenta, Bayer, ETG and SARO had also valued the opportunity to participate in CFU Field Days.

Farmers interviewed during focus group discussions commented on the value of the field days but noted that more centrally located field days would be more inclusive to all types of farmers. In particular, several respondents remarked that sometimes field day locations could be too distant for elderly farmers or those with disabilities to attend – although naturally there is a cost associated to field day organisation and they cannot be close to everyone. Farmers also commented that field days which focused on crops other than maize would be really useful. Another concern reflected by farmers was the fact that CFU did not share information on the drawbacks (such as pest vulnerability) of new seed varieties promoted by agro-dealers at field days but it is hard to gauge the extent to which this is an issue or would be feasible to achieve.

Finding 10 Women are more likely to experience challenges in attending or actively participating in the training. Women in married households also lack access to land and decision-making power which limits their ability to act on the training and to experience the benefits from conservation farming.

CFU has increased its ambition in reaching women farmers and has met its logframe targets for women's participation. Feedback from the focus groups note specific challenges for women in attending and participating fully in the training sessions. For example, comments note the difficulty in attending training alongside domestic responsibilities and also the challenge in participating actively due to gender norms. For example, one female farmer commented "*there are very few women who attend the training because most of them stay home to do house chores and take care of the children*" , another noted "*Women fear that when they get home some men will say that you talked too much at the training."*

Whilst, one response to this challenge could be to provide training specifically for women, it is not clear whether this would be an effective approach since women are rarely the main decision-maker for any particular plot. One focus group respondent noted "*women find it difficult to convince men to adopt conservation farming because men consider themselves being the head of the house*." This is supported by evidence from the household survey which shows that the household head (male) makes decisions about the majority of fields across both the first, second, and third fields, though the spouse (female) makes the decisions on the second field in more households than the first. Breakdown of the decision maker by field number is shown in Table 32. There is are no

significant difference in the gender of the primary decision maker on fields under CSA vs conventionally farmed plots.

Table 32 Primary Decision Maker by Field

Who makes decisions about the field	Head	Spouse	Head/Spouse Together
First field	88% (N=1,822)	3% (N=53)	8% (N=170)
Second field	81% (N=1,329)	10% (N=163)	8% (N=132)
Third field	84% (N=824)	9% (N=90)	6% (N=54)

Issues related to intra-household decision-making do not only affect the adoption of minimum tillage but also affect decision-making related to investment in farm inputs. For example, in focus group discussions where respondents maintained separate plots managed by spouses, a greater volume of inputs were reportedly used on the male farmers' field. This was explained with the following responses:

- Men own the land and grant women small areas of land for gardening alongside their primary domestic role.
- Men make decisions and women have limited say over where inputs are used
- Male-managed fields are usually bigger
- Women-managed fields are often used for legumes which do not require as much fertiliser as maize or other cash crops.

The integration of behaviour change methodologies that encourage both women and men to consider the value of cultural norms guiding decision-making and economic activity to their families. Such activities have been shown to have an impact on the ability of women, particularly those in married households, to benefit from participation in agricultural programmes.[13]

Finding 11 Respondents in focus groups reported post-harvest losses of 0-25% of stored maize due to moisture or pest damage, often this was despite insecticide application. Only a small number had changed practices in response to training by CFU and this topic was less frequently covered in CFU trainings.

When asked about post-harvest losses, households were able to quantify the volumes of maize that had been destroyed by insects, rodents or moisture damage from the previous season and the volumes lost varied extensively but in the majority of focus groups, the majority of participants had lost some of their maize in this way. The majority of farmers noted that their approach to maize storage had not changed recently – maize is dried either on the ground or in purpose-built structures, once it is shelled chemicals are applied and the maize is stored in bags in the house or in sheds. Two respondents were aware of PICS bags but noted that they had been trained by WFP on this topic. It is therefore not clear that CFU has contributed to the reduction of post-harvest losses amongst its farmers. Given the volume of crops lost post-harvest may be greater than that from yield increases due to adoption of minimum tillage, this topic perhaps deserves more attention. Successful approaches to reducing post-harvest losses mentioned by respondents include frequent re-treatment during storage (every 2-3 months), mechanised drying processes and use of PICS bags. At inception, it was reported that CFU would partner with WFP to promote PICS bags but only 1.2% of the treatment sample had purchased PICS bags at midline. When asked why they had not purchased the bags, the most common responses were that they were ot

[13] For example see: Farnworth, C. R., Stirling, C. M., Chinyophiro, A., Namakhoma, A., & Morahan, R. (2018). Exploring the potential of household methodologies to strengthen gender equality and improve smallholder livelihoods: Research in Malawi in maize-based systems. *Journal of Arid Environments*, *149*, 53-61.

aware of the product (50%) or did not have cash at the right time (36%).Just under 9% of the sample reported that they did not need or want the project. There was no difference in awareness of PICS bags between treatment and control groups.

Finding 12 Focus group feedback noted topics of interest that are not currently covered by the CFU training. Participants also raised similar logistical issues as those mentioned at the baseline.

Comments in focus groups indicated an interest in additional topics not currently covered by CFU. Some of these have been reportedly covered by CFU in some areas – such as army worm control or tree planting and others are not within the current scope of the programme such as livestock farming. Several farmers commented on vegetable and cash crop production as an interest suggesting that CFU's partnership with Syngenta MRI to promote vegetable gardening in Chisamba is a valuable activity. Logistical improvements suggested by participants included ensuring trainers communicate early and attend on time; holding training on the weekend to allow people who work during the week to attend; constructing shelters to protect training participants from sun/rain; shortening the time period of training to reduce fatigue and providing sufficient food to match the number of attendees. Women face particular challenges to attend trainings due to their domestic responsibilities, whereas men are more likely to face challenges due to employment.

4.3 Effectiveness

Finding 13 Households in the treatment group use minimum tillage on almost half of their fields. 44% of households report a desire to expand the area under conservation tillage in future. Consistent with the baseline, the most commonly used minimum tillage method is ripping with oxen.

Table 33 shows the percentage of fields upon which different tillage types are applied for the treatment and control groups as they were defined at baseline. Across the 'treatment sample' (who we know are adopters of MT as a result of CFU training), we found that 49% of cultivated fields were under a type of conservation tillage. Conversely, the remaining fields are under conventional tillage either hoeing or ploughing. As reported previously, 82% of our baseline sample reported farming with animal draught power on at least some of their fields – we can see from the midline data, that 76% of all fields are cultivated with animals.

One hypothesis discussed during the inception period was that households who had previously not ploughed with oxen might move straight to ripping with oxen as a result of promotion of CSA. If this occurs, it is on a relatively small scale. The proportion of fields cultivated with animals is only slightly lower in the control group (73%) and the treatment group (76%) and this could be because the group is, on average, poorer. In only 4 of 21 focus groups with adopters, did we locate households who had moved straight to animal draught ripping without having previously ploughed with oxen.

Focus group discussions explored the advantages and disadvantages of basins and ripping respectively. Respondents noted that hoe/basin cultivation was more labour intensive but that when done properly it could store moisture and result in rapid maize growth. However, where basins were not dug correctly yields would reduce. Ripping was reportedly less labour intensive, cheaper than hiring labourers to dig basins and easier to get right. It therefore produced more consistent results.

Table 33 Tillage Type at Midline across all fields

Tillage Type over all fields (more than one type per field possible)	Treatment	Control
Basins	16% (N=432)	8% (N=146)

ADP ripping	31% (N=801)	7% (N=119)
Zero Tillage	1% (N=39)	6% (N=99)
Conventional hand hoeing	6% (N=158)	13% (N=227)
Conventional animal ploughing	45% (N=1191)	66% (N=1170)

Source: Household Survey

As seen in Table 34, of those who have adopted CSA in the 2018-2019 season, 41% (N=387) reported practicing on a larger area this season than in past seasons, and 85% (N=1751) reported that they plan on practicing CSA on more land in the future, which suggests households are on a whole satisfied with CSA methods. In focus group discussions, households also noted that they tended to expand the area under minimum tillage where they say benefits in terms of increased yields or reduced labour (ripping and herbicide use). However, the survey data which records the area of each plot under mimimum tillage does not substantiate these reports from households. In fact. As can be seen in Table 35, the mean area under minimum tillage has decreased from the baseline for all groups except for female headed households.

