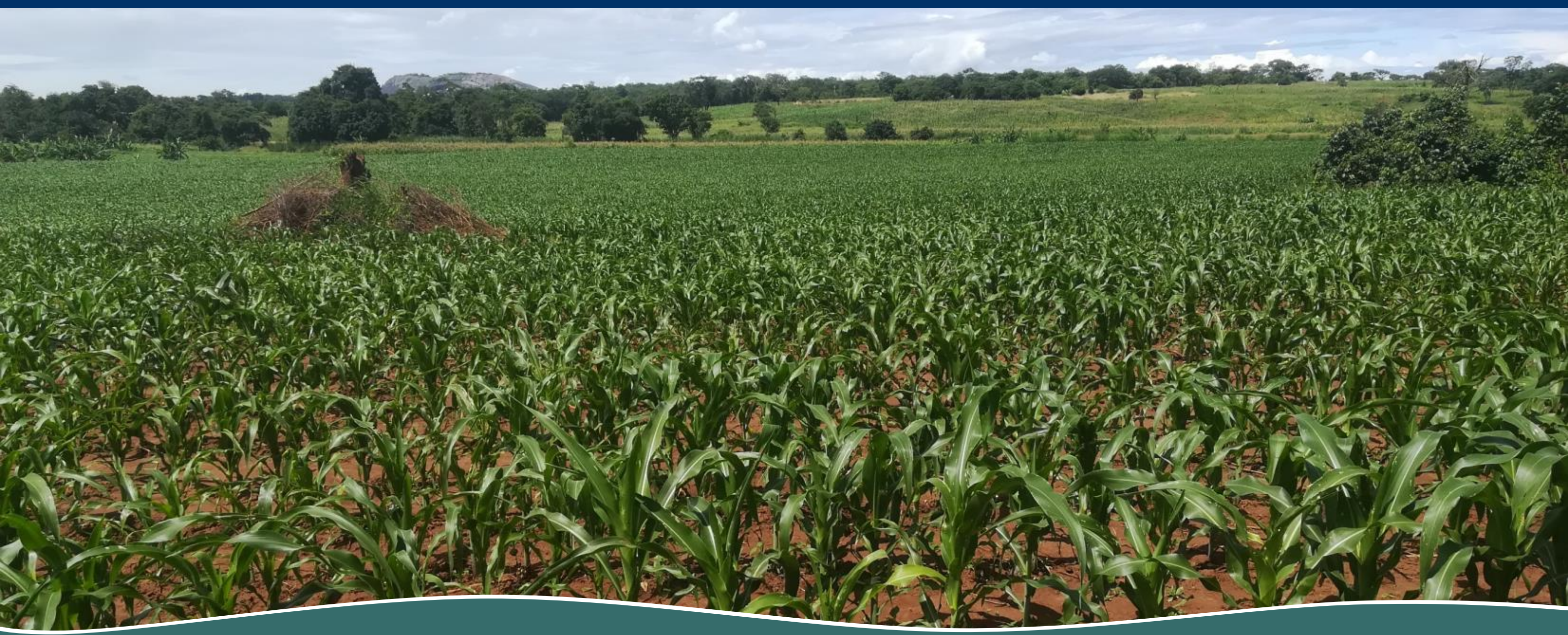
Interventions Impact Analysis: Rainfed Season 2020-2021

APSAN-Vale project



CLIENT Agência de Desenvolvimento do Vale Zambeze (ADVZ)

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1 Introduction

1.1 APSAN-Vale project

The APSAN-Vale project commenced end of 2018 and is a 3.5 year project with the objective to: ‘Pilot innovations to increase the Water Productivity and Food security for Climate Resilient smallholder agriculture in the Zambezi valley of Mozambique’. Water productivity is used as an indicator to quantify the impact of the innovations on smallholder agriculture. These innovations can be technical packages (interventions and trainings), and adoption of lessons-learned through farmer-to-farmer communication. Information on water productivity needs to incorporate both temporal and spatial aspects. The temporal changes in water productivity indicates if an intervention resulted in an increase of water productivity. The spatial patterns in water productivity indicates if the knowledge is being adopted in the region and increased the overall water productivity of the locality, and district. Project activities take place in three districts namely: Báruè, Moatize, and Nhamatanda. Within each district, various localities are selected for piloting innovations. The location of the districts and current project activities are shown in Figure 1.

