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AGRA

Scaling-up Post Harvest Management Innovations for grain legumes in Africa – Study in Mozambique

FINAL REPORT

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List of acronyms

AGRA	Alliance for a Green Revolution for Africa
BCR	Benefit-Cost Ratio
IDRC	International Development Research Centre
NPV	Net Present Value
PHT	Post harvest technology
TNS	Technoserve

Executive Summary

Low agricultural productivity in Mozambique is a major constraint to the growth of the Mozambican agriculture sector. While productivity levels are low even by sub-Saharan countries standards, additional post-harvest losses that farmers experience during threshing and limited/poor storage options serve to make the predicament worse.

This has led the Alliance for a Green Revolution in Africa (AGRA) and the International Development Research Centre to start a three-year (2016-2018) applied research project "Scaling up Postharvest management innovations for Grain Legumes in Africa" to bring effective, field-tested post-harvest innovations for increasing productivity and reducing post-harvest loss of soya bean to smallholder farmers in Mozambique.

The objective of this study was twofold. First, the study sought to identify the most effective way of accelerating the adoption of soybean post-harvest management technologies (PHT) in upper Zambézia, northern Mozambique, more specifically in Gurué district. The selected PHT was the threshing machine. The second objective was to estimate the economic and social impact of increased use of PHTs in terms of production, income, nutrition, women's situation and youth employment.

In order to address these objectives, a two period panel data of about 320 soy farming households was developed between 2016 (baseline study) and 2018 (endline study). Between the two survey studies, a monitoring study was conducted in 2017, applying qualitative research methods such as key informant interviews, focus group discussions, field observations, and weighing of soybean to assess soybean losses during threshing.

In addition to these methods, a cost-benefit analysis of the thresher machine was performed, along with the calculation of a food diversity index and a composite index on women empowerment in agriculture.

Surveyed households were grouped using two typologies, one indicating whether or not the farmer used any thresher, and another classifying the farming households over time (persistent adopters if they used the thresher in both periods; disadopters if they used the thresher in 2016 but not in 2018; new

adopters if they only used the thresher in 2018 but not in 2016; and non-adopters if they have never used the thresher).

On what concerns the first research question, i.e. **what is the most effective way of accelerating the adoption of soybean post-harvest management technologies?**, it is noted that farmers are very positive about the thresher machine and eager to use it. However, the adoption of thresher machines for soybean is associated with both investment profitability and the financial capacity to buy the thresher machine, or to rent it from a local threshing service provider.

The cost-benefit analysis showed that, despite the high acquisition cost of a threshing machine, the investment in the thresher is found highly profitable in a 12-year life cycle with the thresher operating at almost full capacity (1500 kg / day) during 6 months per year. The financial capability to make the required investment of buying the thresher machine can limit the opportunity to expand adoption. The cost of thresher machine was reported too high in all three annual studies[1].

On what concerns the second research question, i.e. **What is the economic and social impact of increased use of postharvest management technologies (PHT)?,** descriptive results of the study indicate that soy farming households who use the thresher machine attain higher productivity levels as they use improved inputs more frequently than non-users. As a result, they also market a higher proportion of their total production, become wealthier and have a more diversified food diet; comparatively to soy farming households who do not use the thresher.

One of the potential impacts of the introduction of the thresher machine, is the creation of employment opportunities for local labour, mostly related to the operation and maintenance of the thresher machine. This extends to local agro-dealers and suppliers of mechanic services, who are sought for spare parts of the machine as well as repair services.

Another impact of the thresher machine is the expansion of soy farming plots and the provision of threshing services to other services. Soy is perceived as one of the most profitable crops and therefore there is a motivation of increasing soy production as soon as the household can efficiently manage the harvest and post-harvest (sales) process.

One additional impact of the thresher machine is the freed labour time for both men and women: mechanized threshing works 6.5 times faster than manual threshing. Female household members are spared from the responsibility of cooking and catering for the manual threshing labour force. The freed time is applied in other activities both leisure and income-generating.

