Smallholder Risk Management Solutions (SRMS) in Malawi and Ethiopia

Replicable Business Model, Ethiopia: Social inclusion and impact evaluation

25 June 2019

Prepared by Oxford Policy Management on behalf of SAIRLA

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Acknowledgements

The lead author of this report is Dr Alastair Orr and the co-authors include Dr Asmare Dejen, Ferdinand Galen, and Peter Porázik. We are grateful to our enumerators (Amare Molla Dinku, Emebet Ayele Sisay, Ephrem Seid Yimer, Ewnetie Takele Getie, Dr Gezahegn Tadesse Derseh, Hunegnaw Abebe Kassaw, Moges Dessale Alemu, Samuel Tadesse Adisalem, Yimam Seid Damtew, Worku Belayhun Temiteme, Dr Adem Mohammed Ahmed, Dr Ali Seid Hassen, and Tewodros Alemu Belay), to Seid Hassen Abegaz who acted as local coordinator, to Meaza Mekonnen (Ministry of Agriculture, Hayke) who facilitated access to farmers, and the farmers themselves who patiently answered our questions. We thank Joachim Weber and Zoltan Tiba for suggestions to improve the questionnaire. The authors are responsible for any errors and omissions. The views expressed in this report are those of the authors and should not be attributed to the organisations with which they are affiliated.

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Acronyms

Acronym	
ARARI	Amhara Agricultural Research Institute
ATT	Average Treatment Effect on the Treated
C1	First-generation Certified seed
C2	Second-generation Certified seed
DA	Development Agent
DFID	Department for International Development
ETB	Ethiopian birr
FAO	Food and Agriculture Organisation of the United Nations
FHH	Female-headed household
ICRISAT	International Crops Research Institute for the Semi-Arid Tropics
NGO	Non-Governmental Organisation
OPM	Oxford Policy Management
PPP	Purchasing Power Parity
PSM	Propensity Score Matching
RBM	Replicable Business Model
SAIRLA	Sustainable Agricultural Intensification Research and Learning in Africa
SPSS	Statistical Package for the Social Sciences
SRMS	Smallholder Risk Management Solutions
US$	United States Dollar

Note: in 2019 1 US Dollar (US$) = 28 Ethiopian birr (ETB)

Abstract

A Replicable Business Model (RBM) using a revolving seed fund and managed by cooperatives was introduced to increase the supply of certified seed of improved teff varieties in South Wollo zone, Amhara region, in the Ethiopian highlands. After two years of operation, a household survey was conducted in the 2018-19 crop year to evaluate the RBM in terms of social inclusion and the commercialisation of teff. A poverty scorecard showed that 20% of households participating in the RBM fell below the national poverty line, while 64 % fell below the international poverty line of US$ 3.10 per day in 2011 (US$ 1.25 per day in 2005). This compares closely with the corresponding figures of 23 % and 65%, respectively, for Ethiopia as a whole. However, significant differences between participants and non-participants were found for some poverty indicators, including ownership of a team of oxen and participation in the national safety net programme. Propensity Score Matching was used to measure the impact of the RBM on commercialisation. In terms of improved teff varieties, the RBM increased farmers' awareness of improved varieties by 14%, access to certified seed by 29%, the adoption of improved varieties by 35%, and reduced the adoption gap (the share of farmers who knew about improved varieties but have never planted them) by 15%. In terms of production, the RBM increased teff production by 1 quintal per household, without increasing the area planted to teff or reducing the production of other cereals. In terms of commercialisation, the RBM increased the share of households selling teff by 11%, the average value of teff sold by US$ 10, and the average value of other cereals sold by US$ 4. However, the average amount of teff sold (8 kg per household) did not change. By contrast, the RBM significantly increased the amount of teff used for home consumption by an average 0.9 quintals per household, the equivalent to two months' consumption. We conclude that, although participants and non-participants in the RBM differed in some poverty indicators, based on national and international poverty lines it was socially inclusive. Within two years, the RBM has had a large impact on improving access to certified seed and the adoption of improved varieties. However, the impact on the commercialisation of teff was small. Most of the increase in teff production was used for home consumption, boosting household food security. In the case of staple food crops like teff, the twin objectives of social inclusion and commercialisation may prove too difficult to combine. On the other hand, by successfully combining social inclusion with higher household food security the RBM has benefitted poorer smallholders.

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1 Introduction

The commercialisation of staple food crops is widely viewed as a pathway from poverty for smallholders in Africa (DFID, 2015). However, commercialisation may exclude poorer smallholders if they lack access to these markets, or are risk-averse, or lack the necessary resources, knowledge and skills. Half the maize sales in Zambia, Kenya, and Mozambique are made by just 2 % of farm households (Jayne et al., 2010). Collective action can help overcome these barriers. Organised into groups, smallholders can share risks, reduce transaction costs, and increase access to new technology. While collective action does not guarantee social inclusion – poorer farmers may not meet the criteria for membership, groups may be captured by wealthier farmers – it has the potential to make commercialisation more socially inclusive than it would otherwise be if participation was left entirely to market forces.

The value chain for teff in Ethiopia is an example of a dynamic value chain for a staple food crop (Minten et al., 2018). Teff is a preferred cereal in high demand thanks to growing urban markets Alem and Soderbom, 2018). However, the supply of certified seed of improved varieties of teff is controlled by state-run seed farms that cannot meet demand (Spielman and Mekonnen, 2018). The Smallholder Risk Management Solutions (SRMS) project developed a replicable business model (RBM) that uses multipurpose primary cooperatives to operate a revolving seed fund.[1] Farmers receive first-generation certified seed (C1) of improved teff varieties rom the cooperative, returning grain which then sold by the cooperative and the income used to buy new certified seed for distribution the following year .[2] Farmers who do not receive fresh certified seed for a second year have the option to recycle the seed they received in the first year, as second-generation certified seed (C2). The advantage of this business model is that the demand for specific varieties of improved seed is driven by farmers themselves and that, provided farmers repay grain to the cooperative, the seed fund is self-sustaining and will operate without the need for further state intervention. Improved teff varieties have higher yields and their white grains attract a price premium. By increasing the supply of certified seed, the RBM is expected to accelerate the commercialisation of smallholder teff production. Despite these advantages, however, the tradition of state control of the seed sector means that this business model has not previously been tried with teff in Ethiopia.

The RBM has now operated for two crop years or four crop seasons. This was judged insufficient time to measure the impact of the RBM on poverty. However, it was considered sufficient time to determine how representative participants in the RBM were of cooperative members, or of the wider farming population. While the RBM may be a convenient instrument for increasing the supply of certified seed, if it excludes poorer smallholders it may be less effective in reducing poverty. Similarly, two years was considered enough time to determine what impact (if any) the RBM has had on the commercialisation of teff. Has improved access to certified teff seed increased the share of farmers selling teff or the average amount of teff sold?

The general objective of this report, therefore, is to assess the performance of the RBM in terms of social inclusion and impact. Specifically, the objectives are to:

1. Compare the poverty status of participating and non-participating households; and
2. Measure the impact of the RBM on the commercialization of teff.

A subsidiary objective is to measure the rate of repayment of first-generation certified seed (C1) that was received in 2018-19, and to review the agronomic performance of C1 seed received in the previous year (2017-18) that was replanted as second-generation certified seed (C2) in 2018-19. This information is presented in Appendix 2.

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[1] In 2014 there were 1,902 primary cooperatives in Amhara region, or which 1,018 (54%) were multipurpose cooperatives (Tesfamariam, 2015).

[2] A full description of the design of the RBM and its operation is given in Weber and Tiba (2018).

2 Data and Methods

2.1 Data

Survey design: The treatment group consisted of households in three *kebeles*[3] that participated in the RBM in the 2017-18 and 2018-19 crop years. The treatment households for survey were selected from households that received 4 kg of certified teff seed (the improved variety Qoncho or Zobil) in the first survey year (2017-18). Two years' experience with improved seed allowed a fairer test of the impact of improved varieties on teff production and sales, gave more information about the spread of improved varieties through farmer-to-farmer diffusion, and gave a better evaluation of a revolving seed fund where farmers planted first-generation certified seed (C1) in year 1, and planted recycled second-generation certified seed (C2) the next year.

The control group consisted of households that did not participate in the RBM but that grew teff in 2018-2019. These households lived in *kebeles* that met three criteria (1) they had similar agro-ecosystems to the treatment *kebeles* and were high-potential areas for teff (2) they were sufficiently far away to prevent diffusion of improved teff seed from households participating in the RBM, and (3) they were accessible by motor vehicle during the Belg[4] rains. Three potential control *kebeles* were selected with the assistance of the local agricultural officers and the manager of government cooperatives for Tehuludere *woreda*.[5] To verify their suitability, they were visited by the lead researcher and partners from the Ministry of Agriculture and Wollo University.

Based on these field visits, Wa Hailu and Amamo were selected as control *kebeles*. The management of the cooperatives in these two *kebeles* told us that very few farmers had access to seed of improved teff varieties. By contrast, in the third *kebele* – Harar by Lake Ardebo – farmers informed us that about half the farmers in the cooperative were growing the improved teff variety Qoncho, which they had received free as "emergency seed" from NGOs and FAO in 2017-18. They were still growing C2 seed in 2018-19. Since the second objective of the survey is to measure the impact of improved teff varieties on commercialisation, we decided to reject Harar as a control.

Sample size: Table 1 shows the treatment and selected control *kebeles*, and the number of farmers that received improved seed in Year 1 (2017-18) and Year 2 (2018-19). In Year 1, 300 farmers (100 in each of the three *kebeles*) received improved seed. In year 2 (2018-19), approximately 270 farmers received improved seed. The lower total of farmers that received certified seed in Year 2 (270) was due to low repayment rate in Gobeya *kebele*, which reduced the amount of grain available to the cooperative for sale, and thus the amount of certified seed of improved teff it could buy. By contrast, in Hitecha and Basso Mille/Jare *kebeles* the cooperatives were able to buy enough fresh certified seed to supply 100 farmers or more.

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[3] A *kebele,* or ward, is the smallest administrative unit of Ethiopia.

[4] Ethiopia has two crop seasons: the Belg season from March to August and the Meher season from September to February.

[5] A *woreda* or district is the third-level administrative divisions of Ethiopia, which is subdivided into *kebeles.*

Table 1: Sample *kebeles* and sample size for 2018-19 survey

Kebele	Hitecha	Gobeya	Basso Mille/Jare	Wa Hailu	Amano	Total
Treatment/Control	Treatment	Treatment	Treatment	Control	Control	
Farmers receiving C1 seed in 2017-18	100	100	100	Nil	Nil	300
Farmers receiving C1 seed in 2018-19	125-130	40	100	Nil	Nil	270
Planted improved teff varieties in 2018-19	Yes	Yes	Yes	No	No	
Sample size for 2018-19 survey	52	57	57	80	70	316

In 2017-18, the seed supply survey collected household-level information on poverty indicators, crops, and crop management from virtually all the farmers that received improved teff seed (n=261). In the 2018-19 survey, we collected information from a subsample of these 261 farmers (50 households from each treatment *kebele*, or 150 farmers) together with information from a subsample of farmers in the control *kebeles* (75 households in each control *kebele*, or 150 farmers). A sample of 150 is considered a safe sample size for Propensity Score Matching (PSM), since non-matched households are dropped from the analysis. Table 1 shows that the actual sample size for the 2018-19 household survey was 316 households, of which 166 belonged to the treatment group and 150 to the control group.