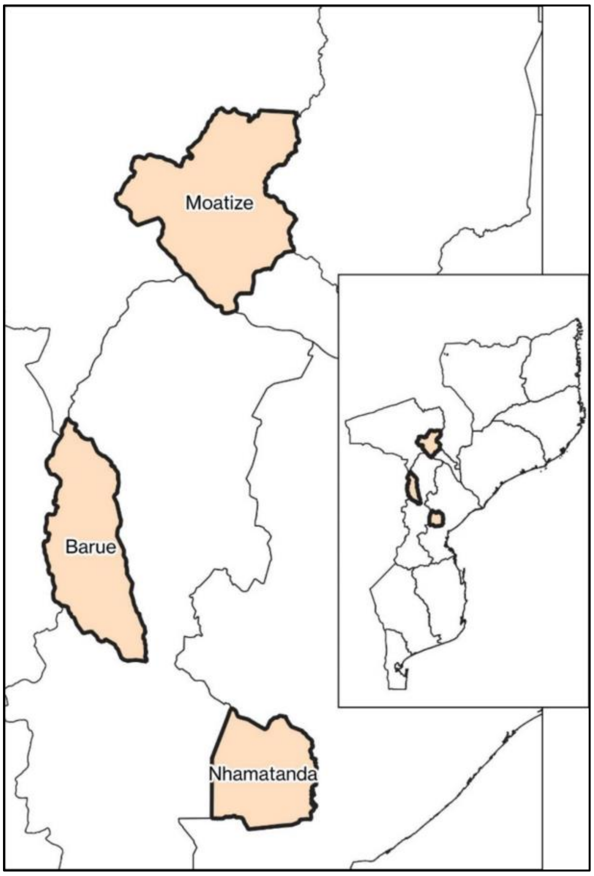

Figure 1 Location districts of APSAN-Vale project activities

1.2 Aim

This report evaluates the preliminary impact of the different field interventions that took place as part of the APSAN-Vale project in Mozambique. This was done by comparing the trained and adopted interventions by farmers against the yield and water productivity data. Goal of this analysis is to gain insight in successfulness of different interventions on the crop- and water productivity of the farmers. The results can be used to select the most successful interventions when scaling up to new areas.

1.3 Reading guide

Chapter 2 elaborates on the different field intervention that took place as part of the APSAN-Vale project during the rainfed season and provides a description of the methodology for the data collection and the interventions impact analysis. Chapter 3 presents the results on the adoption of practices, knowledge sharing, crop yield comparisons with the baseline and control group farmers, farm size changes and the impact of agronomic practices and water management practices. Also, the impact according to the farmers' perspective is described. Chapter 4 provides a discussion on the results, while some concluding remarks are given in chapter 5.

2 Methodology

2.1 Overall approach

The approach of this analysis can be divided into three steps, as shown in Table 1.

Table 1. Overall approach of analyzing the impact of interventions.

Step	Description
1	Categorization of practices
2	Collection of information on adoption of practices and knowledge sharing
3	Crop yield data collection, using three different methods: 1. Farmer recall method 2. Crop-cut method 3. Crop growth modelling
4	Scoring system: system for evaluating the impact of the interventions

Firstly, the various practices are placed into categories and sub-groups. The second step is to collect data on yield using three different methods: 1) Farmer recall method, 2) Crop-cut method, and 3) Crop growth modelling. Lastly, a scoring system (see section 2.5) is used to enable easy comparison of crop yield and adoption of practices results. This is combined with the data on adoption of practices to determine the impact of the various practices.

2.2 Step 1: Categorization of practices

This interventions impact analysis combines various types of data based on implemented practices. The data from these practices needs to be aligned with the crop growth model, data from the adopted practices survey, from the beneficiaries list (trainings), observations from the field and logframe indicators. A categorization of practices is introduced to facilitate the analysis of these different datasets.

The data was collected through the monitoring survey of July 2021. In total 114 beneficiaries being PPE (smallholder farmers) and PPC (small commercial farmers) and 35 other community members have been interviewed using semi-structured interviews following Rapid Rural Appraisal (RRA) guidelines to map out the uptake of training topics. Participants are first asked if a certain practice has been implemented in their field and if so, who has introduced him/her to this new practice. After these questions, the training topics provided by APSAN-Vale, are listed and producers are asked to recall attendance.
The various practices definitions come from the following data:

- The project monitors on 26 of practices related to water management, good agricultural practices and market.
- The logframe indicators mention specific interventions in specific categories (water management practices, crop rotation, mulching, integrated pest management, improved access to input/output markets).