Table 34 CSA Adoption Over Time

	Overall	Treat	Control
Adopted minimum tillage (both first time and continued from prior to midline adopters)	49% (998)	76% (781)	21% (217)
Reported expanded area under minimum tillage since the first time they practiced CSA	41% (387)	43% (338)	35% (50)
Plan on practicing minimum tillage on more land in the future	85% (1751)	90% (919)	81% (837)

Source: Household Survey

Table 35 Area under minimum tillage for households using the practice

Households that adopt minimum tillage	Baseline – Mean area (ha) under minimum tillage on fields 1-3	Midline - Mean area (ha) under minimum tillage on fields 1-3
All	**2.20** sd=5.90	**1.92** sd=2.16
Female-headed households	**1.34** sd=1.56	**1.35** sd=1.27
Hoe farmers	**2.15** sd=12.92	**1.32** sd=1.53

Finding 14 Surveyed households report that moisture retention is the most important benefit they experienced following adoption of minimum tillage. This is consistent with answers to the same question at baseline. Soil quality improvements are the second most important benefit reported.

Table 36 sets out the proportion of households at baseline and midline reporting benefits they experienced from adopting CSA. The results remain relatively consistent across the two years of the survey with slightly lower numbers of farmers reporting benefits in 2018/9 which is perhaps to

be expected given the lower rainfall and yields achieved in this year. Surprisingly, far fewer households reported more efficient fertiliser application as a benefit of CF adoption despite interviews with farmer coordinators and focus groups citing these benefits and noting that CFU training had promoted fertiliser measurement and the substitution of manure with fertiliser. It is possible that this was not universally applied as feedback from survey teams in some areas noted farmers had over-applied fertilizer in relation to field size on the premise that it would help with productivity. This may have occurred as a result of competing or incorrect extension messages.

Table 36 CFU Benefits reported by adopters at Baseline and Midline (multiple responses possible)

Benefit Experienced	Treatment - Baseline (N=961)	CSA Adopters – Midline (N=1,004)
More moisture retained in soil during dry spells	78% (N=749)	73% (733)
Soil quality improved	55% (N=528)	41% (407)
Used less fertilizer	65% (N=629)	28% (275)
Reduced costs	32% (N=308)	24% (235)
Erosion from wind/rain reduced	22% (N=214)	19% (191)

Source: Household survey

Finding 15 Whilst our study focuses on the adoption of minimum tillage as the main driver of benefits, intercropping and crop rotation are also important components of CSA. There was no difference between rates of intercropping between fields under minimum tillage and those not. In terms of crop rotation, 40% of households in the original treatment group switched from maize to legumes on their first fields between baseline and midline compared to only 33% in the control group.

63% of households (N=1461) maintained the same crop on their first field between baseline and midline (overwhelmingly maize). Of the 36% (N=831) that did not, most (94%, N=780) switched away from maize. There is more crop switching in the treatment than in the control (40%, N=443 of those in the treatment compared to 33%, N=388 out of those in the control).

This may provide some evidence for increased crop switching to let fields recover. To get at the reason for crop switching, we can see that 90% of those in the treatment who did crop switching reported that their household uses CF (N=400), compared to 77% of those in the treatment group that did not do crop switching (N=520).

Fewer households (53%, N=1229) retain the same crop on their second fields, so there is more crop rotation. This is true of both treatment and control. There is still more crop rotation in the treatment (58% of the treatment, N=655) than in the control (49%, N=574).

The most common crops planted by households who switched from maize to another crop on their first fields at midline are groundnuts and, soya beans, which provide additional evidence that households are practicing crop rotation to restore soil fertility.

In relation to intercropping, we found that at baseline first fields were mostly used to plant maize, but that 53% of these fields were intercropped with legumes with no significant differences between the rates of intercropping on fields in the treatment and control groups. At midline, intercropping on the first field is no longer reported, with many households now growing legumes as a primary crop on these fields. Relatedly, there's almost no intercropping at baseline on the second field because these fields mostly have legumes as a primary crop.

Finding 16 Residues were retained on 35% of fields in which minimum tillage was used.

At baseline, farmers noted the challenges associated with retaining residues on their CA plots, although baseline data showed that the treatment group were able to maintain residues on just over half of their conservation tillage fields. At midline, the proportion of CSA fields on which residues were retained had decreased to less than 40% (Table 37). There are minimal differences between field types but interestingly female headed households are slightly more likely to retain residues and hoe farmers are slightly less likely to retain residues.

Table 37 Percentage of fields on which residue is retained

	Percentage of fields upon which residues are retained		
	Overall	**Minimum Tillage Fields**	**Fields with No Minimum Tillage**
Field 1	30% (n=2048)	35% (n=998)	25% (n=1050)
Field 1: Female-headed households	30% (n=511)	37% (n=239)	25% (n=272)
Field 1: Hoe farmers	22% (n=354)	32% (n=145)	15% (n=207)
Field 2	33% (n=1640)	38% (n=859)	28% (n=776)
Field 3	31% (n=982)	34% (n=582)	26% (n=400)

In focus group discussions, farmers also commented that CFU training had been influential in promoting proper crop spacing, legume production, the measurement of fertiliser and the use of manure to substitute from fertiliser.

Finding 17 Adopting households report challenges with conservation farming at a similar rate to the baseline. There are no large differences in the proportions of new adopters reporting challenges compared to those who had adopted previously. Labour constraints are the main challenge reported by disadopters. Results from the survey are consistent with challenges described in focus groups.

Table 38 provides an indication of the challenges reported by farmers adopting climate smart agriculture. Farmers have faced very similar challenges to those reported in the baseline and those reported in the literature. Reassuringly, 44% of farmers report that they do not face any challenges. Labour constraints for digging basins was the most significant challenge reported by 12% of adopter – this is a common critique of CSA. Other common challenges cited were not being provided with inputs (9%, 94), lack of labour/time for weeding (7%, 67), and not having money for herbicide (6%, 62). Interestingly, lack of time/labour for digging basins was not cited as a challenge for a greater percent of new adopters than for all CSA adopters.

Examining the challenges faced by disadopters gives us valuable insight into why these households may have stopped practicing CSA on their fields. Disadopters were less likely than other households to claim to have no challenges (30%, N=25). Households who practiced CSA at baseline but disadopted at midline were almost twice as likely to report that the time and/or labour required to dig basins was a challenge (22%, N=18). They were also twice as likely to say that not being provided with inputs was a challenge. Since being provided with inputs was not a part of the CFU program, it is possible they adopted under the premise of getting free inputs, and disadopted when this proved not to be the case.

Table 38 Most significant challenges to CSA Adoption

Challenge	CSA Adopters – Midline (N=998)	New Adopters – Midline (N=231)	Treatment group – baseline (n =961)	Midline disadopters (baseline results) (N=161)
No challenge	44% (437)	44% (102)	37% (N=356)	30% (25)
No time/labor to dig basins	12% (120)	11% (26)	17% (N=159)	22% (18)
Not provided with inputs	9% (94)	7% (17)	10% (N=96)	16% (13)
No time/labor for weeding	7% (67)	3% (7)	5% (N=45)	4% (3)
No money for herbicide	6% (62)	8% (18)	4% (N=36)	4% (3)
Climate isn't good for conservation farming	5% (51)	6% (15)	4% (N=40)	2% (2)
No money to buy equipment	5% (49)	4% (10)	4% (N=38)	1% (1)
No money to hire rippers	3% (34)	5% (11)	4% (N=42)	6% (5)
No livestock for ripping	2% (21)	4% (9)	3% (N=24)	2% (2)

Source: Household survey

Focus group discussions highlighted very similar reasons for failure to adopt. Although some additional reasons were mentioned, including households who felt they did not have adequate information, women who failed to convince their spouse to adopt and those with negative experience of weed growth. Some respondents also noted that ploughing was faster than ripping or that they could not find a ripping service provider in time.