Treatment households for survey were randomly selected from the 261 households that were surveyed in 2017-18. Each household that was surveyed during the first year of the RBM was assigned a random number. The enumerators were required to find the selected households in the field and interview them again. Control households were randomly selected from the list of cooperative members kept by the cooperative management in Wa Hailu and Hitecha *kebeles*.[6] Wollo University obtained the membership lists from the cooperative and OPM chose a random sample of control households from these lists.

Data collection and processing: The questionnaire was pre-tested by the lead author between 2- 8th March 2019. Household interviews were conducted between 25th March and 1st April 2019 by experienced enumerators from Wollo University using hand-held tablets. The time required for interview ranged from one hour at the beginning to half an hour by the end of the field survey. The limiting factor for our progress was to find the randomly selected farmers, who were often ploughing and sowing, or visiting farmers' markets, or who lived in remote areas. About one in four farmers in the treatment *kebeles* refused to be interviewed on the grounds that they had only received seeds once and had already answered questions about them. The data were processed using the Statistical Package for the Social Sciences (SPSS).

2.2 Methods

Social inclusion: The World Bank defines social inclusion as:

1. The process of improving the terms for individuals and groups to take part in society, and
2. The process of improving the ability, opportunity, and dignity of those disadvantaged on the basis of their identity to take part in society (World Bank, 2019).

[6] The cooperative in Hitecha covers three kebeles: 08 (Hitecha); 09 (Amano) and 04 (Woldelulo).

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For the purpose of this report, we define social inclusion in terms of the ability to take part in the process of agricultural commercialisation. In the context of the RBM, this means that participation is not restricted to the non-poor, but includes smallholders living below the poverty line. Inclusion, therefore, was measured by comparing the socio-economic and poverty status of the treatment and control groups. This was done in two ways:

1. Comparison with the national and international poverty lines

The questionnaire used the poverty scorecard for Ethiopia developed by Schreiner (2016) that calculates a household poverty score based on eight indicators from Ethiopia's 2011 Welfare Monitoring Survey to estimate the likelihood that a household has consumption (from Ethiopia's 2010/11 Household Consumption and Expenditure Survey) below a given poverty line. The scorecard can be used to measure the share of a program's participants who are below a given poverty line, including the national poverty line for Ethiopia and a range of international poverty lines. All points in the Poverty Scorecard are non-negative integers, and total scores range from 0 (most likely below a poverty line) to 100 (least likely below a poverty line). To get absolute units, scores must be converted to poverty likelihoods, or the probability of being below a poverty line. This is done via look-up tables. In the case of the national poverty line, for example, scores of in the range 40-44 have a likelihood of falling below the national poverty line of 16.1 % (Schreiner, 2016: 152). The likelihood of falling below a poverty line can also be used to calculate the poverty rate, or the percentage of households below a given poverty line, calculated by averaging the poverty likelihood for individual households. For example, suppose the survey samples three households and that they have scores of 20, 30, and 40, corresponding to poverty likelihoods of 47.0, 31.8, and 16.1 % of the national poverty line. The group's estimated poverty rate is the households' average poverty likelihood of (47.0 + 31.8 + 16.1) ÷ 3 = 31.6 %.

To compare social inclusion, we used four poverty lines: a "food poverty line" based on 2,200 Kcal/day; the "national" poverty line for Ethiopia of ETB/day, which includes both food and non-food items; and the international poverty lines of US$ 1.90 and US$ 3.10/day, measured in Purchasing Power Parity (PPP), which are equivalent to the international poverty lines of US$ 1.0/day and US$ 1.25/day at PPP in 2005.

2. Comparison with other poverty indicators for Ethiopia

Poverty indicators were identified from published literature, including studies of poverty indicators in South Wollo as well as national-level studies of wealth indicators in different livelihoods zones. Based on this literature, we identified seven poverty indicators:

Table 2: Additional poverty indicators

No.	Indicator	Source
1	Female head of household	Shumiye (2007)
2	High dependency ratio [1]	Seif and Singh (2016)
3	Household food insecurity	Shumiye (2007); LIU (2010)
4	Small farm size	Seid and Singh (2016)
5	Low/zero draught animals for ploughing	Seid and Singh (2016); Liu (2010)
6	Sale of labour as a source of cash income	LIU (2010)
7	Food aid as a source of income	LIU (2010)

[1] i.e. a high ratio of children/adults of non-working adults to working adults.

Risk aversion ranking: To measure farmers' degree of risk aversion, we adapted the approach used by Holden and Westberg (2016), which asks farmers to choose between two alternatives, the first with a high yield in a good year and a low yield in a bad year, the second with a lower yield in a good year but a higher yield in a bad year.[7] By progressively reducing yields over six choices, farmers can be categorised into six ranks based on their degree of risk aversion. The higher the rank, the greater the degree of risk aversion. We have called this a "risk aversion ranking". Pretesting this approach revealed that farmers were confused by the labels 'good' and 'bad' years, relating the suggested crop yields to experience on their own fields. This confusion was overcome when we re-labelled 'good' and 'bad' years as 'Year 1' and 'Year 2' and explained that this was an imaginary experiment and not based on their own experience.

Impact evaluation: Since the RBM has operated for only two years it is too soon to measure the full impact of improved teff seed on household welfare. However, it is possible to measure the partial impact on teff commercialisation. To determine if the commercialisation of teff was at the expense of other, competing cereal crops we have included (3) production and (7) income from sales of other cereals (sorghum and wheat) as impact variables. In total, we compared differences in 12 outcome variables (Table 3).

Table 3: Outcome variables for impact evaluation

Potential impact	Outcome variable	Variable name (see Table 17)
Cereal production	Total production of teff (quintals)	lastyearteffproduction
	Area planted to teff (ha)	areaallteff
	Total production of other cereals (maize, sorghum, wheat) (quintals)	totprodother
Commercialisation	Sold teff (1=Yes, 0 =No)	seller1
	Quantity of teff sold (kg)	teffsold1
	Total income from teff sales (ETB)	teffval
	Total income from sales of other cereals (maize, sorghum, wheat). (ETB)	valother
	Quantity of teff kept for home consumption (quintals)	homecons1
Awareness, access, and adoption	Heard about of improved teff varieties (1=Yes, 0=No)	heardmv
	Ever planted improved teff varieties (1=Yes, 0=No)	evermv
	Planted in 2018-19 (1=Yes, 0=No)	adoption
	Adoption gap (9-11)	adoptiongap

Impact evaluation using observational data requires a quasi-experimental approach. In a randomised experiment, the treatment and control groups are statistically identical, except that one received the treatment. With observational data, however, the treatment and control groups are not identical because of non-random differences between the two groups, which may lead to self-selection by the treatment group. Selection bias makes it difficult to be sure that we are observing the effect of the treatment or the effect of these non-random differences. Hence, we cannot be certain that the difference between the two groups is truly caused by the effects of the treatment.

Propensity Score Matching (PSM) controls for non-random differences by matching treatment cases with control cases that are as similar as possible (Calindo and Kopeinig, 2005). Closeness is measured by the

[7] For example, a crop in the Meher season that gives 20 quintals in Year 1 and 0 quintals in Year 2 OR a crop that gives 19.5 quintals in Year 1 and 2 quintals in Year 2.

propensity score, which is the probability of receiving the treatment based on a common set of observed characteristics. The aim is to identify a set of treatment and control cases that have a similar propensity score. Essentially, PSM is a retrospective randomization that creates the counterfactual situation found with experimental data, allowing us to say that the differences between control and treatment groups were caused by the treatment. PSM uses the matched sample to measure the Average Treatment Effect (ATE) on the population and the Average Treatment Effect on the Treated (ATT).

The quality or 'balance' of the match can be measured in two ways. One is to compare the distribution of the propensity scores between the matched treatment and control groups. A balanced sample shows a similar distribution for both groups (i.e. both groups have an equal chance of being selected for the treatment). The second is to test for significant differences in the means of independent variables used to match the sample. A balanced sample shows no significant difference in these means and a mean bias of five percent or less (Grilli and Rampichini, 2011). PSM is based on the matching of observable characteristics. However, there may also be unobserved characteristics that result in non-random differences between the treatment and control groups. This hidden bias can be detected using Rosenbaum bounds, which uses the Wilcoxon signed-ranks test to develop a sensitivity test for matched pairs. Since the degree of hidden bias cannot be observed, the test measures how much bias must be present to significantly change the effect obtained by matching. Rosenbaum bounds are based on a sensitivity analysis of the p values for the null hypothesis and measure the degree of bias required to be unable to reject the null hypothesis ($p < 0.05$). The PSM analysis was made using STATA version 14.0.

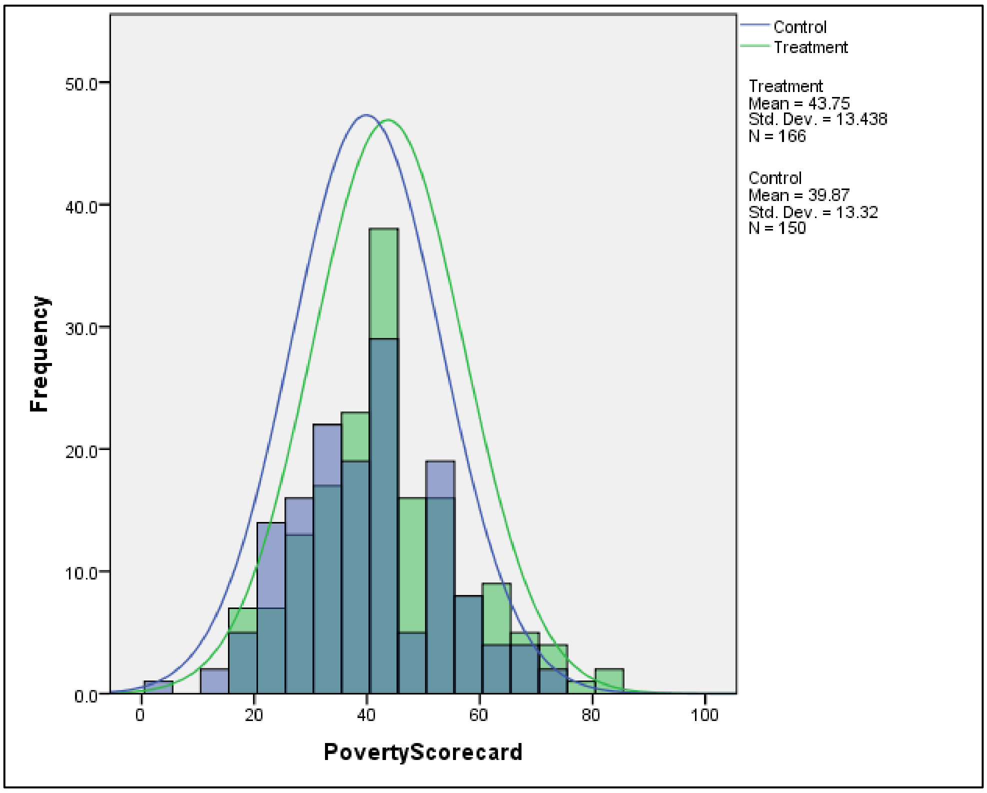
3 Results: Social Inclusion

The first specific objective of the household survey in 2018-19 was to measure social inclusion. This section presents the results, arranged as follows. Using univariate statistics, we compare treatment and control groups in two ways. First, we compare them using the poverty scorecard. Second, we compare them using additional poverty indicators.

3.1 Poverty scorecard

Figure 1 compares the poverty score for the sample households. The treatment households are represented by the green line and the control households by the blue line. The poverty score for both groups follows the normal distribution. However, the histogram shows that a slightly higher number of treatment (green) households have higher poverty scores. As a result, the mean score for the treatment households (43.75) is higher than for the control households (39.87). The difference is statistically significant at the 10% level. Thus, the treatment households have a higher poverty score i.e. are less poor than the control households.