Early 2020, FutureWater developed an intervention framework as part of a project for the FAO, intended to serve as a clear and practical guideline on how to implement “real” water savings in agriculture by selecting suitable interventions for enhancing crop water productivity. The final report states that, to deal with the challenge of developing a structured framework where broader options can be derived into smaller ones, “no universal categorization in options [practices] exist” (FAO and FutureWater, 2020[1]). As there is no universal categorization, we focus on the logframe indicators as the basis for the current intervention analysis.

[1] Van Opstal, J., Droogers, P., Kaune, A., Steduto, P. and Perry, C. 2020. Guidance on realizing real water savings with crop water productivity interventions. Wageningen, FAO and FutureWater.

As a result, all the practices were divided in to three main groups: irrigation and water management practices, good agricultural practices, and market oriented activities. The list below presents all practices introduced for rainfed crops (in *italics*) and how they are grouped. An overview of all practices is presented in Annex 1. A part of the practices such as land preparation, staggering, crop residue retention, mulching, plant density and spacing, crop rotation and use of inputs are described in the rainfed impact interventions analysis report of 2019-2020[2].

1. Irrigation and water management practices

- 1.1 Land preparation for water management
  Bunds, terrasses, dikes, drainage, heaping
- 1.3 Overall water management practices
  Water management practices

2. Good agricultural practices

- 2.1 Land preparation methodologies
  Mechanical ploughing, animal tractions, manual ploughing
- 2.2 Use of inputs
  - 2.2.1 Seeds
    Local seeds, improved seeds, seed beds
  - 2.1.2 Pesticides and herbicides
    Use of herbicides, use of pesticides, sustainable handling of pesticides
  - 2.1.3 Fertilizer
    Organic fertilizer, chemical fertilizer, organic and chemical fertilizer
- 2.2 GAP (planning and spacing)
  Crop spacing, Intercropping, Crop rotation, Staggering and planning
- 2.3 Soil cover
  Incorporating plant rests, complete mulch, partial mulch

3. Market oriented activities

Business plan

For this analysis of the rainfed season, some practices specifically for irrigated agriculture were not analyzed. These practices are:

- 1.1.1 Land preparation for irrigated fields
  Sulcos (furrows), Basins, In lines
- 1.2 Irrigation methods
  Motor pump, solar pump, foot pump, furrows, tubes, buckets, sprinklers, drip
- 1.4 Use of soil sensor
  Soil sensor

2.3 Step 2: Collection of information on adoption of practices and knowledge sharing

This data collection round focusses on the implementation of training topics by farmers and has been carried out to capture farm performance (economic and yield), household demographics, access to input/output markets and to measure the implementation of APSAN-Vale training topics.

[2] Van Opstal, J.D., M. de Klerk, K. van Krieken, D. Chale. 2020. Interventions Impact Analysis: Rainfed Season 2019-2020.

Interviews have been conducted in three districts being the districts of Báruè, Nhamatanda and Moatize (Figure 2). Differences in the social context and agroecological diversity between the locations suggests a difference in impact. Therefore, caution should be taken once averaging the results of the three districts.

Figure 2. The interviews were conducted in Báruè, Nhamatanda and Moatize.

During three weeks, 117 project beneficiaries and 35 non-project farmers (control group) were interviewed. Data collection tools were designed and reviewed by the consortium, according to the following criteria;

1. use simple quick-to-understand language for respondents
2. use a mix of qualitative and quantitative data
3. create a comprehensive and simple tool that at the same time provides answers to the logframe indicators.

The analysis focuses on three groups of farmers: PPC farmers, or impact analysis farmers, project beneficiaries in general and the control group. The 27 PPC farmers are the farmers that are monitored closely throughout the production season. Crop growth modeling and water productivity data is available of fields of these farmers because of Future Water's flying sensor data. The 117 project beneficiaries are a representative group of overall APSAN-Vale beneficiaries. They include PPCs and PPEs who are active in the localities where APSAN-Vale operates and who have interacted with the project (i.e. attended trainings, received technical assistance, benefited from market linkages, were present at market days). The 35 control group farmers, are farmers who were surveyed during the monitoring exercise and the results of this group serve as an in-season comparison to validate the results of project evaluation. These farmers have a comparable socio economic and agro-ecological environment to farmers in the project target group, but have no interference with the project.

Overall, the project analyses four groups; the PPC farmers, the specifically selected impact analysis farmers groups, the PPE farmers, and the control group. When speaking about PPC in general, the report refers to the PPCs as noted in the monitoring survey. The select group of PPCs are called the impact analysis farmers.