Finally, soy milk and other derivatives of soy appear to be well accepted locally. In the long run, this may imply that an increased use of soy could diversify the local diet and boost the nutrition level of local population.

[1] In 2018 the acquisition cost of one TECAP threshing machine (full price without the AGRA grant) was $7,390 (endline study report, 2018).

In terms of recommendations to accelerate the adoption of PHT, it is argued that more affordable thresher machines should be available in the market in order to facilitate investment in thresher machine business. One option would be to facilitate imports and the private sector entry into this market, to make thresher machines available at a relatively lower cost. Additionally, the development of secondary markets (markets of used thresher machines) and machinery-hire markets may also contribute to strengthen markets and expand supply of more affordable machines.

On the demand side, service provision on fee-for-use models (used in site) should be expanded, as well as increasing information on availability of thresher services possibly through information technologies.

1 Introduction

The Alliance for a Green Revolution in Africa (AGRA) is a non-profit organization working with African governments, donors, civil society, the private sector and farmers to improve the productivity and incomes of poor smallholder farmers in Africa. AGRA has been investing in Mozambique since 2007 through projects for improving seed systems by funding the establishment of seed companies, distribution channels via agro-dealers, supporting to the fertilizer industry and the development of agro-dealers.

Low agricultural productivity in Mozambique is a major constraint to the growth of the Mozambican agriculture sector. While productivity levels are low even by sub-Saharan countries standards, additional post-harvest losses that farmers experience during threshing and limited/poor storage options serve to make the predicament worse.

This has led AGRA and the International Development Research Centre (IDRC) to start a three-year (2016-2018) applied research project "Scaling up Postharvest management innovations for Grain Legumes in Africa" to bring effective, field-tested post-harvest innovations for increasing productivity and reducing post-harvest loss of soya bean to smallholder farmers in Mozambique. The following objectives describe the planned actions to meet this goal:

- Objective 1: Scale up innovative post-harvest technologies (PHT), specifically threshers and PICS bags, to achieve meaningful impacts in the lives of farmers, women and youth;
- Objective 2: Assess the effectiveness of selected delivery models for the chosen innovations; and
- Objective 3: Synthesize and disseminate evidence and lessons from the scaling efforts to catalyse the field and inform policy change and investment.

In Mozambique, the key innovation brought by the project was the thresher machine (Objective 1).

The project was implemented by Technoserve (TNS) in Gurué District (Zambézia Province) with a specific focus on soya. Following TNS' model of '*small commercial farmer*' (SCF), the project identified emerging farmers and/ or trusted existing local small agribusinesses who are trained, supported and equipped by the programme to deliver the necessary inputs, extension, mechanisation and other services to the smallholder farmers on a commercial basis.

As part of the three-year project, 20 female SCF in Gurué were equipped with new threshing machines on a co-financed basis. Additionally, 15 existing mechanised SCFs in Gurué were supported to deliver mechanised threshing services, and the production and marketing of nutritious soy-based food products was promoted.

COWI Mozambique was contracted by AGRA to carry out three annual studies for the research project from 2016 to 2018, namely the baseline (2016), monitoring (2017) and endline (2018) studies.

The present document is the Final Report, which follows the base, monitoring and endline studies already submitted to AGRA. The Final Report aims to answer the two main research questions with evidence from the three annual studies.

For that, the report is structured into six sections. After the Executive Summary and this introductory chapter, the rest of the report unfolds according to the following structure:

- Chapter two, Research Problem: presents the two main research questions, objectives and indicators that guided the studies undertaken by COWI as part of the research project;
- Chapter three, Study methodology: describes the methodology undertaken for the collection and analysis of the annual studies data;
- Chapter four, Study findings on the two research questions: provides the key findings of the annual studies to answer the research questions; and
- Chapter five, Limitations and challenges: provides the main challenges faced by the annual studies, and the solutions applied to overcome them;
- Chapter six, Conclusions and recommendations: presents the main conclusions of the study, as well as relevant recommendations for decision making with regards to post-harvest management.