Figure 1: Distribution of poverty scorecard for treatment and control groups



Source: SRMS Household Survey, 2019.

Table 4 compares the results of the poverty scorecard for the treatment and control groups. As already noted, since the RBM has operated for only two crop years, which was considered too soon for participation to have resulted in any change in poverty as measured by the poverty scorecard. Rather, the objective in comparing poverty scores between treatment and control groups was to determine whether poverty status had determined participation in the RBM. Table 4 shows the *likelihood of being poor* for four different poverty lines:

1. The *food poverty line* for Ethiopia in 2010/11, based on a mean consumption of Kcal 2,200. The food poverty line is ETB 5.10 per adult equivalent per day,
2. The *national poverty line* for Ethiopia in 2010/11, based on a mean consumption of Kcal 2,200 plus an allowance for basic needs. The national poverty line is ETB 10.34 per adult equivalent per day.
3. The *international poverty line* of US$ 1.00/day PPP in 2005, updated to US$ 1.90/day PPP in 2010/11.
4. The *international poverty line* of US$ 1.25/day in 2005, updated to US$ 3.10/day PPP in 2010/11.

Table 4 shows that the mean difference in the poverty score between treatment and control households is just 3.88 points (43.75 - 39.87). Although this difference is statistically significantly according to the t-test ($p = 0.011$), to estimate the likelihood of lying below a given poverty line the poverty score is calibrated in intervals of five. This means that the score for the treatment group (44) falls just inside the same interval as the control group (40-44). Consequently, both treatment and control households have the same likelihood of lying below each of the four poverty lines, and the same poverty rates.

In terms of poverty likelihood, there is a 16.1 % likelihood that both treatment and control households lie below the national poverty line of ETB 10.34/day, rising to a likelihood of 64 % that both groups lie below the international poverty line of US$ 3.10/day. In terms of the poverty rate, only 22 % of both groups lie below the national poverty line, but 64 % of households lie below the international poverty line of US$ 3.10/day. The corresponding poverty rates in 2010/11 for households in Ethiopia are 23 % for the national poverty line and 65 % for the international poverty line of US$ 3.10/day (Schreiner, 2016). Thus, the poverty rate among our sample households is remarkably close to the poverty rate at the national level.

Table 4: Poverty scorecard, by treatment and control groups

Poverty Score	Group		
	Treatment	Control	Total
Mean	43.75	39.87	41.91
	Likelihood of living below poverty line (%)		
Food Poverty Line (ETB 5.10/day/adult equivalent)	1.0	1.0	1.0
National Poverty Line (ETB 10.34/day/adult equivalent)	16.1	16.1	16.1
International Poverty Line (US$ 1.90/day/adult equivalent)	20.6	20.6	20.6
International Poverty Line (US$ 3.10/day/adult equivalent)	64.0	64.0	64.0
	Poverty Rate, or households living below poverty line (%)		
Food Poverty Line (ETB 5.10/day/adult equivalent)	1.7	2.5	2.1
National Poverty Line (ETB 10.34/day/adult equivalent)	19.7	23.9	21.7
International Poverty Line (US$ 1.90/day/adult equivalent)	23.5	28.1	25.7
International Poverty Line (US$ 3.10/day/adult equivalent)	61.4	66.7	63.9

Source: Schreiner (2016).

3.2 Additional poverty indicators

In addition to the variables included in the poverty scorecard, we compared treatment and control households using a range of poverty indicators. Table 5 reveals that livestock ownership, value of livestock, access to irrigation, renting/borrowing of oxen for ploughing and household food security differed significantly between the two groups. Table 5 also compares two direct indicators of poverty, namely the number of households that received relief goods after the 2015-16 drought, and the number of households with at least one member enrolled in the national safety net programme. Both these variables differed significantly between the two groups. The share of treatment households receiving relief in 2015-16 was significantly lower (16 %) than for control households (29 %), as was the share of households participating in the national safety net programme (16 %) compared to 59%).

Table 5: Additional poverty indicators, by treatment and control groups

Poverty indicator	Treatment (n = 166)	Control (n=150)	All (n=316)	Sig.-level (*P*> 0.000)*
Sex of household head				
Male-headed households (no.)	139	124	264	.878
Female-headed households (no.)	27	23	50	
Married	13	4	17	.072
Widowed	7	13	20	
Separated	0	2	2	
Divorced	4	4	8	
De jure (no.) (2+4)	11	17	28	.144
De facto (no.) (1+3)	13	6	19	
Dependency ratio				
No. children < 15	1.05	1.37	1.20	.033
No. adults > 60	0.34	0.44	0.39	.167
No. females 15-60	1.90	1.63	1.77	.034
No. males 15-60	1.62	1.51	1.57	.365
Total household size (no.)	4.70	4.97	4.83	.178
Dependency ratio (children + adults over 60 /males + females 15-60)	0.52	0.74	0.62	.009
Household food security				
Household eats own sorghum (months)	4.2	1.4	2.9	.000
Household eats own teff (months)	7.9	6.3	7.1	.000
Household eats own wheat (months)	2.6	1.3	2.0	.000
Household eats own maize (months)	1.7	0.5	1.1	.000
Farm size				
Total area planted to cereal crops in Belg season (ha)	0.18	0.05	0.07	.018
Total area planted to cereal crops in Meher season (ha)	0.44	0.27	0.39	.000
Households renting-in land (no.)	79	42	121	.000

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Households renting-out land (no.)	31	40	71	.059
Ownership of draught animals for ploughing				
Plough oxen owned (no.)	1.40	0.74	1.09	.000
Households renting/borrowing oxen (no.)	96	40	206	.003
Total livestock units (no.)	2.00	1.17	1.60	.000
Use of hired labour				
Households hiring farm labour (no.)	40	22	62	.024
Households using exchange labour (no.)	156	125	281	.002
Food aid as a source of income				
Households with members in national safety net programme (no.)	26	88	114	.000
Households receiving wheat/oil from government in 2015 (no.)	27	44	71	.004

Source: SRMS Household survey, 2019.

*ANOVA for continuous variables, or Chi-square value for categorical variables.

4 Results: Impact Evaluation

A second objective of the household survey was to measure the impact of the RBM in terms of its key objective, namely to accelerate the commercialisation of teff by increasing access to improved teff seed. This section presents the results, arranged as follows. Using univariate statistics, we compare treatment and control groups in three ways. First, we compare the production and management of cereal crops. Second, we compare levels of commercialisation. Third, we compare awareness, access, and adoption of improved teff seed. Finally, we use multivariate analysis (PSM) to measure the impact of the RBM on these variables.

4.1 Cereal crop production and management

Table 6 and Table 7 present information on cereal crop production and management in the Belg and Meher seasons. In the Belg season, there were few significant differences between the two groups (Table 6). There was no significant difference in the area planted to improved and local teff. However, the area planted to cereal crops was significantly higher in the treatment group (0.17 ha) compared to the control group (0.019 ha).

There were more significant differences in the Meher season. The area planted to improved teff varieties by the treatment group was double that of the control group (0.25 ha compared to 0.10 ha). The yield of improved teff varieties among the treatment group (22 quintals/ha) was three times that of the control group (7.12 quintals/ha).[8] In addition, the treatment group had a larger area planted to cereal crops (0.44 ha) than the control group (0.27 ha). This was because treatment households planted more teff, maize, and early-maturing sorghum than control households. By contrast, the control group planted a significantly greater area of local teff varieties (0.13 ha compared to 0.09 ha).

Table 6: Teff production in the Belg season, by treatment and control groups

Belg season	Treatment (n = 166)	Control (n=150)	All (n=316)	Sig.-level (*P*> 0.000)*
Area planted to Qoncho + Zoblil teff (ha)	0.004	0.004	0.006	.129
Area planted to local teff (ha)	0.003	0.004	0.003	.240
Area planted to late maturing sorghum (ha)	0.003	0.00	0.002	.028
Area planted to wheat (ha)	0.001	0.0.001	0.001	.971
Area planted to maize (ha)	0.003	0.00	0.004	.000
Total area planted to cereal crops (ha)	0.017	0.019	0.013	.018
Area planted to Qoncho+Zobil that received fertilizer (ha)	0.003	0.003	0.003	.966
Area planted to local teff that received fertilizer (ha)	0.001	0.001	0.001	.865
Area planted to Qoncho +Zobil teff that received manure (ha)	0.002	0.001	0.002	.237
Area planted to local teff that received manure (ha)	0.001	0.002	0.001	.422
Area planted to late maturing sorghum that received manure (ha)	0.002	0.00	0.001	.192
Area planted to Qoncho+Zobil teff that received pesticide (ha)	0.011	0.011	0.011	.947

[8] Quintals (1 quintal = 100 kg) are the unit generally used to measure grain yield in Ethiopia.

Area planted to late maturing sorghum that received pesticide (ha)	0.002	0.00	0.001	.084
Yield of Qoncho +Zobil teff (quintals/ha) [1]	2.4	0.4	1.4	.001
Yield of local teff (quintals/ha)	0.6	3.4	1.9	.276
Yield of late maturing sorghum (quintals/ha)	1.1	0.00	0.64	.033
Yield of wheat (quintals/ha)	0.5	0.4	0.5	.884
Yield of maize (quintals/ha)	1.6	0	0.8	.000

Source: SRMS Household survey, 2019.

* ANOVA for continuous variables, Chi-square test for categorical variables.

[1]. One quintal = 100kg.

Table 7: Teff production in the Meher season, by treatment and control groups

Meher season	Treatment (n = 166)	Control (n=150)	All (n=316)	Sig.-level (*P*> 0.000)*
Area planted to Qoncho + Zobil teff (ha)	0.25	0.10	0.18	.000
Area planted to local teff (ha)	0.09	0.013	0.011	.020
Area planted to early maturing sorghum (ha)	0.06	0.0.02	0.04	.001
Area planted to wheat (ha)	0.03	0.01	0.02	.065
Area planted to maize (ha)	0.02	0.01	0.02	.012
Total area planted to cereal crops (ha)	0.44	0.27	0.36	.000
Area planted to Qoncho+Zobil that received fertilizer (ha)	0.21	0.09	0.15	.000
Area planted to local teff that received fertilizer (ha)	0.07	0.09	0.08	.045
Area planted to Qoncho +Zobil teff that received manure (ha)	0.09	0.08	0.08	.157
Area planted to local teff that received manure (ha)	0.04	0.08	0.06	.062
Area planted to early-maturing sorghum that received manure (ha)	0.02	0.01	0.01	.053
Area planted to Qoncho+Zobil teff that received pesticide (ha)	0.19	0.10	0.15	.000
Area planted to early maturing sorghum that received pesticide (ha)	0.03	0.01	0.02	.012
Yield of Qoncho +Zobil teff (quintals/ha) [1]	22.24	7.12	5.04	.000
Yield of local teff (quintals/ha)	6.88	8.64	7.68	.144
Yield of early-maturing sorghum (quintals/ha)	5.28	0.96	3.2	.000
Yield of wheat (quintals/ha)	2.16	3.76	2.88	.534
Yield of maize (quintals/ha)	1.68	0.64	1.20	.008

Source: SRMS Household survey, 2019.

* ANOVA for continuous variables, Chi-square test for categorical variables.

[1]. One quintal = 100 kg.