The outcomes of the interviews have been analyzed using descriptive statistics. Data is predominantly expressed in percentages to express how a (group of) producer(s) relates to the total group respondents. In addition, the adoption data of specific farmers is used for the impact analysis of this report.

All results from the monitoring survey can be found in the APSAN-Vale Rainfed Season's 2021 Monitoring Report.[3]

2.4 Step 3: Crop yield data collection

The APSAN-Vale project uses three measurement methods for yield estimation as defined by FAO (2017)[4] to collect data on production: farmer recall method, crop-cut method and crop growth modelling. The three methods on collecting yield data are shown in Table 2 and elaborated on in detail in the following sections. In chapter 4.1 the different crop yield measurement methodologies are compared to have a better understanding of their advantages and shortcomings.

[3] Gundana C., N. Marula, K. van Krieken, D. Levelt, J. van den Akker. 2021. Monitoring and Evaluation progress and results Rainy season 2020-2021. Production & Implementation of APSAN training topics. APSAN-Vale.

[4] FAO (20170 Methodology for Estimation of Crop Area and Crop Yield under Mixed and Continuous Cropping. Publication Prepared in the framework of the Global Strategy to Improve Agricultural Rural Statistics. Food and Agriculture Organization of the United Nations. http://www.fao.org/3/ca6514en/ca6514en.pdf

Table 2. Input Data Sources.

Methodology	Input data source	Provides data on	Comment
Farmer recall method	Monitoring survey	- Adoption of practices - Crop yield	114 project beneficiaries, 35 control group farmers, surveyed in July 2021
Crop-cut method	In-field production measurement	- Crop yield	27 PPC farmers, specifically impact analysis farmers, collected from September to November 2020
Crop growth modelling	Flying sensor data	- Crop yield - Water productivity	27 PPC farmers, specifically, impact analysis farmers,, surveyed from December 2020 to April 2021

2.4.1 Farmer recall method

Farmer recall is an interview methodology where during the monitoring exercise structured interviews are conducted to collect information on production at the season of PPCs and PPEs. This method can be used as an auxiliary variable in crop yield estimation.
In total 117 project beneficiaries (PPE and PPC) and 35 non-project farmers have been interviewed after harvest to capture farm performance, household demographics and access to input/output markets. From these farmers, a selection was made for the farmers where the flying sensor flights were taken.

For PPC producers, the farmer field book was a helpful tool to capture farm performance. This data was used for the PPCs to support them on answering their productivity through the recollection (or recall)[5] approach. Here, producers have been asked about past production seasons. The farmer recall method is simple, the data are quickly available, and is not expensive to implement. For PPE beneficiaries, and when no field book was available for PPCs, this approach was used. Through this method there may be intentional over- or underreporting and low accuracy with longer recall periods.

The workflow of data collection has been optimized using data collection tool Mwater and data storage and analyses tool Farmcollect. Using Farmcollect all interview outcomes linked to corresponding proof (PDF of full interview + pictures of field book) are stored directly linked to the beneficiaries.

To capture farm performance, data is collected on items including the cropping patterns, labor, the yield of products along with their use and price. The data collection process is designed in structured interviews and copying the data from the farm field book. To analyze the production data a multitude of units has been used to express the volume of yield, an extensive translation table is made to absorb and compare all these differences.

2.4.2 Crop-cut method

The crop-cut method is a field measurement methodology. It is commonly regarded as the most reliable and objective method for estimating crop yield. In-field measurements were taken for the crop-cut method. The crop-cut method is a field measurement where crop yield is determined by random demarcating of a plot of a specified size and shape, harvesting the produce from the plot and determining the (dry) weight.

To facilitate fieldwork and reduce costs and time required, a clustered sampling procedure is usually applied when crop cuts are used for larger-scale surveys. Yield samples from the field or production in

[5] http://www.fao.org/3/ca6514en/ca6514en.pdf

wagons were weighed to have an estimate of the total production. This was divided by the total farm area in hectares to have a number in ton/ha.

2.4.3 Crop growth modelling

In the crop growth modelling methodology, we apply a AquaCrop model simulation that is calibrated to local conditions (soil, climate, crop varieties) and data collected by drones. Data is generated specifically for the 'Intervention impact analysis' farmers.

AquaCrop is a crop simulation model developed the FAO. In this report, the AquaCrop model was calibrated for the local conditions in Báruè, Moatize, and Nhamatanda, for 27 PPC farmers, surveyed from December 2020 to April 2021. Flying sensor imagery throughout the growing season, at regular intervals, was used to provide a good estimate of the canopy cover, from which an estimation of the crop yield and water productivity can be derived. Details of the methodology with AquaCrop is described in the water productivity report, either in the baseline[6] (for the calibration parameters) or subsequent seasonal water productivity reports.