Finding 18 As noted in the baseline, adopting minimum tillage is associated with the adoption of other good agricultural practices. Since CFU targets 'serious farmers', the causal relationship is likely multi-directional, particularly for fertiliser. Herbicide is more likely to be adopted for the first time after starting minimum tillage. Most farmers secure inputs from FISP but 22% of farmers in the treatment group report being linked to input sellers by CFU.

Table 39 shows the extent to which inputs are used on fields under conservation tillage and on conventionally cultivated fields.

Table 39 Agricultural inputs and investment on first field

	Fields under conservation tillage	Fields under conventional tillage
Uses basal fertilizer	54% (385)	32% (433)
Uses top dressing (urea) fertilizer	57% (403)	33% (448)
Used herbicide on plot	28% (284)	11% (119)
Used insecticide on plot	17% (166)	12% (125)
Applied lime on plot	1% (12)	1% (15)

Source: Household survey

Focus group responses indicate that farmers prioritise fertiliser over other inputs and aim to use it whenever they can afford it and access it at the right time. These discussions also explored how

households decided which plots to apply fertiliser to. Responses indicated that they prioritise fertiliser on fields where maize and cash crops are grown, in fields with poorer or sandier soil and in fields where yields have been previously low. Some farmers also noted that they prefer to use more fertiliser on fields with better soil to maximise their chances of a good yield. Respondents also reported that the field in which they applied fertiliser changed from year to year and that they use less fertiliser in fields where they had recently rotated crops or where they were able to use animal manure instead. There was little consideration given in focus groups to the financial return from investment in fertiliser and inputs with most farmers reporting that if cash was available, they would prioritise fertiliser. Whilst some respondents explained that they prioritised fertiliser use on the fields under minimum tillage, others mentioned that they would only apply fertiliser on these fields after first covering conventionally cultivated fields. Of the 21 focus groups for adopters, respondents reported using fertiliser on minimum tillage plots in 13 cases and manure in 8 cases. Hoe/basin cultivation was reported to increase the efficiency of fertiliser to a greater extent than ripping since households who rip may still broadcast fertiliser. Inability to use fertiliser was noted because of a lack of cash, late availability of fertiliser from the subsidy programme and the long distance to the retail shops coupled with lack of transportation.

Herbicide use was considered more closely adopted with minimum tillage and in 17 of the 21 focus groups, respondents commented that they had started using herbicides after adopting minimum tillage. This was motivated by the messages heard in training and because weed pressure increased once conventional tillage was stopped. In 3 focus groups, households reported using herbicide on conventionally cultivated plots prior to minimum tillage adoption where it was seen as a cost-effective approach to manage weeds in a large field or where tough grasses that could not easily be weeded were growing.

The survey does not ask directly how households finance input purchase, but we ask some questions about where inputs are acquired that may give some insights. Results are shown in the table below. Notably, most farmers are receiving their fertilizer at no cost from FISP (45%, N=905). Roughly one in five treatment farmers were connected to an input supplier by CFU (22%, N=223), and 10% of treatment farmers reported buying farm inputs directly from CFU (N=103). We assume this relates to CFU Farmer Coordinators acting as agents. Loans from outgrower schemes, taken by 15% of households (N=300), could also provide farmers with inputs. No households have taken loans from the Zambia National Farmers Union.

Table 40 Source of farm inputs

	All households (N=2023)	Treatment (N=1001)	Control (N=1022)
Bought farm inputs from CFU	6.52%, (132)	10.29%, (103)	2.84%, (29)
Was connected to an input supplier by CFU	13.45%, (272)	22.28%, (223)	4.79%, (49)
Acquired fertilizer from FISP	44.74%, (905)	56.24%, (563)	33.46%, (342)
Took out a loan from a farmer union or co-op	0.2%, (4)	0.2%, (2)	0.2% (2)
Took out a loan from an outgrower scheme	14.83%, (300)	13.49%, (135)	16.14% (165)

Finding 19 At midline around 40% of households report receiving training on farming as a business and 85% of those **households received this training from CFU.**

As presented in the table below, there is a statistically significant difference in the incomes of those who have received training compared to those who have not. However, we can not state with confidence that business training is the cause of this difference.

Table 41 Crop income for households who received business training

	Average household crop income in ZMW	p-value
All households (N=2,292)	2637 (sd=5900)	NA
Households received training about farming as a business from any organization (N=822)	3711 (sd=6887)	T=-4.74 p<=.001***
Households who received training from CFU about farming as a business (N=698)	3584 (sd=7080)	T=-5.11 p<=.001***

Finding 20 CSA adoption influences food security and incomes through an increase in production of food and cash crops.

In the literature, the contribution of conservation agriculture to family food security is reported as resulting from an increase in cash income and dietary diversity which occurs through increased legume production[14] and through behaviour change interventions which increase gender equality and nutritional awareness.[15] According to our household survey data, the dietary diversity of CSA adopters has increased since baseline but the number of months in which households experience hunger has also increased. This is logical given yields across the country reduced as a result of rainfall shortages, including for farmers adopting conservation farming. However, conservation farmers are more likely to produce legumes and as a consequence have opportunities to diversify diets and generate additional cash to purchase food. As discussed above, CFU's approach does not aim to influence gender equality in household decision-making or household behaviour in consuming or purchasing nutritious food. There are also limitations to the extent that CFU supports crop marketing or the production of higher value crops that might focus on household-decision. Incorporating such interventions could potentially increase the interventions impact on incomes and household food security.

Finding 21 Access to cash for inputs and to profitable markets with timely payment terms remains a constraint to farmers despite CFU's ongoing efforts to promote bulk marketing. The factors influencing maize markets in Zambia, including the state involvement are not within the scope of this study.

Farmers in focus group discussions noted that they cannot always sell their maize at the prices they would like and that transport costs and a lack of bargaining power can depress prices. The availability of cash to purchase inputs was also a major constraint to their use. This is compounded by the fact that many farmers sold their maize to the Government Food Reserve Agency and waited long periods for payments.

CFU has also begun reporting on the linkage of farmers to financial institutions – they has reached 1,653 farmers who have accessed finance from One Acre Fund, Jacana, Rent-to-own, Agricon, Vitalite and Vision Fund. This money has been used for a range of agricultural equipment including

[14] Nyanga, P (2012) Food Security, Conservation Agriculture and Pulses: Evidence from Smallholder Farmers in Zambia. Journal of Food Research.

[15] Beuchelt, T. D., & Badstue, L. (2013). Gender, nutrition-and climate-smart food production: Opportunities and trade-offs. Food Security, 5(5), 709-721.

irrigation equipment for horticulture, household solar devices and boreholes. However, funds from One Acre Fund are particularly focused on fertiliser, maize and legume seeds which could have an impact on the indicators of interest for this study. However, the numbers of farmers involved are too small to be visible in our study at present.

CFU have also linked over 17,000 farmers to bulk marketing opportunities for 1,248 tons of maize and 234 tons of soya. Arrangements were made firms such as CHC commodities, ETG, Mount Meru, Crop King Limited and M1 Milling. Under these conditions' farmers have also received more timely payments for their crops. Whilst we know that market conditions are a key constraint to farmers, the CFU bulk marketing activities are relatively new and had not yet reached the farmers involved in our evaluation in any number. Our endline evaluation can seek to explore these aspects in more detail.

4.4 Sustainability

Finding 22 There was a 12% disadoption rate across all tillage types between baseline and midline. Disadoption rates were slightly higher for hoe farmers than those using ADP. Disadopters are older and are less likely to have secondary education than those sustaining adoption.

Our survey investigated disadoption of minimum tillage practices. We found that 181 households practiced CSA at baseline, but not at midline. Of the disadopting households in our sample, 72% were in the treatment group. This means that 131 households of those trained by CFU and adopting the practice at baseline had disadopted the following year. This reflects a disadoption rate of around 12%. This is higher than the 7.7% annual disadoption rate for basins reported by Kabwe and Donovan (2005)[16] but lower than the 20% rate reported for minimum tillage from monitoring data in Haggblade and Tembo (2003).[17] It is also lower than the rate of 25% reported from survey data in Grabowski et al (2016)'s[18] study of Eastern Province in Zambia, though it is important to note that this study looked at changes over a four year period.