The use of purchased inputs – inorganic fertiliser and seed – differed between the two groups. Table 8 shows that there was no significant difference in the share of households buying fertiliser (82 % for treatment households and 81 % for control households). However, total expenditure on fertiliser was significantly higher among treatment households (ETB 787 compared to ETB 471). This was mostly due to higher expenditure on basal fertiliser. Both groups were equally likely to buy fertiliser from government cooperatives or local markets and the reasons given for not buying fertiliser were the same for both groups. Sources of teff seed differed significantly between the two groups. As expected, a significantly higher share of treatment households used improved seed, sourced mainly from the cooperative or own saved seed, while a significantly higher share of control households used local seed, mainly from own saved seed (

Table 9). Interestingly, 25 treatment households reported that they did not use improved seed in 2018-19, suggesting that they had had no first-generation certified seed (C1) left from the previous year to recycle as second-generation certified seed (C2)..

Table 8: Fertiliser use, by treatment and control groups

	Treatment (n = 166)	Control (n=150)	All (n=316)	Sig.-level (*P*> 0.000)*
Buying fertiliser (no.)	136	121	257	.116
Bought fertiliser from cooperative (no.)	108	80	188	
Bought fertiliser from local market (no)	27	40	67	
Belg season, 2018-19:				
Total cost of basal (ETB)	57	15	37	.013
Total cost of urea (ETB)	25	25	25	.949
Total cost of fertiliser (ETB)	81	40	62	.087
Meher season, 2018-19:				
Total cost of basal (ETB)	445	247	351	.000
Total cost of urea (ETB)	262	184	225	.020
Total cost of fertiliser (ETB)	706	431	576	.000
Total cost Belg and Meher seasons (ETB)	787	471	637	.000
Reasons for not buying fertilizer (no.)				
No need because soil is good	13	13	26	.628
Don’t know how to apply	0	2	2	
Fertiliser not available	1	1	2	
No money to buy fertiliser	14	9	23	
Quality fertilizer not good	0	1	1	
No transportation available	0	0	0	
Other	0	0	0	

Source: SRMS Household survey, 2019.

* ANOVA for continuous variables, Chi-square test for categorical variables.

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Table 9: Sources of teff seed in 2018-19, by treatment and control groups

	Treatment (n = 166)	Control (n=150)	All (n=316)	Sig.-level (*P*> 0.000)*
	Qoncho + Zobil varieties			
Did not use	25	93	118	.000
Own saved seed	55	30	85	
Cooperative	60	20	80	
Local market	7	3	10	
Bought from friend/neighbour	19	4	23	
Other	0	0	0	
Total	166	150	316	
	Local teff varieties			
Did not use	104	45	149	.000
Own saved seed	44	97	141	
Cooperative	2	0	2	
Local market	7	3	10	
Bought from friend/neighbour	9	4	13	
Other	0	1	1	
Total	**166**	**150**	**316**	

Source: SRMS Household survey, 2019.

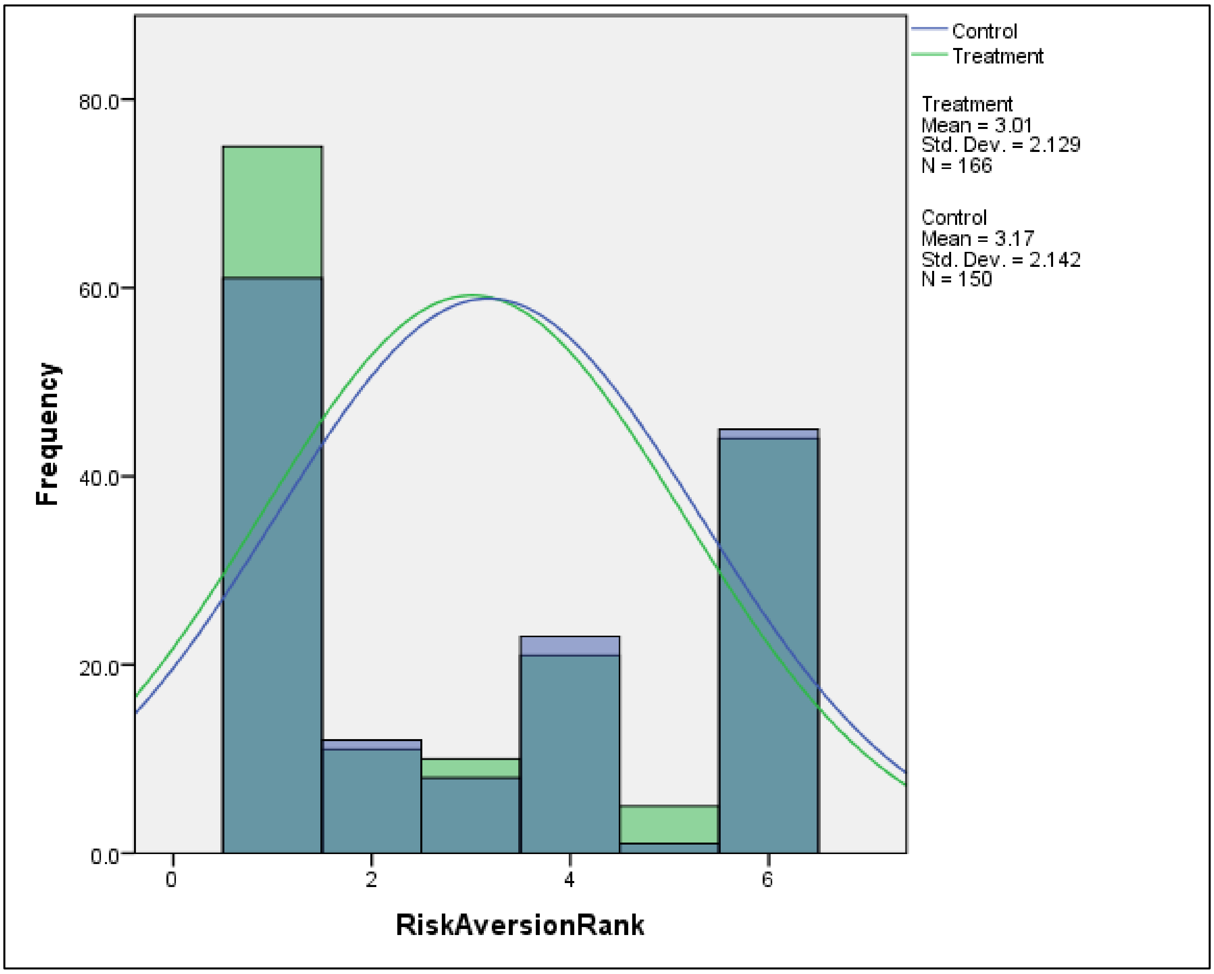
* ANOVA for continuous variables, Chi-square test for categorical variables.

4.2 Commercialisation

4.2.1 Risk aversion ranking

Smallholders may be reluctant to commercialise teff if they are risk averse. Consequently, it is important to compare aversion to risk between the treatment and control groups. Figure 2 compares the frequency distribution for the risk-aversion ranking conducted by the household survey for the treatment households (green line) and control households (blue line). The frequency does not follow the normal distribution but shows higher frequencies at the extremes ranks 1 (low risk aversion) and 6 (high risk aversion). The t-test showed no statistically significant difference in mean risk ranking for the treatment group (3.01) and the control group (3.17).

Figure 2: Distribution of risk aversion ranking for treatment and control groups



Source: SRMS Household survey, 2019.

4.2.2 Income from sales

The share of households selling teff in the survey year was significantly higher than among the treatment group (21% compared to 5% in the control group). However, the amount of teff sold was not significantly different. Nevertheless, treatment households had a higher income from the sale of teff (ETB 328). A similar proportion of treatment and control households reported that they were unable to increase the area planted to teff (42% and 54%, respectively), mainly because of shortage of land.

Table 10: Income from crop and livestock sales, by treatment and control groups

	Treatment (n = 166)	Control (n=150)	All (n=316)	Sig.-level (*P*> 0.000)*
Growers selling teff (no.)	34	7	41	.001
Growing selling sorghum (no.)	8	0	8	.127
Growers selling wheat (no.)	3	1	4	.564
Share of teff sold (%)	29	4	17	.149
Share of sorghum sold (%)	12	0	10	.262

Mean qty of teff sold (kg)	17.1	6.9	12.3	.129
Mean qty of sorghum sold (kg)	4.6	0	2.4	.046
Value of teff sold (ETB)	328	57	198	.013
Value of sorghum sold (ETB)	87	0	46	.042
Value of wheat sold (ETB)	25	0	13	.126
Value of maize sold (ETB)	16	0	8	.157
Total value of crops sold (ETB)	447	56	262	.005
Total value of livestock sold (ETB)	85	90	175	.045
Can increase land to plant teff? (no.)	81	59	140	.057
Shortage of land	70	81	151	.295
Land not suitable for teff	4	3	7	
Shortage of labour for teff	10	4	14	
Other	1	2	3	
Teff needed to feed family (quintals)	5.3	4.7	5.0	.303
Teff needed for sale (quintals)	6.8	6.3	6.5	.501

Source: SRMS Household survey, 2019.

* ANOVA for continuous variables, Chi-square test for categorical variables.

Farmers reported that they often exchanged goods for teff, rather than sell teff for hard cash. Over a three-year period, the average quantity of teff sold by the treatment group (1.04 quintals) exceeded that of the control group (0.16 quintals).

Table 11: Sale of teff in last three years, by treatment and control groups (quintals)

	Treatment (n = 166)	Control (n=150)	All (n=316)	Sig.-level (*P*> 0.000)*
		Last year (2018-19)		
Production	3.79	2.13	2.99	.000
Sold	1.60	0.08	0.88	.056
		Two years ago (2017-18)		
Production	5.44	2.11	3.86	.037
Sold	1.03	0.20	0.64	.054
		Three years ago (2016-17)		
Production	4.07	2.30	3.23	.000
Sold	0.49	0.19	0.34	.057
		Mean in last three years (2016-19)		
Production	4.4	2.18	3.36	.000
Sold	1.04	0.16	0.62	.020

Source: SRMS Household survey, 2019.

* ANOVA for continuous variables.

Market prices for teff grain differed significantly between different varieties. Farmers reported that the highest price paid was for Qoncho and the lowest price paid for local varieties of red teff (Table 12). However, the price of local teff with white grains was not significantly different from the price for improved teff varieties.

Table 12: Price of teff grain in market now (March 2019) (ETB/kg)

Teff variety	Mean price	N
Qoncho	28.24 *a*	258
Zobil	27.28 *ab*	58
White teff (local)	28.11 a*b*	308
Mixed teff (local)	26.23	308
Red teff (local)	25.12	301

Source: SRMS Household survey, 2019.

Note: means with at least one common letter are not significantly different at the 10% level.

Farmers were asked to score their problems about growing teff for sale. For both treatment and control groups, the problem with the highest score was the low production of teff (Table 13). Access to certified seed of improved varieties was scored third, and high cost of improved seed scored fourth. Interestingly, the treatment group gave significantly higher scores to problems with access to improved varieties and to the poor quality of seed available in local markets. One explanation is that participation in the RBM has increased the demand for quality improved seed

Table 13: Biggest problem growing teff for sale, by treatment and control groups (mean scores, 10=highest)

	Treatment (n = 166)	Control (n=150)	All (n=316)	Sig.-level (*P*> 0.000)*
Low production of teff	5.7	6.1	5.9	.357
Low market prices	5.4	5.9	5.6	.259
Seed of improved teff varieties is not available	4.2	3.5	3.9	.026
High cost of C1 seed of improved varieties	3.9	3.8	3.9	.541
Poor quality of improved seed available in local markets	3.8	3.1	3.5	.035
Market prices are too variable	2.9	2.4	2.7	.097

Source: SRMS Household survey, 2019.