2.5 Step 4: Scoring system

The observed impact of the practices on the crop yield and water productivity is evaluated using a scoring system. The relevance of applying a scoring system is two-fold. Firstly, a scoring system provides a unitless number (0 – 10) to indicate if the given crop yield or water productivity value is in the upper range or the lower range compared to the baseline values, which are by definition 0. A score is more understandable than the results in crop yield itself. Secondly, a scoring system also enables better comparison between different districts, crops and seasons. These aspects are shown in Figure 3.

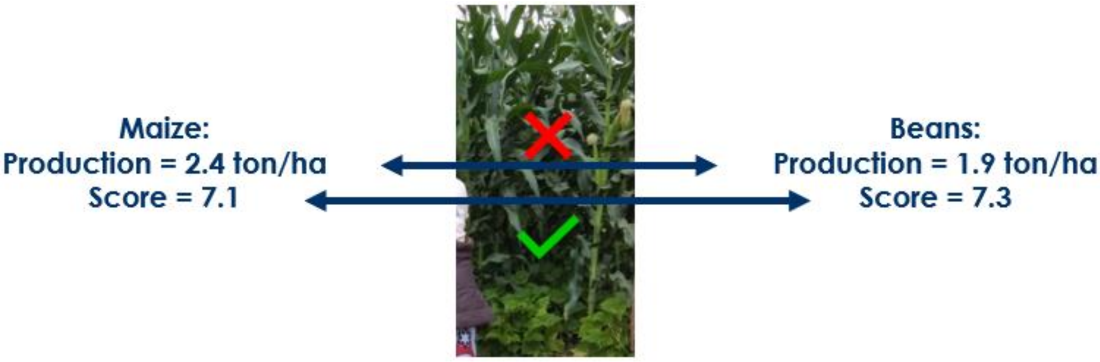

Figure 3. The added value of the scoring system: allowing to compare different crops in different districts.

The scoring system works according to the following formula:

$$Score\ [-] = ((Value_{max} - Value)/(Value_{max} - Value_{min})) * 10$$

In which $Value_{max}$ is the highest value of the average crop yield of the different measurement methods in a district, Value represents the crop yield value for which the score is determined and $Value_{min}$ is the crop yield value according to the APSAN-Vale baseline study[7]. The minimum value receives a score of 0 and the maximum value a score of 10.

[6] Van Opstal, J.D., A. Kaune. 2020. Water Productivity Technical Report - Baseline assessment for APSAN-Vale project. FutureWater Report 195.
[7] Van Opstal, J.D., A. Kaune. 2020. Water Productivity Technical Report - Baseline assessment for APSAN-Vale project. FutureWater Report 195.

3 Results

3.1 Adoption of practices and knowledge sharing

In this section we will present the adoption of practices and provide insight on the various ways of knowledge sharing.

3.1.1 Adoption of practices

Figure 4. Average number of practices applied for impact analysis farmers, project beneficiaries and control group per districtFigure 4 shows the average number of practices applied, comparing the impact analysis farmers, project beneficiaries and control group per district. The figure shows that, for all districts, the impact analysis farmers and project beneficiaries have included a higher number of practices than the control group farmers.