2 The Research problem

The study in Mozambique aimed to answer two key learning questions[2]:

1 What is the most effective way of accelerating the adoption of soybean and cowpea post-harvest management technologies?

2 What is the economic and social impact of increased use of postharvest management technologies (PHT)?

As such, the objective of this study was twofold. On the one hand, the study sought to identify the most effective way of accelerating the adoption of soybean post-harvest management technologies (thresher machine) in Gurué. On the other hand, the study sought to estimate the economic and social impact of increased use of PHTs in terms of production, income, nutrition, women's situation and youth employment.

The thresher machines provided in the frame of the AGRA grant were acquired as a matching grant with support from Technoserve (TNS). The grant was 50% of the total value, farmers had to co-participate with 10% of the total amount, and the remaining 40% pertained to bank loans. Some farmers received both a thresher and a tractor.

The research project was also guided by pre-defined project indicators, namely:

Average number of months of adequate household food provision;

Household dietary diversity index;

1 Income generated from target crop by target farmers;

2 Percentage of crop losses during storage;

3 Volume of target crop sold by supported farmers (in Meticais);

4 Value of target crop sold by supported farmers;

5 Percentage of household using PHT technologies and

6 Number of household beneficiaries using PH technologies.

The research questions and project indicators guided the three annual studies (2016-2018) conducted by COWI, namely the baseline (2016), monitoring (2017) and endline (2018) studies.

In essence, COWI assessed the impact and the outcome of the thresher machine project. This, combined with TNS data at input/output level, as well as specialized

[2] Terms of Reference of the project and Inception Meeting held in Nairobi, Kenya in July 2016.

studies on post-harvest losses conducted by AGRA/TNS, will inform the impact evaluation of the Post-Harvest Management Innovations project in Mozambique.

3 Study methodology

This section presents the methodology followed by the three annual studies in Mozambique.

Data collection methods

In order to address the study objectives, a two period panel data of about 320 soy farming households was developed between 2016 and 2018. The sample was distributed between Gurué district (240 households), considered the treatment group served by the TNS intervention, and neighbouring Malema district in Nampula province (80 households) considered the control group[3].

Between the two surveys (2016 and 2018), a monitoring study was conducted in 2017. This study applied qualitative methods such as key informant interviews with mechanized threshing service providers, the District Government, TNS and other implementing partners; focus group discussions with soy farmers; field observations and weighing of soybean to assess soybean losses during threshing.

The surveyed households were grouped into two typologies, being the first a binary indicator of whether the farmer used any thresher; and the second a more dynamic definition that looks at farming households over time. As a result, surveyed farmers were classified into four categories:

1 *persistent adopters* if they used the thresher in both periods;

2 *disadopters* if they used the thresher in 2016 but not in 2018;

3 *new adopters* if they only used the thresher in 2018 but not in 2016; and

4 *non-adopters* if they have never used the thresher.

Data analysis methods

For the qualitative a qualitative analysis matrix was prepared, while the quantitative data was entered into a database. The data obtained from the quantitative and qualitative methods were analysed by the research team, with the support of AGRA in two preliminary data discussion rounds.

The impact of the intervention (adoption of mechanized threshing) was assessed by comparing between the four categories of surveyed farmers, age and gender of household head, and other characteristics.

Regression based models such as regression and matching, sub-classification and regression, and the doubly-robust model were also considered to estimate the impact of the intervention based on matched observations of beneficiary and the counterfactual group.

[3] Malema also practices soya production and has similar agro ecological conditions to those of Gurué.

All analyses were carried out in Stata 14.1 software.

Financial analysis

A financial analysis of mechanical threshers in soybeans and other grains was conducted for both the monitoring (2017) and endline (2018) studies. The financial analysis was based on the following theoretical framework:

Benefit-Cost Ratio (BCR): BCR is calculated by dividing the sum of present benefit worth of stream (12 years) is divided by the sum of present cost. BCR > 1, signals a profitable investment at a given discount rate. Assumed discount rate is 15%, corresponding to Banco de Moçambique (Central bank) rate of lending to commercial banks in November 2018. The discount rate represents the opportunity cost of capital.