* ANOVA for continuous variables

4.3 Awareness, Access and Adoption

A significantly higher share of RBM participants were aware about improved teff varieties (92% compared to 69% among the control group) and had access to these varieties, as evidenced by those reporting that they had ever planted them (89% of participants compared to 45% in the control group) (Table 14). Since 'what farmers don't know can't help them', farmers unaware of improved varieties cannot be considered non-adopters. On the other hand, being aware of improved teff varieties but not planting them may imply a lack of access to seed. We call this the "adoption gap". This gap was significantly lower for the treatment group (2%) than for the control group (24%).

Table 14: Awareness, access and adoption of Improved teff varieties, by treatment and control groups

	Treatment (n = 166)	Control (n=150)	All (n=316)	Sig.-level (*P*> 0.000)*
Heard about Qoncho (Yes)	147 (88.6)	104 (69.3)	251 (79.4)	.000
Heard about Zobil (Yes)	45 (27.1)	5 (3.3)	50 (15.8)	.000
Heard about Qoncho or Zobil (Yes)	152 (91.6)	104 (69.3)	256 (81.0)	.000
Ever planted Qoncho (Yes)	141 (84.9)	68 (45.3)	208 (65.8)	.000
Ever planted Zobil (Yes)	32 (19.3)	0 (0.0)	32 (10.1)	.000
Ever planted Qoncho or Zobil (Yes)	148 (89.2)	68 (45.3)	216 (68.4)	.000
Heard about and planted	148 (89.2)	68 (45.3)	216 (68.4)	.000
Heard about but not planted	4 (2.4)	36 (24.0)	40 (12.6)	.000

Source: SRMS Household survey, 2019.

Note: Figures in parentheses are percentages

* Chi-square test for categorical variables.

Among the control group, farmers reported the main reason for non-adoption as ignorance about improved varieties (64%). Only a small number (5%) were happy with existing local varieties. Surprisingly, although all the treatment farmers had received improved teff varieties in the previous year (2017-18), 18 reported non-adoption of improved teff varieties. This may reflect lack of awareness of the variety Zobil, which was distributed in only one of the three *kebeles*.

Table 15: Reasons for not planting improved teff varieties, by treatment and control groups

	Treatment (n = 166)	Control (n=150)	All (n=316)
I am not aware of these teff varieties	15	51	66
I tried planting these varieties before and do not like them	0	8	8
I don't know how to best plant these varieties	3	10	13
Seeds of these varieties are not available	0	2	2
I did not have money to buy seed of these varieties	0	5	5

I am happy with local teff varieties	0	4	4
Total	18	80	98

Source: SRMS Household survey, 2019. Chi-square = 73.413 *P* > .000

4.4 Impacts

The results in section 3 on social inclusion revealed significant socio-economic differences between the treatment and control groups. To evaluate the impact of the RBM on the commercialisation of teff, we need to control for these differences. In this section we use Propensity Score Matching (PSM) to obtain a matched sample of treatment and control groups that will give unbiased estimates of treatment effects.

4.4.1 The propensity score

We first estimate the propensity score using logit regression, identifying independent variables that might influence allocation to the treatment, in this case variables that might bias the cooperative management to include some farmers to receive certified seed and exclude others. These include socio-economic descriptors (gender of head, age of head, dependency ratio, poverty scorecard, having a household member in the national safety net programme), the head's experience with teff cultivation, ownership of an ox team to ensure timely ploughing, as well as membership of the cooperative.

Table 16 shows the estimation results. Of the nine independent variables, four were statistically significant, indicating that selection to receive improved seed was biased. Households where the household head was younger, a cooperative member, without a member in the safety net programme, with a lower dependency ratio and that owned a plough team had a significantly higher likelihood of being selected. Thus, there is clear evidence of selection bias, which means the treatment group is not random. This makes it difficult to infer a causal connection between the treatment and its effects.

Table 16: Determinants of selection into RBM

```
Logistic regression                             Number of obs     =        316
                                                LR chi2(9)        =      87.41
                                                Prob > chi2       =     0.0000
Log likelihood = -174.92423                     Pseudo R2         =     0.1999
```

treatment	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
genderhh	.0324645	.3746887	0.09	0.931	-.7019117	.7668408
agehh	-.0405145	.0154396	-2.62	0.009	-.0707755	-.0102535
educhh	-.0294768	.0384849	-0.77	0.444	-.1049059	.0459523
depratio	-.3904103	.1892722	-2.06	0.039	-.761377	-.0194436
yearsteff	.0164666	.0130288	1.26	0.206	-.0090694	.0420026
member	.9758435	.3763469	2.59	0.010	.2382171	1.71347
povscore	-.0043779	.0106882	-0.41	0.682	-.0253264	.0165707
safetynet	-2.195928	.3124675	-7.03	0.000	-2.808353	-1.583503
rentox	-.5329979	.2813976	-1.89	0.058	-1.084527	.0185312
_cons	2.402755	1.06286	2.26	0.024	.3195871	4.485922

Source: SRMS Household Survey 2018-19

4.4.2 Treatment effects

To overcome selection bias, treatment households were matched with control households based on their propensity score, or likelihood of selection. We used four different matching algorithms (kernel, nearest neighbour, radius and caliper matching) to obtain a matched sample. The mean bias ranged from 5.7 % with kernel matching to 27.2% with radius matching. Since kernel matching (which uses a weighted average of *all* the control households within the range of a specific propensity score) gave the mean bias closest to the recommended level of 5%, we selected kernel matching to estimate treatment effects.[9]

The matched sample was tested for balance using t-tests for each independent variable in the logit regression, and for sensitivity using Rosenbaum bounds. Results from these tests are shown in Appendix 1. The t-tests showed that the match was well-balanced, with no statistically significant differences in independent variables between the treatment and control groups (Table 18). The Rosenbaum bounds test for sensitivity of treatment effects showed that the estimated impacts were not significantly affected by unobserved variables at levels of gamma between 1 and 1.5 (Table 19). In combination, these tests confirm that we can have confidence in our estimates of impact.

Table 17 shows the treatment effects of the RBM, for the 12 outcome variables defined and named in Table 3. The result of interest is the mean difference in the average treatment effect on the treated (ATT), which shows the impact of participation in the RBM. In 9 of the 12 outcome variables, the ATT was statistically significant at the 95 % confidence level (t-value 2 >). These included one of the three production effects (production of teff in 2018-19), four of the five commercialisation effects (selling teff, the value of teff sold, value of sales of other cereals, and home consumption of teff), and all four adoption effects (awareness, access to seed, adoption of improved varieties, and the adoption gap).

In terms of production, the RBM significantly increased production of teff by 1 quintal, but did not increase the area planted to teff, or reduce the production of other cereals (wheat, sorghum, and maize). In terms of commercialisation, the RBM increased the proportion of households selling teff by 11%, and the value of teff sold by ETB 274, and the value of other cereals sold by ETB 111. However, the RBM did not significantly increase the amount of teff sold (6.5 kg). Instead, the increase in teff production was used for home consumption, which was significantly higher (0.93 quintals) for the treatment group. In terms of the adoption of improved varieties, the RBM increased awareness by 14%, access to improved seed by 29%, adoption by 35%, and reduced the adoption gap by 15%.

[9] Using the STATA command: kernel k(normal) bwidth(0.05).

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Table 17: Treatment effects

Variable	Sample	Treated	Controls	Difference	S.E.	T-stat
lastyearteffpr~n	Unmatched	3.76506024	2.13333333	1.63172691	.237120582	6.88
	ATT	3.76506024	2.74983994	1.0152203	.279396018	3.63
areaallteff	Unmatched	3.08433735	2.12666667	.957670683	.217773193	4.40
	ATT	3.08433735	2.64627747	.438059879	.266361841	1.64
totprodother	Unmatched	1.12650602	.64	.486506024	.36270045	1.34
	ATT	1.12650602	.406620798	.719885226	.508403779	1.42
seller1	Unmatched	.198795181	.066666667	.132128514	.038023955	3.47
	ATT	.198795181	.085277392	.113517789	.042636266	2.66
teffsold1	Unmatched	17.1024096	6.94	10.1624096	4.81374173	2.11
	ATT	17.1024096	10.6377472	6.46466244	5.78128848	1.12
teffval	Unmatched	307.951807	56.3333333	251.618474	106.65714	2.36
	ATT	307.951807	33.9008238	274.050983	113.731517	2.41
valother	Unmatched	111.036145	0	111.036145	47.1368525	2.36
	ATT	111.036145	0	111.036145	44.8007743	2.48
homecons1	Unmatched	3.57144578	2.05266667	1.51877912	.232825915	6.52
	ATT	3.57144578	2.64384494	.927600844	.276163742	3.36
heardmv	Unmatched	.915662651	.693333333	.222329317	.042510289	5.23
	ATT	.915662651	.772958381	.14270427	.058148885	2.45
evermv	Unmatched	.891566265	.453333333	.438232932	.046379142	9.45
	ATT	.891566265	.59868951	.292876755	.063098937	4.64
adoption	Unmatched	.84939759	.38	.46939759	.047817965	9.82
	ATT	.84939759	.497170092	.352227499	.063272255	5.57
adoptiongap	Unmatched	.024096386	.246666667	-.222570281	.035837288	-6.21
	ATT	.024096386	.178037229	-.153940843	.051851537	-2.97

Note: S.E. does not take into account that the propensity score is estimated.

psmatch2: Treatment assignment	psmatch2: Common support On suppor	Total
Untreated	150	150
Treated	166	166
Total	316	316

Source: SRMS Household Survey 2018-19

5 Discussion

5.1 Social inclusion

Social inclusion – the extent to which smallholders below the poverty line were selected to participate in the RBM – was measured by comparing the poverty status of treatment and control households. Both groups of households were members of a primary, multipurpose cooperative. The main reason for selecting cooperative members as the control group was to facilitate sampling, since control households could be randomly selected from the membership list. However, if the membership of primary cooperatives is not representative of the wider population but biased towards better off households, this limits our measure of social inclusion.

In Ethiopia, cooperative members are only 9 % of the total population (Tesfamariam, 2015). A nationwide survey in 2005 found evidence that poorer farmers tended either not to join cooperatives or, if they did, not to participate in cooperative decision-making (Tanguy and Spielman, 2009). A survey of cooperatives in eight districts in 2009 found that cooperative members were more likely than non-members to be male, literate, have bigger farms, own oxen, have bigger households, and belong to the upper wealth quartile (Abegaw and Haile, 2013). Similarly, a survey of four wheat-growing districts in 2016 found that, while age, household size and livestock ownership did not differ significantly between members and non-members, members had more education and more land under cultivation (Wassie et al., 2019). Based on these poverty indicators, poorer households seem to be under-represented, which supports the view that cooperatives are not socially inclusive.

Our discussions with cooperative managers suggest that cooperatives are reasonably inclusive of farming households. This is because (1) membership is based on buying shares priced at only 16 Birr per share; those who buy multiple shares receive a bigger share of the profit from cooperative sales (2) there are no annual membership fees (3) there is no minimum farm size required for membership (4) the only other membership qualifications are residency in the *kebele* and to be aged over 18. Farmers do not even have to be a member to purchase inputs from the cooperative. Since 2017, non-members can buy fertiliser or improved seed through the cooperative just like members. Since 2005, therefore, it is possible that the reduction in the price of cooperative shares (from ETB 45 to ETB 16 per share) and the abolition of annual fees has made membership more inclusive. However, in the absence of direct evidence comparing members and non-members in South Wollo zone, it seems wise to restrict our analysis of social inclusion to households that are cooperative members.