We also conducted six focus group discussions with disadopters to understand the reasons behind disadoption. Similar to the challenges mentioned above, respondents noted the labour-intensiveness of the practice, the difficulty in buying herbicides and the fear of weed pressure as well as a lack of incentives available. Key informants also noted that, CF farmers in common with other farmers, found that there are few incentives to increase production where market linkages are weak and the maize price is low. Other informants commented that the FISP and other subsidy programmes are not used to incentivise conservation farming and that this could encourage farmers to sustain adoption.

In Table 42, we compare the characteristics of CSA Disadopters with characteristics of the treatment group overall to learn more about the characteristics associated with CSA disadoption. Disadopters are more less educated and older than the rest of treatment group. The percent with secondary education in the disadopters group is significantly higher than the others in the treatment group ($p<.001$). More female headed households disadopt, although this is not a statistically significant difference.

[16] Kabwe, S., & Donovan, C. (2005). Sustained use of conservation farming practices among small and medium scale farmers in Zambia. *Food Security Research Project/Michigan State University*.
[17] Haggblade, S., & Tembo, G. (2003). Early evidence on conservation farming in Zambia.
[18] Grabowski, P. P., Kerr, J. M., Haggblade, S., & Kabwe, S. (2016). Determinants of adoption and disadoption of minimum tillage by cotton farmers in eastern Zambia. *Agriculture, Ecosystems & Environment*, *231*, 54-67.

Table 42 Characteristics of CSA Disadopters

Midline	Treatment	Disadopters (CF at baseline, no CF at midline. Treatment Group) N=131
Head age	48.1 (stdev 13.54)	50.7, stdev 15.5
Head – no education	9% N=98	5%, N=8
Head – some primary (up to grade 7)	52%, N=581	70% N=92
Head – some secondary/tertiary ed	31% N=44 35%, N=723 for those who use CF at midline	20%, N=26
Number of adults (13+)	3.96 (stdev 1.95) N=231	3.8 (stdev 2.08)
FHH	23% N=259	26% N=42
Total field size	1.06 (sd=1.09)	1.02 (sd-1.06)
Only Hoe tillage	11%	14%
ADP	88%	86%
Distance nearest market	25.7 N=1117 stdev 27.9	27.5 stdev 26.57

Source: Household survey

Finding 23 Maize yields are highest for continuous CF adopters and lowest for households who never adopted CF. Yields for disadopters are slightly higher than those who never adopted but lower than those for adopters. Because of differences between farmers in each group, we cannot conclude these differences are caused by conservation farming.

Table 43 shows the maize yields on the first fields for new CF adopters, continuous CF adopters, disadopters, and those who never adopted CF. Yields are highest for continuous adopters of CF, followed by new adopters, then disadopters, and lowest for households who never adopted CF. While this correlation is promising, because of the inherent differences between farmers in each group we cannot conclude these differences are caused by conservation farming, though we can conjecture. Yields for groundnuts and maize are not included because the number of farmers in some categories is too small to draw accurate conclusions.

Table 43 Maize yields in first fields (Kg per hectare)

	Maize in field 1 (kg/ha)
All households	1170 (sd=1097)
New adopters (N=262)	1276 (sd=1282)
Continuous Adopters (N=373)	1423 (sd=1195)
Dis-adopters (N=96)	1167 (sd=1082)
Never adopters (N=499)	965 (sd=924)

Finding 24 During the programme design, CFU and agro-dealers considered working with community agro-dealers (CADs) as a possible long-term model to sustain training on climate smart agriculture topics and improving last mile access to CSA equipment and inputs. However, relatively few Farmer Coordinators appear to operate as or with CADs and some agro-dealers reported that they have stopped working with CADs.

Of the eight Field Officers interviewed, six reported active interaction with community agro-dealers in their operational area. Some reported that Farmer Coordinators were being recruited to act as CADS and one noted that Farmer Coordinators were given targets to engage with community agro-dealers. In one case, the Field Officer commented that only 4 out of the 33 Farmer Coordinators were acting as CADs, whereas another noted that 6 of 32 Farmer Coordinators worked as CADs. In two cases, individuals are no longer Farmer Coordinators but are still CADs. A more widespread survey of Farmer Coordinators would be needed to make a generalisable statement about the sustainability of the CAD model. However, the supply of CADs is not the only potential issue with the approach. CADs must engage with larger agro-dealers to fulfil orders. Of the eight agro-dealers interviewed for the study, six had worked with CADs, with five still doing so. Four of those noted that they had begun working with CADs without the involvement of CFU, for example one dealer worked with 30 agro-dealers but noted that this was an independent arrangement, and another noted that their engagement with CADs had been facilitated by SeedCo. Two agro-dealers were offering credit arrangements to CADs but neither was satisfied with the arrangement. Two dealers had offered products on a ‘pay as you go’ basis direct to farmers which had been successful but did not rely on CADs who were not involved in the arrangement. One informant noted that CADs could not be a substitute for Farmer Coordinators or for CFU training because they were not able to provide detailed information about the products they sold. Agro-dealers suggested that CFU can continue to provide training to CADs with a particular focus on budgeting and financial management.

Finding 25 CFU relationships with private sector companies have mostly deepened since baseline, with all companies advertising in CFU brochures and increased levels of investment in training on conservation farming and the establishment of demonstration plots.

A baseline on institutional commitment to conservation farming was developed across four private sector companies which have developed partnerships or are expected to partner with CFU in future. These companies were re-visited at midline and further information on the companies’ activities and their contribution to CFU was requested. All but one company have increased their score using the scoring rubric developed during the inception phase as shown in Table 44. Whilst two firms commented that the benefits of their relationship with CFU outweighed the costs, one firm noted that they felt the costs (advertising in the brochure, investing in attendance at field days etc.) exceeded the benefits and the final one noted that the partnership could not yet be evaluated. Two of the firms expressed concerns about the sustainability of the CFU model for the future. One highlighted the need for stronger linkages with financial services providers to develop financial products that would allow farmers to invest in their farming businesses. The other noted that the cost of the CFU model was too high and that they should explore technology that could reduce extension costs.

Table 44 Baseline Responses Demonstrating Private Sector Companies' Commitment to Conservation Farming

Company	Baseline KII Score (0 to 14)	Midline KII Score (0 to 14)	MOU status with CFU	Financial Contribution to CFU	New business models related to conservation farming
SARO Agri	12	11	Yes	In-kind only.	Yes, continued R&D for CA equipment.
Bayer PTY	10	12	Yes	Yes, provided inputs for 50 demo sites. Lost due to drought.	No
Syngenta / MRI Seed	9	14	Yes	Yes, field days and demo plots in Southern Province. Lost due to drought.	Yes, vegetable seedling sales and showcasing of greenhouses with CFU in Chisamba.
ETG	6	9	No, but planning to develop	Yes, trained 150 agro dealers and 90 Camp Officers.	No.

Source: Interviews with Private Sector Partners

Finding 26 Key informants noted that CFU could improve the sustainability of its activities by addressing constraints along the whole value chain and by deepening collaborations with other organisations. However, this may not be within the scope of the current DFID-funded programme.

Key informants are mostly positive about the effectiveness of the CFU model but several question its reliance on donor funding and its limited focus on production as opposed to catalysing systemic change in agricultural markets. This partly reflects the relative rarity of the CFU business model in the DFID's agricultural portfolio. Whilst several respondents recommend that CFU improve the sustainability of its model by attracting further private sector investment through monetising its services, its existing efforts show that private companies are not yet unanimously convinced on the value they derive from their existing level of investment. Others suggest that CFU could form a broader consortium of other organisations to provide services across the market system and that donor money invested in this way could leverage greater benefits for farmers and wider investments from private sector that go beyond promoting conservation farming. Other respondents' question whether CFU focuses enough on ensuring that Government staff are committed to continuing the promotion of CF after the programmes' exit and suggest that greater investment in Camp Extension Officers would help improve sustainability. Evaluating the effectiveness of this approach would require comparisons with data from the EU's CASU programme which took this approach, but which was not able to provide data to enable such a comparison.