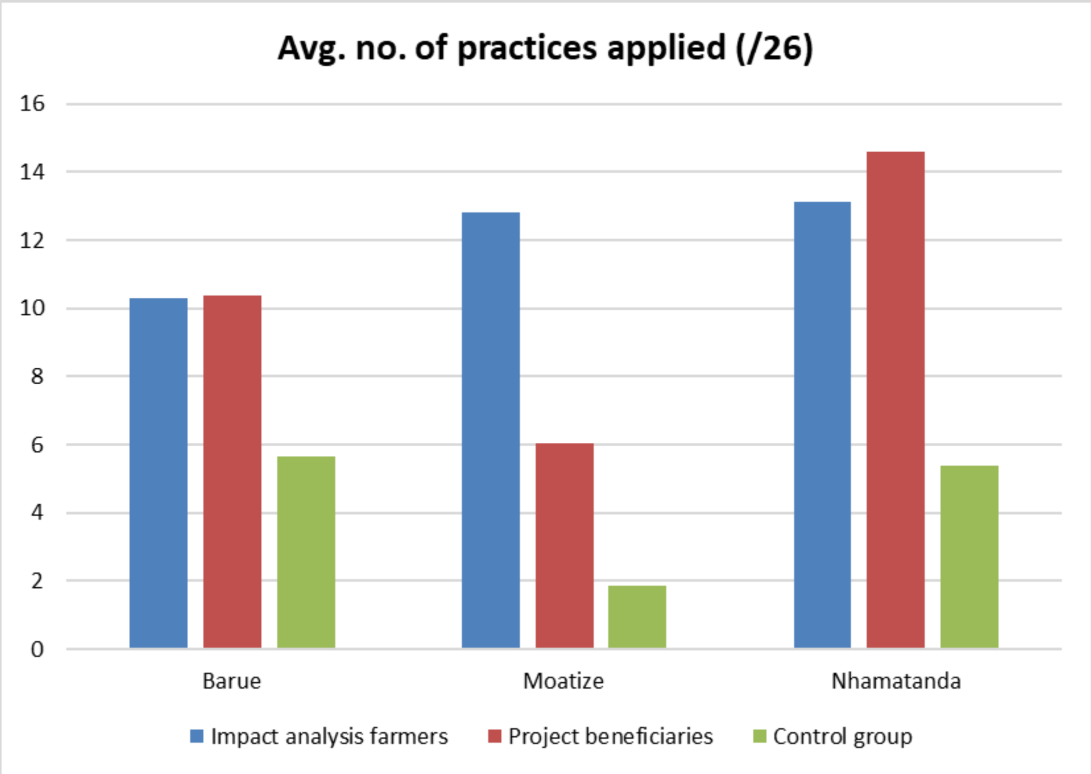

Figure 4. Average number of practices applied for impact analysis farmers, project beneficiaries and control group per district

The figure below shows the average number of log frame practices applied for the three groups per district. Afresh, the control group shows less practices adopted compared to the impact analysis farmers and project beneficiaries.

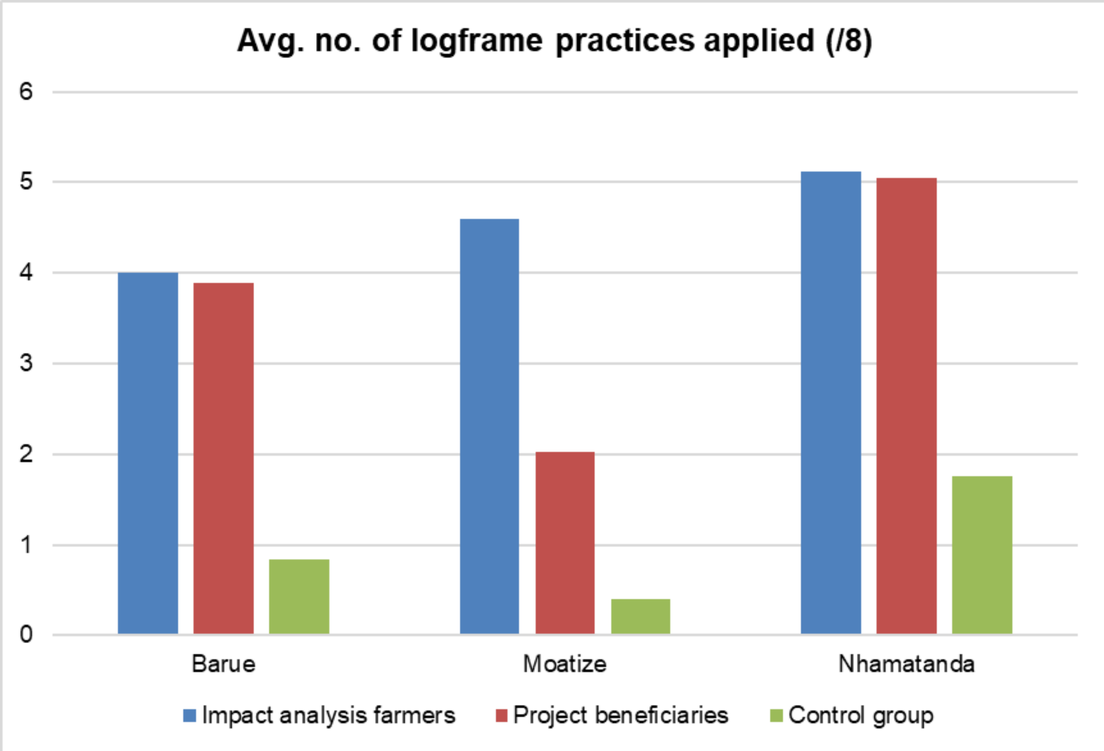

Figure 5: Average number of log frame practices applied for impact analysis farmers, project beneficiaries and control group per district

Furthermore, Figure 5 shows that in the districts of Barué and Nhamatanda, the project beneficiaries applied almost just as many practices as the impact analysis farmers. In Moatize, however, this is not the case, indicating that more attention should be paid to the sharing of practices to project beneficiaries in Moatize. In all three districts, we can see from the figure that the control group adopted less practices than the project beneficiaries and the impact analysis farmers. We would hereby like to emphasize that the difference between the control group and the project beneficiaries, meaning that project beneficiaries have had a potential head start as their selection criteria to participate in the project were similar to those of the impact analysis farmers.