Social inclusion was measured using the poverty scorecard, which allows us to relate poverty among the sample households to poverty at the national level. We found no difference between treatment and control groups in the likelihood of being below the national poverty line (21%) (Table 4). Differences between treatment and control households emerged when we compared the poverty rate or the share of households below the poverty line. However, these differences were small. In terms of the national poverty line, the poverty rate among treatment households was 4 % lower than for control households, while for the international poverty line of US$ 3.10 per day (equivalent to US$ 1.25 in 2005), the poverty rate was 6% lower. These small differences should not mask the close correspondence between poverty among our sample households and poverty at the national level. For the combined treatment and control groups, the likelihood of being below the national poverty line (16%) was identical to that for Ethiopia as a whole. Moreover, the poverty rate for the combined treatment and control households was close to the national level. In the case of the national poverty line, 21% of the sample households were poor compared to 23% for Ethiopia as a whole. In the case of the international poverty line of US$ 3.10 per day, 64% of the sample households were poor compared to 65% for Ethiopia as a whole. In terms of the overall levels of poverty in Ethiopia, therefore, the RBM was socially inclusive. On the other hand, several poverty indicators did suggest lower levels of poverty among the treatment group (Table 5). These included indirect indicators such as ownership of a team of plough oxen and direct indicators such as participation in the national safety net programme.

How can we reconcile these seemingly conflicting results? Three reasons suggest themselves. The first is that the poverty scorecard is a composite index based on eight indicators (Schreiner, 2016). Hence, a low score for one indicator may be offset by a high score for another. Arguably, this makes a composite index a more reliable measure of poverty than a measure based on a single variable. The second reason is that indicators are *indicative* rather than *measures* of poverty. To be sure, some indicators – participation in the national safety net programme, for example – are a direct measure of poverty. But others, such as a higher dependency ratio, are not precise measures but continuous variables with no pre-determined level to distinguish the poor from the non-poor. Finally, the poverty scorecard uses a *rate criterion of poverty*, which conceals variation among the poor. Where the share of households living below the international poverty line of US$ 3.10 per day is six in ten, we would expect to find significant differences in some poverty indicators. On average, households that were selected by the DA and the cooperative management to receive certified seed were younger, owned a team of oxen to ensure timely ploughing, and had a lower dependency ratio, implying a bigger labour force. This suggests that cooperatives chose participants with the resources to make the best use of improved seed,

5.2 Commercialisation

The RBM is predicated on the assumption that increasing the supply of improved seed will accelerate the commercialisation of teff. Our results show that the RBM has indeed had a significant impact on farmers' access to certified seed and the adoption of improved teff varieties, but that these changes have had a relatively small impact on the commercialisation of teff.

Ethiopia's centralised, state-run seed system has failed to meet smallholder demand for improved teff seed. The initial value chain analysis revealed that less than 5% of the area under teff in Tehuledere *woreda* was planted with certified seed (Weber and Tiba, 2017), In responding to this unmet demand, the RBM has had a significant impact. Comparing matched samples of participants and non-participants gives some striking results. In the space of just two years, the RBM has increased farmers' awareness of improved varieties by 14%, their access to certified seed by 29%, and their adoption of improved varieties by 35% (Table 17). The "adoption gap" – the share of farmers who had heard about improved varieties but had never planted them – was reduced by 15%. Thus, while most farmers were already aware of improved teff varieties, a significant share were unable to find certified seed or to plant these varieties in their own fields. Participants confirmed these results, with 7 in 10 agreeing that the RBM had increased the availability of improved seed (Table 23). In addition, there were spillover benefits through farmer-to-farmer diffusion. However, these were relatively small. Among our sample, of the 131 farmers who received certified seed in Year 1, only 30 (23 %) shared or sold some of their harvested grain (Table 22). These results compare favourably with those from earlier research which found that cooperatives increased the adoption of inorganic fertiliser but had no significant impact on the adoption of improved seed (Abegaw and Haile, 2013).

Accelerated adoption of improved teff varieties has led to an increase in the production of teff by 1 quintal per household (Table 17). This increase was achieved without an increase in the aggregate area planted to teff, or a concomitant drop in the production of other cereal crops like sorghum, wheat and maize. Thus, higher production has been the result of intensification, rather than of increasing the area planted or displacing other cereal crops. Clearly, the increase in teff production reflects the higher yields from improved teff varieties. Nine in ten farmers participating in the RBM agreed that yields were higher than with local varieties (Table 23). This is supported by other evidence, which suggests that under farmers' field conditions yields of the improved teff variety Quncho are 35 % higher than that of traditional varieties (Hailu et al., 2018: 223).

Despite this increase in teff production, however, the impact on commercialisation was disappointing. The average treatment effect (ATT), which compares mean differences between a matched sample of treatment and control households, showed that while the RBM increased the proportion of households selling teff by 13%, the average *amount* of teff sold did not change (Table 17). Moreover, the average amount sold was small (only 12 kg) (Table 10). True, the RBM significantly increased the value of teff sold, perhaps reflecting the price premium for white grain. Again, however, the increase was small, just ETB 274 (US$ 10). While the RBM can claim to have had some impact of the commercialisation of teff, the real question is why the impact was not bigger.

The simple reason is that the increase in teff production has been used for home consumption. Participation in the RBM significantly increased home consumption in the treatment group by 0.93 quintals per household (Table 17). This is equivalent to an increase in household food security of two months.[10] The decision to use higher production for consumption rather than for sale is not difficult to understand. Over a three-year period, the average farm produced 3.32 quintals of teff per year (Table 11). This fed the average household for 7 months (Table 2). To feed the household for a full year, farmers would need to produce 5 quintals (Table 10). When asked how much teff was needed to have enough for sale, the answer was 6.5 quintals, or twice the amount that households currently produce in one year (Table 10). Thus, even with the higher yield from improved varieties, teff production still did not reach the level that farmers saw as the threshold for commercialisation. In their view, the main barrier to commercialisation was not access to certified seed, the cost of this seed, or the poor quality of this seed on local markets (Table 13). All these were secondary. Rather, they identified the primary barrier to commercialisation as "low production". In other words, their farms are too small. Given low production because of limited land, it is hardly surprising that so few households sold teff (13%, Table 10) or that the average amount of teff they sold was so small (12 kg, worth just ETB 198 or US$ 7).

The priority given to home consumption also reflects the status of teff as the preferred cereal crop. Farmers grow wheat and sorghum as well. However, wheat is not regarded as a substitute for teff because it is not used to make *injera* (a flat, spongy bread made from fermented flour) but bread, which is eaten only as a breakfast food. Similarly, farmers have been reluctant to adopt improved varieties of early-duration sorghum, such as Girana 1, because it produces *injera* that is too dry and easily broken, requiring a mix of two parts teff to one of sorghum to produce *injera* of the desired quality. Consequently, farmers prioritise teff over other cereal crops, managing variable rainfall to maintain a consistent level of teff production, by sacrificing sorghum and wheat (Orr et al., 2018b). Given these taste preferences, any increase in teff production is more likely to be eaten than sold.

These findings have wider implications. DFID's conceptual framework for agriculture sees the commercialisation of smallholder agriculture as instrumental for poverty reduction (DFID, 2015). One strategy for commercialisation is to give smallholders access to new technology that increases output from limited land. Armed with this technology, smallholders can take advantage of new market opportunities. However, this was not true of teff in South Wollo. This suggests that commercialisation is a viable strategy for poverty reduction only in specific contexts. While commercialisation may be viable for certain value chains, such as horticulture, organics, or for intercrops such as pigeonpea in Malawi, it is more problematic for staple food crops. This is true particularly in rainfed farming systems, where the risk of yield loss from variable rainfall is high. Farmers in South Wollo estimated the probability of a 'normal' Belg and Meher seasons as no more than three years in ten, and the probability of a complete crop failure in both seasons as one in ten (Orr et al., 2018b). Against this background, the farmer's priority is household food security, which explains why they valued an additional two months' of teff consumption more than additional cash income. In drought-prone regions characterised by chronic food insecurity, the commercialisation of the staple cereal crop is a high-risk strategy.

[10] Average teff production of 3.36 quintals (Table 11) feeds the average household for 7.1 months (Table 2). This gives an average consumption of 0.5 quintals per month. An additional 1 quintal is therefore equivalent to two months' household food security.

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Which brings us back to the focus of this research project, namely risk and risk management. The objective of the project was to design an RBM to manage the systemic risks preventing commercialisation. The RBM focused on the systemic risks posed by lack of economic coordination and opportunism on the supply of certified seed. The RBM successfully addressed these risks, raising farmers' adoption of improved teff varieties by one-third. In itself, this achievement is nothing remarkable. Any project with a single distribution of certified seed might produce a similar jump in adoption. In this case, however, the seed distribution is self-sustaining. Farmers' access to certified seed will not stop with the end of the project. The RBM is based on a revolving seed fund which, if farmers continue to repay, may continue indefinitely. Currently, the rate of repayment averages over 70 % in both years (Appendix 1). Thus, the RBM provides a successful example of a farmer-managed seed delivery system that can be scaled-out in Amhara region.

However, the RBM did not result in commercialisation. The number of sellers increased but the amount they sold stayed the same. Improving access to new technology may be a necessary condition for commercialisation, but it is not sufficient. What more was needed? Should the RBM have included a marketing component? This was ruled out, on the grounds that the value chain for teff was highly competitive and left little scope for collective action to increase growers' share of the final price (Orr et al., 2017). Should the RBM have included an insurance component? But compensating farmers for low yields in drought years would not have increased the volume of teff available for sale. Ultimately, the failure of the RBM to deliver commercialisation lay in its assumption that resource-poor farmers were willing to risk household food security in exchange for cash income. However, this assumption proved unfounded.

This highlights the limitations of 'institutional fixes' to manage systemic risks. While it is relatively easy to design institutions to manage systemic risks to commercialisation caused by market failures, it is more difficult to manage the systemic risk posed by natural shocks. Teff in South Wollo is the staple food crop in a rainfed, drought-prone farming system. In such cases, it is easier to reduce poverty by increasing household food security than through commercialisation.

6 Conclusion

The basic assumption of the RBM was that a de-centralised seed system based on a revolving seed fund and managed by a cooperative would accelerate the adoption of improved varieties and increase the commercialisation of teff by resource-poor farmers. After two years' field experience, this evaluation was conducted to test social inclusion and the impact on commercialisation.

The results are mixed. On the one hand, the RBM is socially inclusive. Among the participants, the likelihood of being poor and the share of households living below either national or international poverty lines are very close to the figures for Ethiopia as a whole. We conclude that the RBM and the cooperative system have proved an effective channel for delivering certified seed to resource-poor farmers. This has resulted in greater awareness of improved varieties, greater access to certified seed, and higher adoption. In consequence, the RBM has been instrumental in reducing the "adoption gap", or the share of farmers who know that improved varieties exist but who without access to seed have never planted them. On the other hand, the RBM assumed that access to certified seed would increase the commercialisation of teff. Clearly, this has not happened. The share of growers selling teff remains low, as do the average amount of teff that is sold and the income from teff sales. Consequently, this original assumption has proved unfounded, with the result that one key objective of the RBM has not been met.