Finding 27 Government of Zambia remains supportive of CFU's approach and is keen for private sector providers to engage in extension. Despite field officers reporting involvement of Camp Extension Officers and District officials in many activities, at national level GoZ recommends greater involvement of camp extension officers and more joint planning with district and provincial staff.

The evaluation team interviewed the key ministry contact for conservation farming within the Zambian Government Ministry of Agriculture, the Principal Agriculture Specialist for Land Management and Conservation Farming, to understand how the government perceives the CFU and supports their work. The Ministry values the CFUs work and feels it is both in line with the government's priories and the needs of smallholder farmers. However, it considers that closer collaboration and planning could leverage the effective use of camp extension officers given this is a substantial manpower resource. CFU Field Officers reported that they do not work in isolation and that they collaborate with CEOs, and in some cases District officials and councilors in the organisation of Field Days and training sessions. Some tractor and ADP tillage service providers also receive support through the CEO who assist with mobilizing farmers who want ripping services. CEOs also advise ADP tillage service providers on the medicines to use and give support on the issue of army worms. No progress on joint work to develop national-level CF materials nor on efforts to bring private sector participation to the Zambia Integrated Agriculture Management Information System (ZIAMIS) was noted.

Finding 28 As number of advocacy opportunities were identified by stakeholders, highlighting that CFU does not currently have a targeted strategy to influence Government of Zambia and other development partners to adopt its approach.

Stakeholders noted that CFU is a well-respected provider of extension information and has been a centre of learning on conservation farming across the region. However, the Government of Zambia does not endorse a particular approach to conservation farming promotion nor use CFU's tried and tested materials. Conservation farming is also only included in the curriculum for extension workers to a limited extent. Other advocacy priorities that might be relevant to CFU include encouraging tax relief on conservation farming implements and incorporating the promotion of CF into major agricultural initiatives such as the farmer input support programme. Additional actions required to improve the enabling environment include the incorporation of small, medium and large companies under the Zambia Seed Trade Association (ZASTA) and use this as a platform to promote CA; reduction of state interference in grain prices; and creation of tax incentives for businesses that promote conservation farming.

5 Discussion

5.1 Implications for the Programme Theory of Change

The programme theory of change and associated assumptions are presented in Annex 3. As per the baseline, the midline survey results support the majority of these assumptions.

5.1.1 Input to Output Assumptions

Midline data supports the assumption that both male and female farmers will access training provided by Farmer Coordinators and find the content relevant and useful.

The theory of change also assumes that farmers will believe that the benefits of CF adoption outweigh the risks implicit in any change in farming practice and that adoption will take place. Whilst this study did not study adoption, we note that newly trained farmers in comparison areas now report adoption of CF whereas the majority of farmers who had previously adopted minimum tillage have maintained the practice.

5.1.2 Output to Intermediary Outcome Assumptions

The programme theory of change assumes that minimum tillage plots will generate higher yields for maize and legumes under a wider range of conditions. This midline report documents that adoption of minimum tillage and fertiliser application are correlated but that regression analysis can identify the benefits which are associated with each of these practices individually. Our regression model also suggests that minimum tillage is associated with an increase of 245-420 kg of maize per hectare whereas fertilizer is associated with an even larger increase of 400-684 kg per hectare. It is important to note that this data reflects the performance of maize crops in an area with poor rainfall performance and where yields overall were reduced. It will therefore be of interest to repeat the exercise at endline to observe whether this changes under different rainfall conditions. Households also report their own perceptions of benefits which relate to increased moisture retention in the soil and improvements in soil quality, both of which are the expected mechanisms through which CSA increases yields.

The programme theory of change also assumes that minimum tillage plots use less labour than conventional plots. Our baseline survey found that one-hectare plots farmed with conventional tillage and hoe power used three additional person-days of labour compared to those one-hectare plots farmed using minimum tillage and the hoe/basin approach, a small but significant difference ($p=.02$). However, at midline farmers report using significantly larger volumes of time and money on minimum tillage fields. This is more consistent with focus group responses at both baseline and midline where farmers report finding hoe/basin cultivation labour-intensive and note that weed pressure increases overall with CA unless herbicide is used.

The CFU theory of change assumes that farmers will transition from one type of minimum tillage to another and will also increase the area of land upon which they practice conservation tillage. We found evidence the trend of increasing land area in the midline with farmers reporting increased land area under minimum tillage since adoption as well as intention to further increase the land under minimum tillage. We did not find evidence of large numbers of farmers transitioning from one tillage type to another following CF adoption but did note that the proportion of farmers using solely hoe/basin tillage declined by 7%. Animal draught tillage is the most popular form of tillage on both conservation agriculture plots and those conventionally farmed. The majority of focus group respondents noted that they had been ploughing with animals before adopting animal draught ripping.

The CFU intends to convert its Farmer Coordinators into community agro-dealers in order to sustain the extension approach after the cessation of donor funding. This approach is in a nascent stage and there is limited evidence that it is widespread. Nevertheless, the evaluation design did not systematically collect data from a statistically representative sample of farmer coordinators on the proportion of them acting as agro-dealers.

As noted at baseline, it is not clear whether the conditions for community agro-dealers to succeed currently exist or will exist during the programme lifetime. Whilst farmers do want access to inputs closer to home, their primary reason for not purchasing inputs is a lack of cash at the right time. The lack of cash flow and the poor credit worthiness of both farmers and community agro-dealers were raised as potential constraints by larger agro-dealers. Pay-as-you-go or community savings and loan groups could help community agro-dealers to succeed by overcoming cash flow issues and there were isolated reports of these schemes in operation during focus groups. CFU have become work with Vision Fund to start to address this challenge and this can be explored in greater detail at endline.

5.1.3 Outcome to Impact Assumptions

The programme theory of change assumes that increased crop production under minimum tillage will result in increases in crop income. For crop income to increase, farmers must have access to reliable markets, and storage facilities to allow them to sell at optimal prices. Currently focus group discussions indicate that availability of a reliable market is a challenge for many farmers and that post-harvest losses are significant. There is not yet consistent evidence that CFU's support to marketing is impacting farmers.

For food security to improve, it is assumed that farmers will use the additional food produced for their own consumption or to be able to buy greater volumes of food with profits from sale. The midline indicates that farmers adopting CSA have more diverse diets and higher incomes than those who do not adopt CSA. Nevertheless, the survey cannot measure the impact of water and sanitation or intra-household differences on nutrition so cannot comment on whether food consumption gains could be lost by poor health or if certain household members would benefit more than others from food increases.

The programme theory of change assumes that households will use increased crop income to invest in other less weather-dependent income streams. At baseline we highlighted that this would require a number of other conditions to be present such as demand for alternative businesses, skills to run such businesses and capital to start them. CFU monitoring data also showed that successful farmers are most likely to re-invest income into their farms and this is consistent with findings from our focus groups.

5.2 Implications for the Impact Assessment Design

CFU's new organisational strategy, developed in 2018, sets out a new course of action for the CFU which includes the following features:

- Widening the training offering to focus on post-harvest activities and crop marketing;
- Deepening relationships with private sector fund CFU activities;
- Utilising online and mobile channels to promote Conservation Farming;
- Facilitating the growth of FC and TSP enterprises to take over CSA promotion and allow CFU to withdraw;
- Using CFU's agro-forestry Farm in Chisamba to generate income from legume seed multiplication; and
- Seeking to transition from dependence on a single donor to a viable and sustainable organisation with multiple income streams.

The evaluation terms of reference focused on the documentation of impacts associated with the adoption of conservation farming based on CFU's prior business model. It was not designed with a particular focus on progress against the priorities set out in this new CFU strategy.