Figure 6 presents the adoption of practices for the grouped practices as described in section 2.2. This allows to compare the adoption of impact analysis farmers, the overall 117 monitored project beneficiaries and the 35 interviewed control group.

Almost all grouped practices are implemented by more than 60% of the impact analysis farmers. The most adopted practices were good agricultural practices (spacing and planning) (94%), land preparation with water management practices (especially heaping) (94%) and land preparation (generally, 89%). The fewer practices adopted were market (64%), soil cover (64%) and overall water management practices (71%). These farmers are a good representation of PPCs, meaning these farmers are improving their irrigation and water management and good agricultural practices.

The practices that are not or barely taken over by control group farmers (<30%) are soil cover (8%), fertilizer use (12%), overall water management practices (3%) land preparation for water management (8%).

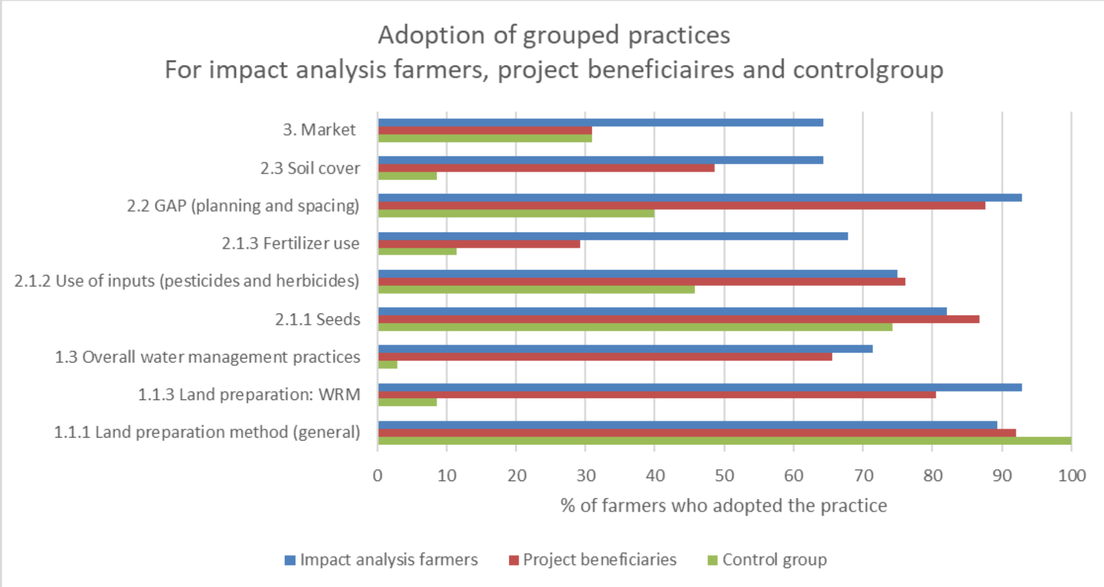

Figure 6. Adoption of grouped practices for impact analysis farmers, project beneficiaries and control group.

More than 80% of impact analysis farmers and project beneficiaries use improved seeds during the rainy season. This is important because it means farmers are willing and able to invest in crops that are considered more traditional. 72% of control group farmers primarily use local seeds for their rainfed production whereas only 18% of the impact analysis farmers use local seeds (Figure 7). This means that 82% of these farmers only use improved seeds for their production, a major development into commercial farming. In sum, farmers are able and willing to invest into their production system.