High social inclusion and low commercialisation are two sides of the same coin. In a farming system characterised by small farms, chronic food insecurity and a high rate of poverty, it is possible to achieve a high rate of social inclusion, but the prospects for commercialisation are limited. Commercialisation may be possible through high-value crops (like spices) or intercrops (like pigeonpea) which do not compete with staple food crops. But in the case of a preferred cereal crop like teff, commercialisation is harder to achieve. It is not difficult to understand why participants in the RBM might prioritise household food security over cash income. Poor households are also food-deficit households. In this case, participating households are self-sufficient in teff for an average of just 7 months a year. Given the scale of this deficit, it is unrealistic to expect them to use higher production for sales rather than for home consumption. This suggests that the driver for adoption of improved varieties by resource-poor farmers has not been the allure of higher cash income from Ethiopia's booming value chain for teff, but the need for higher yields from limited land. The RBM has raised teff production by 1 quintal per household, which is equivalent to two months' home consumption. Thus, although the RBM has not achieved its original objective of stimulating commercialisation, it has had a positive impact on household food security. Combining these two findings – a high rate of social inclusion and higher household food security – suggests that the RBM has significantly benefitted resource-poor farmers.

We conclude that the RBM has been effective in managing two systemic risks – economic coordination and opportunism – that limit the supply of certified seed. The RBM demonstrates that the farmer-managed revolving seed fund is a model of seed delivery which is socially inclusive and that can accelerate the adoption of improved teff varieties and improve household food security. However, the RBM does not address the systemic risk caused by natural shocks. Structural constraints in the farming system – variable rainfall and chronic food insecurity – will continue to limit the ability of resource-poor farmers to benefit from commercialisation.

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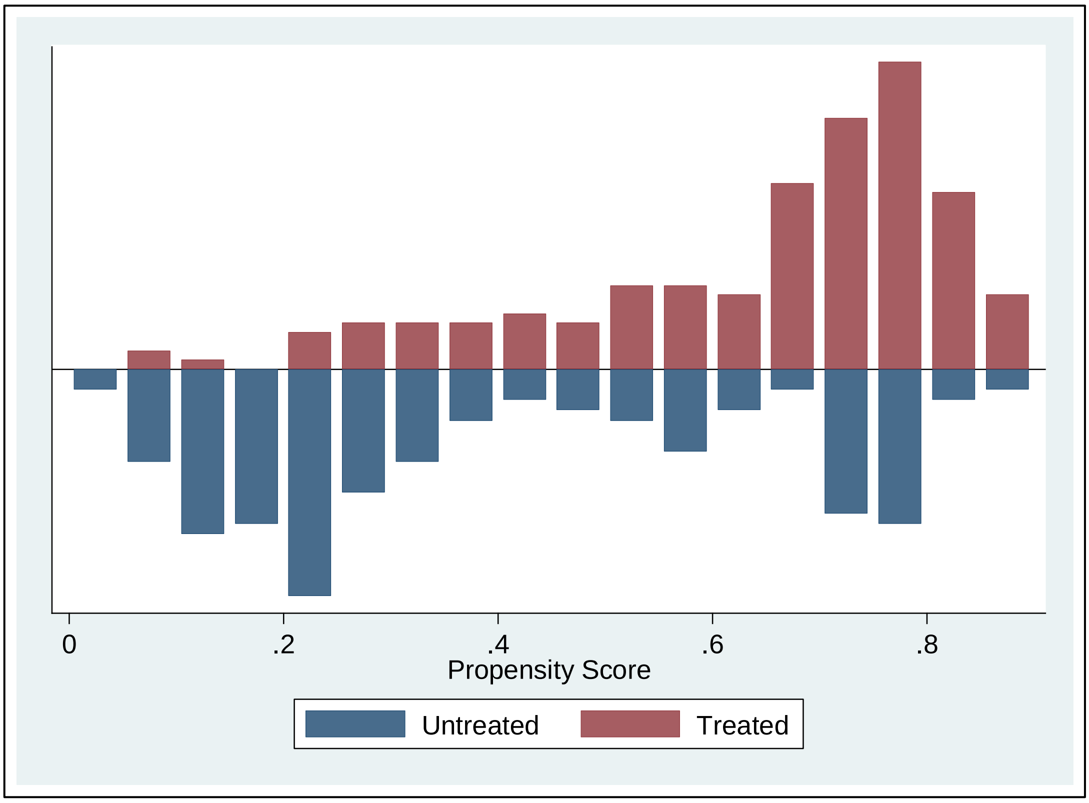
Appendix 1. Testing results for Propensity Score Matching

Balance

Figure 3 shows the distribution of propensity scores obtained using kernel matching. The histogram shows different densities for RBM participants (treated) and non-participants (Untreated). This implies that many households would not be good matches as the density of propensity scores of potential controls occurs at low propensity scores while than of treatment households are at high propensity scores.

Figure 3: Distribution of propensity scores for treatment (treated) and control (untreated) groups



Source: SRMS Household Survey 2018-19

Table 18 compares the mean values of the independent variables in the logit regression for both treatment and control groups after matching using kernel matching. The t-test shows that, for the matched sample, the mean values of the independent variables do not differ significantly between the two groups (t-values < 2). The mean bias for the matched sample is 5.7 %, which is close to the recommended value of 5 % (Grilli and Rampichini, 2011). This implies that kernel PSM using kernel matching has reduced selection bias due to these variables and that the matched treatment and control households have the same propensity for selection into treatment. The estimated Rubin's R (the ratio of treated to (matched) non-treated variances of the propensity score index) value is 1.01 which is within the standard value of (0.5, 2).

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Table 18: Significance tests for matched sample with kernel matching

Variable	Mean Treated	Mean Control	%bias	t-test t	t-test p>|t|	V(T)/ V(C)
genderhh	1.1627	1.1591	1.0	0.09	0.931	1.02
agehh	48.825	48.832	-0.1	-0.00	0.996	0.68*
educhh	2.9036	3.1441	-6.3	-0.55	0.582	1.01
depratio	.51232	.61283	-14.1	-1.38	0.170	1.22
yearsteff	27.88	28.362	-3.4	-0.30	0.763	0.74
member	.89157	.85554	9.9	0.99	0.325	.
povscore	43.747	44.852	-8.3	-0.78	0.434	1.20
safetynet	.15663	.14257	3.2	0.36	0.721	.
rentox	.57831	.55537	4.9	0.42	0.674	.

* if variance ratio outside [0.74; 1.36]

Ps R2	LR chi2	p>chi2	MeanBias	MedBias	B	R	%Var
0.009	4.19	0.899	5.7	4.9	22.5	1.01	17

* if B>25%, R outside [0.5; 2]

.

Source: SRMS Household Survey 2018-19

Sensitivity analysis

Treatment effects are sensitive to variables that influence selection into treatment but which are unobserved. Sensitivity analysis is used to measure the influence of these unobserved variables. The analysis was made using Rosenbaum bounds, which uses the sensitivity parameter gamma (Γ) to measure the log odds of being assigned to the treatment group due to unobserved factors. Gamma = 1 corresponds to the random assignment of treatments in experimental data, i.e. the absence of selection bias due to unobserved factors. Gamma = 1.1 measures the effect of a 10% change in the log odds of selection into treatment due to the influence of unobserved factors. The significance of the change in log odds is tested by the *p*-value of the upper bound at the 0.05 confidence level.

Rosenbaum bounds is appropriate only for continuous variables. Sensitivity analysis was carried out on the 7 continuous variables in Table 17. Table 19 reports the results. Based on the assumption that the treatment effect is over-estimated, the relevant statistic is the upper Rosenbaum bound (sig+). For example, the result for teff production (lastyearteffproduction) shows that even when $\Gamma = 1.5$, i.e. an increase of 50% in the log odds of selection into treatment, the *p*-value of the upper bound significance level (sig+) does not change but remains at 0. Hence, we can reject the null hypothesis of no treatment effect.

Table 19 shows that *p*-value of the upper bound significance level (sig+) does not exceed 0 between $\Gamma = 1.1$ and $\Gamma = 1.5$ for all seven outcome variables. We therefore reject the null hypothesis of hidden bias on the treatment effects for the continuous variables in Table 11.

Table 19: Sensitivity analysis of treatment effects

Rosenbaum bounds for lastyearteffproduction (N = 316 matched pairs)

Gamma	sig+	sig-	t-hat+	t-hat-	CI+	CI-
1	0	0	2.5	2.5	2.5	3
1.1	0	0	2.5	3	2.5	3
1.2	0	0	2.5	3	2.5	3
1.3	0	0	2.5	3	2.5	3
1.4	0	0	2.5	3	2	3.5
1.5	0	0	2.5	3	2	3.5

* gamma - log odds of differential assignment due to unobserved factors
sig+ - upper bound significance level
sig- - lower bound significance level
t-hat+ - upper bound Hodges-Lehmann point estimate
t-hat- - lower bound Hodges-Lehmann point estimate
CI+ - upper bound confidence interval (a= .95)
CI- - lower bound confidence interval (a= .95)

Rosenbaum bounds for areaallteff (N = 316 matched pairs)

Gamma	sig+	sig-	t-hat+	t-hat-	CI+	CI-
1	0	0	2.5	2.5	2	2.5
1.1	0	0	2.5	2.5	2	2.5
1.2	0	0	2	2.5	2	2.5
1.3	0	0	2	2.5	2	2.5
1.4	0	0	2	2.5	2	3
1.5	0	0	2	2.5	2	3

Rosenbaum bounds for totprodother (N = 316 matched pairs)

Gamma	sig+	sig-	t-hat+	t-hat-	CI+	CI-
1	0	0	-4.3e-07	-4.3e-07	-4.3e-07	.5
1.1	0	0	-4.3e-07	.5	-4.3e-07	.5
1.2	0	0	-4.3e-07	.5	-4.3e-07	.5
1.3	0	0	-4.3e-07	.5	-4.3e-07	.5
1.4	4.4e-16	0	-4.3e-07	.5	-4.3e-07	.5
1.5	4.3e-15	0	-4.3e-07	.5	-4.3e-07	.5

Rosenbaum bounds for teffsold1 (N = 316 matched pairs)

Gamma	sig+	sig-	t-hat+	t-hat-	CI+	CI-
1	2.8e-11	2.8e-11	-3.7e-07	-3.7e-07	-3.7e-07	-3.7e-07
1.1	2.1e-10	3.2e-12	-3.7e-07	-3.7e-07	-3.7e-07	-3.7e-07
1.2	1.1e-09	3.6e-13	-3.7e-07	-3.7e-07	-3.7e-07	-3.7e-07
1.3	4.6e-09	4.0e-14	-3.7e-07	-3.7e-07	-3.7e-07	-3.7e-07
1.4	1.5e-08	4.6e-15	-3.7e-07	-3.7e-07	-3.7e-07	-3.7e-07
1.5	4.4e-08	5.6e-16	-3.7e-07	-3.7e-07	-3.7e-07	-3.7e-07

Rosenbaum bounds for teffval (N = 316 matched pairs)

Gamma	sig+	sig-	t-hat+	t-hat-	CI+	CI-
1	8.1e-07	8.1e-07	-3.5e-07	-3.5e-07	-3.5e-07	-3.5e-07
1.1	2.4e-06	2.5e-07	-3.5e-07	-3.5e-07	-3.5e-07	-3.5e-07
1.2	6.0e-06	7.5e-08	-3.5e-07	-3.5e-07	-3.5e-07	-3.5e-07
1.3	.000013	2.3e-08	-3.5e-07	-3.5e-07	-3.5e-07	-3.5e-07
1.4	.000025	7.0e-09	-3.5e-07	-3.5e-07	-3.5e-07	-3.5e-07
1.5	.000045	2.1e-09	-3.5e-07	-3.5e-07	-3.5e-07	-3.5e-07

Rosenbaum bounds for valother (N = 316 matched pairs)