Furthermore, the focus on quantification of the impacts of CF on yields could now be reassessed due to the limitations encountered with the quasi-experimental design at midline. The lessons learned make some recommendations for further development of the endline evaluation approach.

6 Lessons Learned and Recommendations

6.1 Lessons Learned for the CSAZ

Lesson 1: There is an opportunity to consider how to improve the value for money of conservation farming promotion in Zambia through avoiding repeat training and using modern communication tools to promote the practice.
Farmers find training on conservation farming useful and a lack of knowledge was the primary reason for the control group not adopting minimum tillage. However, baseline analysis found that participants in CFU's programme have been trained by other conservation farming promoters and in this study, including the Ministry of Agriculture and the NGO COMACO, others noted that sometimes the training content is not the main motivation for attending the annual training focused on farming. The CFU Strategy describes a focus on social media messaging but there may be other low tech solutions such as voice recognition interactive messages, SMS messages and radio programmes that could be effective in transmitting CFU extension messages. Experimentation and data collection will show if there are potential value for money benefits from shifting to less face-to-face interaction to a greater use of other communication tools.

Recommendation 1: CFU to explore opportunities to experiment with the degree to which Farmer Coordinators allow repeat training of the same farmers and to alter training approaches to identify the approach offering optimal value for money.

Lesson 2: CFU's gender strategy has resulted in increased efforts to include women in conservation farming training. However, their ability to benefit from conservation farming is significantly constrained by their ability to access land or make farming decisions. There is insufficient evidence that implementation of the CFU Gender Strategy has translated into changes in household decision-making or women's access to productive resources which are vital pre-requisites for women's economic empowerment.

Recommendation 2: CFU to explore options to integrate household methodologies[19] or other behaviour change techniques into its extension packages or to partner with other organisations which have this capability.

Lesson 3: Cash flow remains a significant constraint to input purchase and there is insufficient evidence of the impact of CFU's efforts to promote last mile input and output sales. Efforts to promote input sales via Farmer Coordinators need further investigation to assess progress in a more systematic manner. However, as per the findings at baseline it is clear that efforts to promote input sales must take place in tandem with measure to ease farmers' cash flow constraints and to promote 'farming as a business' if they are to be successful.

Recommendation 3: CFU to sustain efforts to roll-out financial literacy training and to partner with other organisations able to promote savings and credit or 'pay as you go' technologies for input

[19] You can read more about household methodologies here https://www.ifad.org/en/web/knowledge/publication/asset/40253899. A recent study of the approach from Malawi is available here: https://www.sciencedirect.com/science/article/pii/S014019631730191X

sales, as they began doing in late 2019. LTS to identify better approaches to measuring the effectiveness of the community agro-dealer approach at endline.

Lesson 4: Post harvest losses are resulting in farmers losing out on productivity gains achieved through adoption of climate smart agriculture. Evidence from focus groups suggested losses of up to 25% are being experienced by some farmers. Whilst we did not collect data from a larger group on this topic through the household survey, the responses in the focus groups are not surprising given other literature on this topic and farmers did not report any behaviour changes as a result of CFU training on post-harvest management suggesting that it may be an area requiring further attention.

Recommendation 4: CFU to investigate opportunities to strengthen support on post-harvest management as part of its training package. LTS to incorporate more analysis of this area in the endline survey.

Lesson 5: There are a range of other programmes promoting conservation farming, including large World Bank and EU programmes. Whilst CFU has influenced numerous programmes (See Finding 5), it could achieve a yet wider impact through investing in advocacy to encourage new programmes to use CFU best practices. Our evaluation focuses on the impacts of CFU's activities on the farmers with which they work. However, wider considerations of value for money and sustainability also bring into question the extent to which impacts could be achieved via influencing and leveraging the impacts of other development investments in the promotion of conservation farming. Currently CFU has limited engagement with the Government of Zambia CA National Task Force and has not resourced sustained discussions with other large CF programmes such as the World Bank Eastern Province programme.

Recommendation 5: CFU and DFID to investigate opportunities to shift investment to advocacy and influencing work with a focus on promoting the use of CFU materials and training approaches in other programmes.

Lesson 6: Given challenges associated with maize production in the changing Zambian climate and the potential profitability of other legume crops, some farmers have expressed an interest for CFU to organise a greater number of field days focused on crops other than maize. Farmers have also noted concerns about the accuracy of information provided by seed sales personnel at these field days.

Recommendation 6: CFU to explore whether it is feasible to increase the proportion of field days which focus on crops other than maize and whether these days can be organised with offtakers for legumes or other crops. CFU to also provide some oversight and quality control of the claims made by companies at field days and to flag to their head offices if benefits are being presented without an appropriate evidence base.

6.2 Lessons Learned for the Impact Evaluation

Given the change in CFU Strategy and the challenges associated with the difference-in-difference design, it is suggested that the design of the endline assessment is re-visited to ensure maximum usefulness for CFU and for DFID. Some recommendations for further discussion include:

- Maintaining our plot-level assessment of yields to continue to build the evidence base on CSA impact on yields under different weather conditions. Explore the opportunity to integrate controls for field type and weather conditions into the regression analysis;

- Invest greater resources into surveying farmer coordinators, community agro-dealers and traction providers to explore the support they need to become self-sufficient business entities able to take forward CFU's new strategy;

- Invest in a cost benefit analysis of the CFU model with significant sensitivity assessment to allow an exploration of the drivers of benefits and the opportunities to reduce costs;

- Explore the opportunity to include research topics that have particular policy-relevance or are live questions for CFU. A process to re-visit the evaluation questions will be initiated after the delivery of a cost-benefit analysis, evidence synthesis report and during discussion with CFU at the planning phase of the endline.

- Further explore interesting details identified in our research to date with the goal of academic publication to add to the global evidence base on CSA. This could include investigation into the relationship between market prices and yields; further exploration of the impacts of crop rotation on yields, or greater investigation onto the drivers of household crop income or food security changes.