Net Present Value (NPV): NPV is compounded by deducting the present worth of cost stream from present worth of benefits. NPV > 0, signals investments financially profitable at a given discount rate.

Mathematic terms:

$$BCR = \frac{\sum_{t=1}^{n} \frac{B_t}{(1+i)^t}}{\sum_{t=1}^{n} \frac{C_t}{(1+i)^t}}$$

$$NPV = \sum_{t=1}^{n} \frac{B_t - C_t}{(1+i)^t}$$

Where:

n = 12 years

t= 1,2, 3, ……n(120

B_t = Benefit stream in each year

C_t = Cost stream in each year

i = Discount rate = 15%

4 Study findings on the two key research questions

This section reflects upon the two research questions, using the key findings of the three annual studies (2016-2018).

4.1 What is the most effective way of accelerating the adoption of soybean post-harvest management technologies?

All three annual studies found that, in general, farmers appear very positive about the thresher machine and are eager to use it. However, as argued in the endline study report (2018) based on the results of a cost-benefit analysis, the adoption of thresher machines for soybean is associated with both investment profitability and the financial capacity to buy the thresher machine, or rent it from a local threshing service provider. In those years when the market price of soy is low, farmers cannot afford renting a PHT but instead they thresh manually.

The availability of relatively large markets demanding for mechanical thresher services, such as the one in Gurué, may contribute to accelerate the adoption of soybean and cowpea post-harvest management technologies. Thus it is important to expand these services to farming areas/ markets with high population density and relatively high agriculture production. The investment in the thresher is found highly profitable in a 12-year life cycle with the thresher operating at almost full capacity (1500 kg / day) during 6 months per year i.e. the full harvesting season (endline study report, 2018).

On the other hand, the financial capability to make the required investment of buying the thresher machine can limit the opportunity to expand adoption. The cost of thresher machine was reported too high in all three annual studies[4]. To facilitate more investment in thresher machine business, more affordable thresher machines should be available in the market. One option would be to facilitate imports and the private sector entry into this market, to make thresher machines available at a relatively lower cost.

In addition, development of secondary markets (markets of used thresher machines) and machinery-hire markets may also contribute to strengthen markets and expand supply of more affordable machines.

On the demand side, service provision on fee-for-use models (in use on the project site) should be expanded, as well as, increasing information on availability of thresher services. ITC should be explored to better match the supply of thresher services with demand from farmers who need the services.

[4] In 2018 the acquisition cost of one TECAP threshing machine (full price without the AGRA grant) was $7,390 (endline study report, 2018).

4.2 What is the economic and social impact of increased use of postharvest management technologies (PHT)?

Descriptive results from the two surveys[5] undertaken indicate that soy farming households who use the thresher machine usually belong to households whose head is older, and they usually have a non-farm income source. Participation in non-farm income generating activities is usually positively and significantly correlated with education, which implies that better educated households have better access to PHTs. PHT users have better housing, although it is difficult to establish causality.

In terms of production, PHT users attain higher productivity levels as they use improved inputs more frequently than non-users. As a result, they also market a higher proportion of their total production, and have a more diversified food diet, both women and men.

Additionally, the study points that continuing or persistent adopters became wealthier. Persistent adopters were able to expand their cropped area and animal stocks, used improved inputs more frequently and therefore obtained higher productivity levels. They also increased their incomes and nutritional status, proxied by food diversification index. Non-adopters and disadopters show no improvement in asset ownership.

The endline study (2018) found that it takes between 2-5 people to operate a thresher machine, typically one *operador* who is the main responsible for the machine itself, and 1-4 assistants who help feeding the machine with soy, checking the bagging of clean grains and controlling that the remaining parts of the plant are discarded.

Thus one of the potential impacts of the introduction of the thresher machine, is the creation of employment opportunities for local labour, mostly related to the operation and maintenance of the thresher machine. This extends to local agro-dealers and suppliers of mechanic services, who are sought for spare parts of the machine as well as repair services.