Gamma	sig+	sig-	t-hat+	t-hat-	CI+	CI-
1	.00135	.00135	-4.3e-07	-4.3e-07	-4.3e-07	-4.3e-07
1.1	.002116	.000827	-4.3e-07	-4.3e-07	-4.3e-07	-4.3e-07
1.2	.003086	.000508	-4.3e-07	-4.3e-07	-4.3e-07	-4.3e-07
1.3	.004256	.000313	-4.3e-07	-4.3e-07	-4.3e-07	-4.3e-07
1.4	.005616	.000193	-4.3e-07	-4.3e-07	-4.3e-07	-4.3e-07
1.5	.007155	.000119	-4.3e-07	-4.3e-07	-4.3e-07	-4.3e-07

Rosenbaum bounds for homecons1 (N = 316 matched pairs)

Gamma	sig+	sig-	t-hat+	t-hat-	CI+	CI-
1	0	0	2.5	2.5	2.5	2.94
1.1	0	0	2.5	2.5	2.35	3
1.2	0	0	2.5	2.6	2	3
1.3	0	0	2.5	3	2	3
1.4	0	0	2.425	3	2	3
1.5	0	0	2.25	3	2	3

Source: SRMS Household Survey 2018-19

Appendix 2. Seed Supply Survey, 2018-2019

In the first season of operation (2017-18) the SRMS project conducted a Seed Supply Survey to monitor the distribution, performance and repayment of C1 seed by the revolving seed fund. The sample for this survey was restricted to farmers that received C1 seed from the cooperative. The results were published as a separate report (Orr et al., 2018). We assumed that farmers who received certified (C1) teff seed in Year 1 (2017-18) would recycle this seed and plant C2 teff seed in Year 2 (2018-19). To evaluate the performance of recycled C2 improved seed, we asked farmers who replanted C1 seed questions about crop performance. We hypothesized that C2 seed of improved varieties will out-yield local teff varieties. To test this hypothesis, we asked farmers who planted both C2 improved seed and local teff varieties to compare the crop management and yields of both improved and local varieties. This Appendix presents the results from the survey module.

The RBM is only sustainable if farmers are willing to repay harvested grain in exchange for C1 seed. Table 20 shows the repayment rates among the treatment farmers sampled in the household survey in 2018-19. Among the 166 farmers in this sample, 131 had received C1 seed in the previous crop year (2017-18). Of these, only 44 (34%) received seed in 2018-19. Thus, only one-third of the participants received certified seed two years in a row, which suggests that the cooperatives tried to stick to the plan of the RBM to reach new households each year.

Of these 131 farmers, 77 % had repaid grain to the cooperative, with 66% claiming that they had repaid the agreed amount. The amount repaid averaged 4.6 kg, which was 3.4 kg below the 8 kg of grain that they had agreed to repay. In the 2018-19 crop year, 73% of those who had received certified seed reported that they had repaid grain to the cooperative, with 77 % claiming that they had repaid the agreed amount. The amount repaid averaged 2 kg of grain, which was 3 kg below the 6 kg of grain that they had agreed to repay.

Table 20: Repayment rates, 2018-19, by kebele

	Kebele				Sig.-level (*P* > 0.000)*
	Gobeya (n=57)	Hitecha (n=52)	Bassomille/ Jare (n=57)	All (n=166)	
Received seed in 2017-18	40	48	43	131	.013
Received seed in 2018-19	23	24	22	69	.707
Received seed in both years	12	20	12	44	.062
Quantity received in 2017-18 (kg)	2.74	3.58	3.09	3.12	.052
Quantity received in 2018-19 (kg)	1.83	1.83	1.56	1.61	.672
If you received seed in 2017-18, did you repay?	26 (85.0)	42 (87.5)	33 (76.7)	101 (77.1)	.001
If you received seed in 2017-18 and repaid, how much did you repay?	3.47	6.23	6.18	4.58	.000
If you received seed in 2017-18 and repaid, did you repay the agreed amount?	22 (73.9)	37 (77.1)	28 (65.7)	87 (66.4)	.003
If you received seed in 2018-19, did you repay?	17 (73.9)	14 (58.3)	19 (86.4)	50 (72.5)	.765
If you received seed in 2018-19 and	1.79	1.81	2.42	2.01	.519

repaid, how much did you repay?					
If you received seed in 2018-19 and repaid, did you repay the agreed amount?	11 (47.8)	11 (45.8)	12 (34.5)	34 (77.3)	.963

Source: SRMS Household survey, 2019.

Note: Figures in parentheses are percentages

* ANOVA for continuous variables, Chi-square test for categorical variables.

The sustainability of the RBM hinges on the willingness of participants to return grain harvested from C1 seed to the cooperative, which is then sold to buy fresh C1 seed for distribution the following year. Among the sample households, the repayment rate in Year 1 averaged 77 % (Table 20). Visits to the three cooperatives revealed that of the 300 farmers who received certified seed in Year 1, 195 (65%) repaid grain to the cooperative (Weber, 2018). Repayment rates between the three cooperatives varied from 37 % (Gobeya) to 82 % (Hitecha), which suggests that better management can raise repayment rates. However, repayment rates were reduced by a general perception that returning 2 kg of grain for each 1 kg of certified seed was equivalent to interest and contrary to Islam. Two-thirds of participants believed that amount of grain repaid was too high (Table 23). However, the RBM requires farmers to repay a higher amount of grain because the cost of certified seed is higher than the cost of grain. This highlights the importance of the cultural context in the design of an RBM and the need for greater farmer participation in management decision-making.

Table 21 shows crop production and management for those who planted C2 seed, i.e. those who replanted certified seed received in 2017-18. Of the 131 participants who received C1 seed in 2017-18 (Table 18), 29 (22%) reported replanting this grain as seed in the Belg season in 2018-19 while 81 (62%) reported replanting this grain as seed in the Meher season in 2018-19. In total, 87 farmers (67%) who received C1 seed in 2017-18 recycled this seed in 2018-19. Thus, two-thirds of those who received seed through the RBM in Year 1 recycled it in Year 2.

The C2 grain performed well as seed. Of the 87 farmers who used it, 76 (87%) reported "good" germination and 51 (59%) reported a "good" yield (Table 21). Only 8 farmers (9%) reported a "poor" yield. The main reason given for poor yield was drought or low rainfall. The average area planted to C2 seed (1.94 temads) was lower than the area planted to C1 seed in the previous year (2.0 temads), with the result that production was lower, as were average yields. However, the majority of growers (68 or 78%) reported that yields of C2 seed were higher than yields of local varieties.

Higher yields from improved teff varieties may reflect better crop management rather than genetic gains. We asked farmers who grew both local and improved teff to compare their crop management between varieties. The results showed no significant differences in crop management practices, including fertiliser application or number of weedings (Table 21).

Table 21: Crop management and production for C2 seed, by kebele

	Kebele				Sig.-level (*P* > 0.000)*
	Gobeya (n=28)	Hitecha (n=31)	Bassomille /Jare (n=28)	All (n=87)	
Used for planting in own field					
In Belg season	18	4	7	29	.000
In Meher season	26	29	26	81	.993
Broadcast	28	28	26	82	.260
Line-sowing	5	3	9	17	.091

Germination of C2 seed: Good Average Poor	 21 7 0	 29 2 0	 26 1 1	 76 10 1	 .050
Yield of C2 seed: Good Average Poor	 12 14 2	 20 6 5	 19 8 1	 51 28 8	 .062
Reasons for poor yield:					
Drought/low rainfall	1	5	1	7	.178
Insect pests	0	0	0	0	
Plant diseases	1	0	0	1	
Weeds	0	0	0	0	
Other	0	0	0	0	
C1 seed 2017: Area planted (temads) Production (quintals) Yield (quintals/temad)	 1.61 2.57 1.56	 2.35 3.65 1.60	 2.00 8.04 3.27		 .094 .377 .992
C2 seed 2018: Area planted (temads) Production (quintals) Yield (quintals/temad)	 2.00 2.32 1.19	 2.03 3.16 1.34	 1.79 2.57 1.28		 .780 .398 .822
Yield of C2 seed higher than local teff? (Yes)	24	22	22	68	.602
Grow local teff last year (2018)? (Yes)	10	7	10	27	.448
Crop management of C1 seed compared with local teff:					
Number of ploughings Same Less More	 6 1 3	 4 1 1	 7 1 1	 17 3 5	 .818
Sowing Same Broadcast for local, line for C1 Broadcast for C1, line for local	 8 1 1	 5 0 0	 9 0 0	 22 1 1	 .418
Pesticide sprays Same Less More	 5 1 0	 9 0 0	 9 0 0	 23 1 0	 .388
Basal fertilizer Same More Less	 7 3	 5 1	 7 0	 23 0 0	 .197

Urea fertilizer					
Same	7	6	8	21	.307
More	2	0	0	2	
Less	1	0	0	1	
Manure					
Same	9	6	9	24	.577
Less	1	0	0	1	
More	0	0	0	0	
Number of weedings					
Same	7	5	9	21	.253
Less	2	0	0	2	
More	1	0	0	1	

Source: SRMS Household survey, 2019.

* ANOVA for continuous variables, Chi-square test for categorical variables.

The RBM is expected to increase indirect access to improved seed through farmer-to-farmer diffusion. Table 22 shows that, of the 131 farmers who received certified seed in 2017-18, only 21 (16%) reported that they shared grain from this seed with other family members, while only 9 (7%) shared grain from this seed with other farmers or neighbours. By contrast, the proportion of farmers who claimed they would share C1 seed with family members in 2017-18 was 61%, with 56% claiming they would share with non-family members (Orr et al., 2018).

Table 22: Use of grain from C1 seed in 2018-19, by kebele

	Kebele				Sig.-level (*P*> 0.000)*
	Gobeya (n=40)	Hitecha (n=48)	Bassomille/ Jare (n=43)	All (n=131)	
For planting own field	28	31	28	70	.455
Gave/sold to family members	7	12	4	21	.192
Gave/sold to other farmers	2	4	3	9	.584

Source: SRMS Household survey, 2019.

* Chi-square test for categorical variables.

Finally, we asked participating farmers directly for their views on the assumptions behind the design of the RBM. The questions used a five-point Likert scale. The results presented in Table 23 combine the answers for agree/totally agree and for disagree/totally disagree. The results show that a large majority of farmers viewed improved teff varieties as performing better than local varieties, with higher yields, earlier-maturity and higher resistance to pests and diseases. A large majority (74%) also agreed that the RBM had improved access to certified seed as well as to seed of higher quality than is available in local markets (77%). However, 59% of participants also believed that the amount of grain they are expected to repay is too high.

Table 23: Treatment farmers' views on Replicable Business Model (n=87)

Statement	Totally disagree + disagree	Agree + totally agree	Neutral
Qoncho/Zobil reduces the risk of crop loss from drought because it matures earlier than local teff varieties	6 (6.9)	77 (88.5)	4 (4.6)
Qoncho/Zobil is more resistant to pests and diseases than local teff varieties	18 (20.7)	62 (71.3)	7 (8.1)
In a normal year, Qoncho/Zobil gives a higher yield than local teff varieties	8 (9.2)	77 (88.5)	2 (2.3)
Getting certified seed from the cooperative has increased the availability of Qoncho/Zobil seed	17 (19.5)	64 (73.6)	6 (6.9)
Getting certified Qoncho/Zobil seed from the cooperative has reduced the risk of buying poor quality seed	16 (18.3)	67 (77.0)	4 (4.6)
The quantity of Qoncho/Zobil teff grain that I must repay to the cooperative is too high	30 (34.5)	51 (58.6)	6 (6.9)

Source: SRMS Household survey, 2019.

Note: figures in parentheses are percentages.

Funded by: UKaid from the British people

Implemented by: wyg and University of Greenwich NRI | Natural Resources Institute