Annex 1. Terms of Reference

PO-7780-Annex A ToRs.pdf

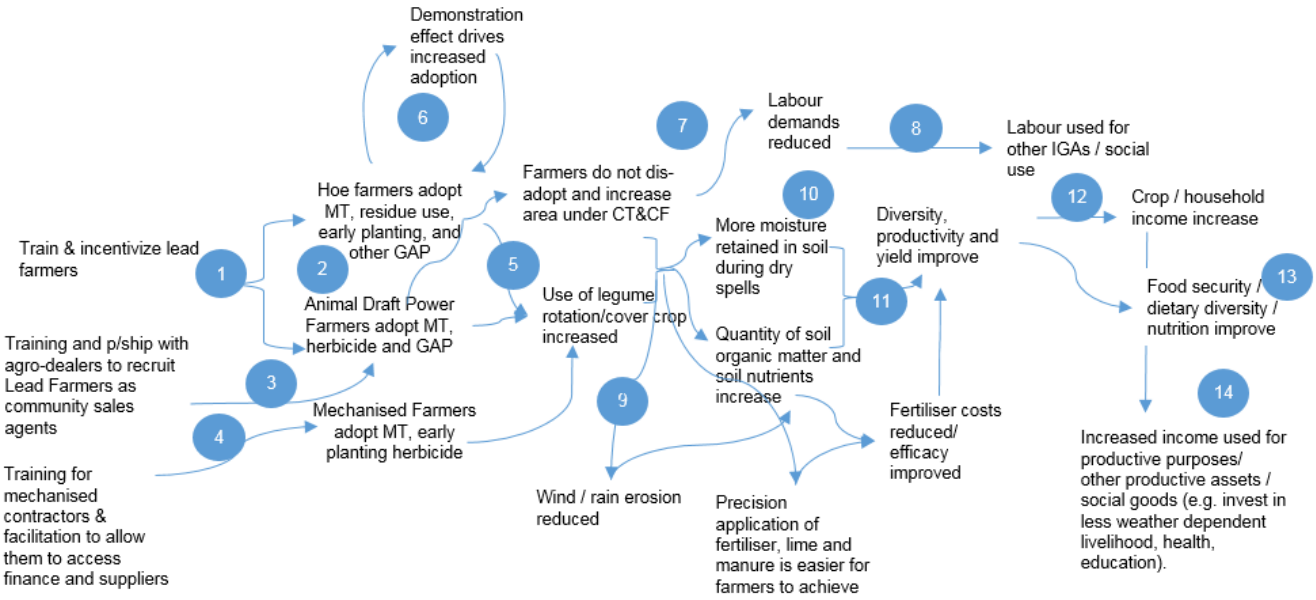
Annex 2 Evaluation Matrix

Question	Relevant Indicators
1. Was the design of CFU relevant given its objectives? • Was targeting and geographic scope appropriate given the Zambian context and the programme's objectives? • Were gender and intra-household dynamics considered in design? • Is the content of training / inputs provided appropriate for the objectives? • Are the strategies for linking with private sector suitable given programme objectives?	- Number of farmer coordinators and coverage across relevant agro-ecological zones - # of years training is repeated in each FCs area - % of farmers receiving training over multiple years - Coordination and complementarity between the approaches used by CFU and CASU - Existence of a relevant gender strategy; availability of evidence of its implementation - % of female FCs and % female farmers trained - % of female headed households adopting CF - Level of satisfaction with the training provided and number of training sessions attended by an average farmer - Number of private sector partners and level of activity undertaken within private sector partnerships. - Stakeholder perception of the relevance of strategies for linking with the private sector.
2. How efficient and effective is the CFU's implementation of the Climate Smart Agriculture programme? • Is programme delivery done in a cost-effective way? • Are adopting farmers practicing CF/CT as CFU has trained them to? • To what extent is CFU successfully converting Farmer Coordinators to community agro-dealers? • How does adoption compare on plots managed by women and men or on jointly farmed plots?	- # of logframe output targets met - % variance of expenditure from budget - Total staff costs as a % of total programme costs - Cost per farmer trained per region - Cost per farmer per region receiving mechanisation training - Publicity and promotion cost per beneficiary per region (e.g. field days and agricultural shows) - % of adopters reporting correct adoption of trained practices - % of Farmer Coordinators surveyed acting as agro-dealers - Adoption rates for male/female headed household

• Does soil improve & under what conditions?	- % of plots upon which CT/CF is adopted in which men and women are listed as the main decision-maker. - % of CFU field plots in which soil improvements detected - Average % of adopters who perceive soil has improved since adoption of CF / perception of mechanisms by which CT/CF works and role of soil change.
• Among adopters, what share of total cultivated land do farmers apply CT to?	- Difference in average % of total land area under CT for sampled 'treated' adopters and comparison households (disaggregated by tillage type and by gender of HH head)
• Do yields increase & under what conditions?	- Difference in average yield per hectare of maize planted under CT / CF (disaggregated by tillage type) - Average yield for legume crops planted by CT/CF adopters
• Is CT/CF labour & cost saving? And does it change the labour burden for men or women?	- Difference in average % of farm labour undertaken by women in CT adopting households compared to those not adopting(disaggregated by tillage type) - Average expenditure on farm inputs for CT adopting households compared to those not adopting (disaggregated by tillage type) - Perception of adopting men and women as to the labour and cost saving effects of CT/CF
3. Do CFU activities improve the incomes, food and nutrition security of smallholder farmers through the promotion of conservation tillage and conservation farming?	
• Does CT/CF adoption improve the incomes, food and nutrition security and climate resilience of smallholder farmers? What are the differences in outcomes between male and female headed households?	- Difference between average dietary diversity and household hunger index scores for adopting households compared with those not adopting. (Disaggregated by tillage type and gender of household head). - Average asset values of adopting households compared with those not adopting (Disaggregated by tillage type and gender of household head) - % of CFU trained adopters investing in less weather dependent livelihood options compared with those not trained by CFU.

	- Average number of different crops grown by CFU trained adopting households compared with those not trained by CFU - Difference in average crop income of CFU trained adopters compared with those not trained by CFU (disaggregated by tillage type and gender of household head).
• Under what conditions / and with what other GAPs, do farmers achieve best results from CA adoption?	- % of adopters and non-adopters also using other GAPs, including timely planting, herbicide use, fertiliser use. - Farmer perceptions of conditions under which adoption delivers best results and of the causal direction of the relationship between CF adoption and GAP use; disaggregation of yield data by farmers who perceive they have been affected by drought.
• Were there other, unintended results of the programme, positive or negative?	- Difference in ZKW spent on hiring casual labour amongst adopters and non-adopters.
4. To what extent is the support for CSA institutionally sustainable?	
• Within CFU promotion areas, what is the rate of "disadoption" and the factors that explain this? Does this vary across male and female headed households?	% of panel respondents disadopting CT/CF practices in the midline and endline in the sample (disaggregated by tillage type and gender of household head).
• To what extent are external institutions contributing to the sustainability of the outcomes?	CFU's exit strategy and continued funding plan Likelihood of private sector and government support to CF promotion in the future Perception of private sector in relation to the sustainability of their support to CFU.
• Are there wider impacts on the rural economy? (e.g. demand for labour, food prices)	Farmer and Headman perception of changes in demand for labour, availability of food and relevance of CF/CT and other contextual factors to these changes.

Annex 3. Theory of Change



Assumptions

	Assumption
1	1.1 Both male and female farmers will access training by Farmer Coordinators and will find the content relevant and practical and the source trust-worthy. Farmers will understand the rationale for adopting conservation farming practices and will perceive the risk of MT, CT or CF adoption to outweigh the risks of maintaining current practices.
	1.2 Training will communicate need for complementary GAPs to maximise benefits from CT/CF, farmers will understand the rationale for correct spacing, timely weeding, application of organic matter to soil, use of lime, fertiliser and appropriate herbicides and pesticides.
2	2.1 Hoe farmers will have labour to dig basins / additional weeding (where herbicides / mulch does not limit this)
	2.2 Draft power farmers will have access to and cash to buy rippers and herbicides.
	2.3 All farmers will understand whether their land is suitable for mulching and, where needed, protect residues from livestock
	2.4 Farmers will have cash / FISP vouchers on a timely basis to buy inputs for timely planting or will be able to access credit / pay as you go / loans for input purchase
	2.5 Intra-household / gender dynamics will not create conflict around additional labour / inhibit adoption
	2.6 Farmers will have sufficient tenure security to invest in land improvement
3	3.1 Agro-dealers will find it economically viable to stock CF products; farmers to buy them
	3.2 Staff training will result in agro-dealers promoting CF practices and products
	3.3 Agro-dealers will find it economically viable to hire community sales agents

	Assumption
	3.4 There are farmers with appropriate skills in the area willing to work as sales agents for remuneration provided by agro-dealers
	3.5 Farmers will have cash available to buy inputs and there will be available finance / trust to support community agro-dealers to acquire stock.
	4.1 Tractor service providers understand the rationale for minimum tillage and are interested in developing a business to provide ripping services instead of ploughing services.
4	4.2 Credit will be available for timely purchase of appropriate equipment
	4.3 Cash will be available for loan repayments and maintenance costs to enable machinery to continually operate (will depend on prices/demand for maize and other crops)
	4.4 Mechanised contractors will find it economically viable to offer services to small / medium farmers
5	5.1 Farmers will be motivated to sustain their practice and expand the area (likely because results are positive, required labour/tools/inputs/residues remain available, costs affordable and farming remains profitable)
	5.2 Farmers using basins retain permanent basins in one place which accumulate the soil fertility benefits from precision application of fertiliser and manure.
	5.3 Farmers will be motivated to increase use of legumes/cover crops as seeds are available and benefits understood / accessed
6	6.1 Farmers not previously receiving CFU training attend field days or access extension messages
	6.2 Farmers not previously receiving CFU training seek out training and inputs in order to adopt
7	7.1 For hoe farmers doing basin planting, they do this correctly digging only 20% of the soil surface to the required width/depth. In addition, herbicide use reduces weeding
	7.2 For draft power farmers, new tools make land preparation/planting faster and herbicide use reduces weeding
	7.3 Farmers find it affordable/acceptable to use mechanised contractors for ripping services and can afford both mechanised tillage and herbicides.
8	8.1 Farmers identify other IGAs that are feasible given available finance, knowledge and skills
	8.2 Economic conditions allow multiple IGAs to thrive, i.e. there is sufficient and sustained demand
9	9.1 Farmers are able to incorporate sufficient residue into the soil to improve quality (i.e. no burning of residue and alternative livestock feed available); termites breakdown residues to improve soil structure.
	9.2 Farmers incorporate all elements of CF, including MT, residue retention and legumes.
	9.3 Farmers carry out the practices on the same plot of land for several seasons
10	10.1 Basins dug in sufficient soil depth, in advantageously sited rows and appropriate soil type (e.g. soil with lower permeability such as silt and clay)
	10.2 Areas prone to waterlogging are not prioritised for basins.