Another impact of the thresher machine identified in the three annual studies is the expansion of soy farming plots and the provision of threshing services to other services. According to the endline study report (2018), farmers that used PHTs were able to expand their average cropped area from about 12 hectares in 2016 to about 21 hectares in 2018; compared to about 5 hectares among non-adopters in 2018. The increase in landholding size was boosted by the production of soybean seeds among PHT users. A recently constructed seed factory operates in Magige, about 20 km to Gurué city. Many farmers debushed new fields to cultivate soybeans, both grains and seeds.

Soy is perceived as one of the most profitable crops and therefore there is a motivation of increasing soy production as soon as the household can efficiently manage the harvest and post-harvest (sales) process.

[5] Baseline study (2016) and Endline study (2019).

One additional important impact of the thresher machine found in the three annual studies, is that it frees labour time. Both men and women are involved in manual threshing (baseline study report, 2017), and the use of PHT has a direct impact on their time saved. According to the endline study (2018[6]), mechanized threshing works 6.5 times faster than manual threshing. Additionally, for female household members in particular, the use of the thresher machine frees them from the responsibility of cooking and catering for the labour force hired to perform manual threshing. The freed time of both men and female is applied in other activities both leisure and income-generating.

Finally, soy milk and other derivatives of soy appear to be well accepted locally. In the long run, it is possible to assume that an increased use of soy could diversify the local diet and boost the nutrition level of local population.

[6] Based on TNS data from the Progress and Results of" Research Project on Post-Harvest Losses in the Soybean Value Chain in Mozambique", 24/10/2018.

5 Limitations and challenges faced

Several challenges were faced in each of the three annual studies.

The Baseline study was initially affected by the political instability that ran the country in 2016, resulting in local farmers' mistrust towards the survey team. Another challenge faced then was the mapping of soy farming areas in Malema, in the absence of a mapped registry by the district authorities. Last but not least, the availability of COPAZA member threshing service providers was in some cases compromised, and those were interviewed by phone. In order to mitigate these challenges, several identification measures were set up.

The main constraint faced in the Monitoring study was the soy weighting exercise (conducted with harvested soybean in piles, rather than in bags). Additionally, it was rather difficult to mobilize female thresher owners for the study, as they had just recently adhered to the project and received the threshing machine. Additional communication efforts were made with the husbands.

As for the observation of threshing in Malema, all observations made were for manual threshing. It was not possible to observe mechanized threshing as there are considerably fewer PHT users in Malema than in Gurué, due to the fact that most the threshing machines used in Malema come from Gurué. During the field visit mechanized threshing was still occurring in Gurué and was expected to move to Malema within a few weeks' time, after data collection had ended. As such, mechanized threshing was only observed in Gurué.

The main constraint faced in the Endline study was the high attrition rate due to household mobility, linked to high commodity price volatility, especially for soybeans, pigeon peas, and maize. In order to overcome this, replacements were made with soy farmers from the same geographic unit, to reach the study sample.

6 Conclusions and recommendations

In order to accelerate the adoption of PHT, particularly mechanized threshing, the overall study results suggest that the AGRA grant via TNS is very helpful for the farmer, who would not be able to bear the full cost of the thresher (or the combo of thresher and tractor). The mechanisms to accelerate the adoption of PHTs should include a grant to farmers.

There is also a need to find ways to operate the machines for longer periods per year, to increase its current profitability level. The threshing of other grains (such as maize) and beans (such as cowpea) apart from soy, could play an important role in this.

Additionally, it is recommended that more affordable thresher machines should be available in the market in order to facilitate investment in thresher machine business. One option would be to facilitate imports and the private sector entry into this market, to make thresher machines available at a relatively lower cost.

Additionally, the development of secondary markets (markets of used thresher machines) and machinery-hire markets may also contribute to strengthen markets and expand supply of more affordable machines.

On the demand side, service provision on fee-for-use models (used in site) should be expanded, as well as increasing information on availability of thresher services possibly through information technologies.