	Assumption
	10.3 Organic matter added to basins to increase moisture conservation and soil fertility
	10.4 Draft power / mechanised MT practiced appropriately exposing less soil and reducing evapo-transpiration
11	11.1 Farmers access inputs and markets which allow them to plan diversity of crops planted.
	11.2 Both diversity and productivity increases depend on suitable agro-ecological and weather conditions. Whilst increased moisture conservation widens the range of conditions under which production can increase, this still requires sufficient water.
	11.3 Productivity increases require benefits of the practice to be accrued and existing GAP to also be practiced on the plot – i.e. farmer must have used appropriate spacing, planted appropriate seeds, efficiently applied fertiliser, protected crops from pest or weed damage and harvested on a timely basis.
	11.4 Yield increases require productive cultivation on the same or larger land area, so that improved productivity per unit of land equals higher total yield.
12	12.1 For crop income[20] to increase either costs of production must decrease, sale value increase or total volume sold at profit increase.
	12.2 For both crop and household income to increase, the cost of investing in farm equipment or other income generating activities should not exceed increases in profit from such activities
	12.3 For crop income to increase, farmers must have access to reliable markets, and ideally storage facilities and savings/credit to allow them to sell at optimal prices. CFU activities to promote the use of PICS bags reduce post-harvest losses and increase available food or crops for sale.
13	13.1 For food security to improve, farmers have to use the additional food produced for their own consumption or to be able to buy greater volumes of food with profits from sale.
	13.2 Women and men will collaborate to conserve food for household use or to use income for the whole family. No one member of the household will sell food to meet personal cash needs at the expense of other household members.
	13.3 Households will consume more diverse food as a result of increased availability of legumes and cereals. They will use increased income to purchase more diverse food and will have sufficient cooking fuel to prepare the food. All household members will consume the prepared food according to their needs.
	13.4 Household nutrition will improve with increased food consumption and gains will not be lost through sickness caused by poor water and sanitation facilities in the area.
14	14.1 Households have the knowledge and skills to use increased crop income to invest in other businesses as demand for such businesses exists locally at levels sufficient to make them profitable.
	14.2 Households prioritise investment in less weather dependent activities or in social goods such as health and education and have opportunities to use their income to purchase such services in their local area.

[20] We assume increased income refers to net additional income change (NAI) as per the Donor Committee for Enterprise Development (DCED) definition. This will be measured on an annual basis, but modelling may be used to identify farmer break-even points.

Annex 4. Balance Tests

The table below shows the summary statistics for the variables used in the regression. Because these are baseline values, the table does not show difference between CSA and non-CSA users.

Note that soil type, rainfall, and temperature are excluded due to low variation. Top and basal fertilizer are highly correlated (70%). PPI and education of the household head are 40% correlated. Village population density is highly correlated with village area (over 80%).

Covariates – for first field, BASELINE values on fields that at MIDLINE do or don't use CF	No CSA Mean	CSA Difference	P Value[21]	N (Sample Size)
Village distance to Market (hectare)	31.59	-5.16	.001***	1985
Village time to market (20k)	6.35	-1.07	.001***	N=2054
Village Population Density	0.96	-.03	.79	2031
Age of household head	45.04	2.18	<.001***	1969
Education of household head	5.78	.99	<.001***	2163
Household size	5.55	.27	<.05*	2053
Percent likelihood that household falls below 200% of the poverty line	36.93	3.44	<.001***	2042
Basal Fertilizer	.48	.12	<.001*	2048
Top Fertilizer	.50	.14	<.001*	2048
Subgroup variables				
Female-headed household	.26	.01	.54	2053
Plot farmed using ADP	.74	1.26	.165	2053
Outcome Variables				
Maize yield in metric ton/ha	2085	-395	<.60	1911
Soya yield in metric ton/ha (field 2)	823	103	.50	160
Groundnut yield in metric ton/ha (field 2)	546	109	<.05*	717

[21] A small p-value (typically ≤ 0.05) indicates strong evidence that these differences are not due to chance. A large p-value (> 0.05) indicates weak evidence of the same.

Annex 5. CSA Training in Control Areas

	TREATMENT				CONTROL			
TRAINING TOPIC	**Trained in the last year**	**Of those trained, Trained by CFU in the last year**	**Trained prior to May 2018**	**Of the trained, Trained by CFU prior to May 2018**	**Trained in the last year**	**Of the trained, Trained by CFU in the last year**	**Trained prior to May 2018**	**Of the trained, Trained by CFU prior to May 2018**
MAINTAINING BASINS IN SAME PLACE YEAR AFTER YEAR	89% (907)	93% (846)	52% (500)	89% (447)	33% (338)	81% (275)	45% (428)	89% (380)
DIGGING BASINS TO SUFFICIENT SOIL DEPTH	64% (622)	89% (553)	52% (502)	89% (448)	56% (540)	90% (485)	45% (428)	89% (383)
DIGGING BASINS IN ROWS ACROSS THE SLOPE	59% (568)	91% (519)	46% (444)	93% (441)	53% (503)	90% (453)	40% (382)	92% (350)
DIGGING BASINS ON SOIL WITH LOWER PERMEABILITY	44% (424)	91% (386)	34% (332)	93% (310)	42% (399)	89% (355)	31% (295)	93% (273)
CORRECT SPACING FOR KEY CROPS	61% (595)	89% (460)	50% (486)	89% (433)	54% (515)	89% (460)	42% (389)	89% (354)
THINNING AND GAPPING COTTON	31% (303)	81% (245)	28% (267)	80% (213)	30% (284)	77% (219)	25% (237)	73% (174)
ADDING ORGANIC MATTER TO BASINS	57% (554)	87% (484)	46% (446)	88% (392)	52% (495)	89% (439)	40% (386)	89% (343)
IMPROVING POST-HARVEST STORAGE	32% (312)	84% (261)	25% (238)	86% (205)	33% (312)	88% (274)	24% (227)	89% (201)
MAINTAINING CROP RESIDUE IN THE FIELD AFTER HARVEST	60% (585)	89% (519)	49% (478)	91% (433)	52% (496)	89% (440)	41% (397)	90% (357)
NEED TO PROTECT CROP RESIDUE FROM LIVESTOCK	35% (335)	92% (308)	26% (255)	96% (246)	34% (324)	90% (292)	26% (251)	93% (234)
NEED TO PLANT	46% (442)	85% (375)	38% (368)	86% (317)	42% (405)	86% (350)	33% (317)	8%% (270)

LEGUMINOUS TREES								
NEED TO PROTECT EXISTING TREES	37% (360)	87% (313)	29% (286)	90% (257)	35% (334)	88% (293)	27% (263)	90% (238)
APPLYING LIME	49% (471)	91% (427)	37% (357)	93% (333)	43% (413)	89% (366)	32% (309)	93% (287)
RIPPING WITH OXEN	62% (604)	88% (533)	50% (480)	92% (441)	55% (526)	90% (471)	42% (401)	92% (369)
FERTILIZER APPLICATION	62% (604)	88% (531)	50% (484)	89% (430)	55% (531)	88% (456)	42% (403)	89% (357)
FARMING AS A BUSINESS	42% (407)	86% (350)	32% (313)	89% (280)	38% (360)	84% (301)	29% (279)	85% (236)