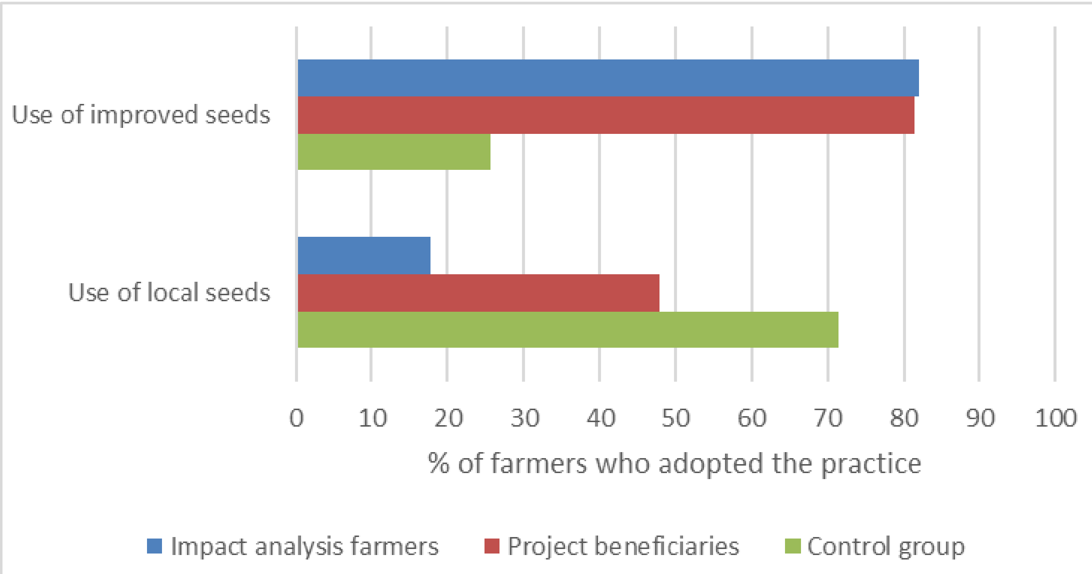

Figure 7. Use of local and improved seeds.

Another interesting observation into the willingness and ability of farmers to invest in their rainfed production is the means of ploughing (Figure 8). Farmers can plough mechanically, through animal traction of manually (with the hoe). Through mechanical ploughing and animal traction, farmers can produce on larger fields, allowing them to shift into more extensive production systems. 64% of analysis farmers applied mechanical ploughing to their field compared to 28% of the control group. Only one third of the overall project beneficiaries has applied mechanical ploughing. This means that there are gains to be made by increasing access to mechanical ploughing to this group of farmers.

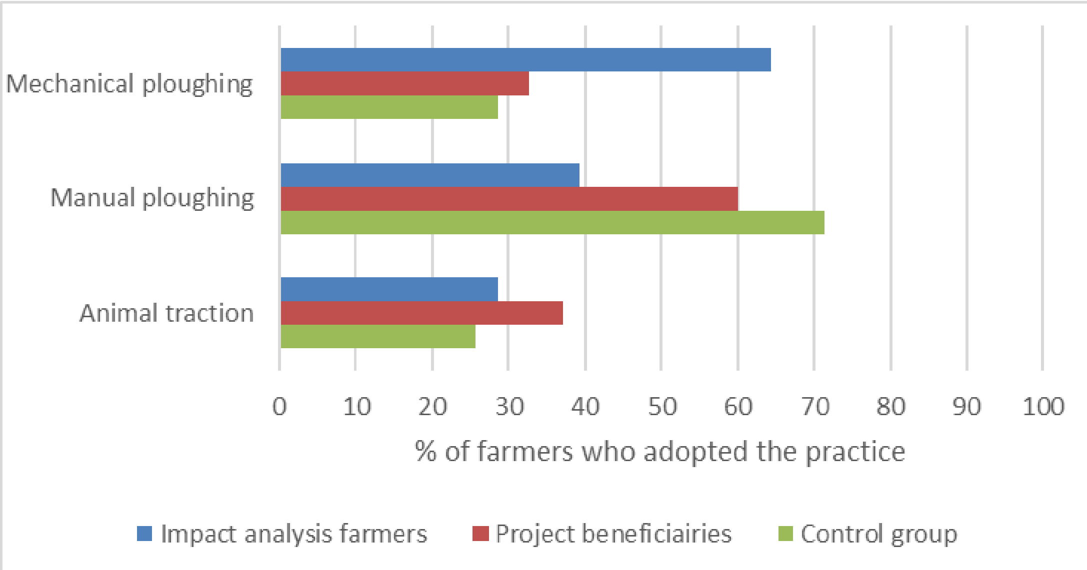

Figure 8. Forms of ploughing under analysis farmers, project beneficiaries and the control group.

3.1.2 Knowledge sharing

The monitoring data also allows to compare whether farmers implement practices that they know. Two observations are most remarkable: a comparison between practices known by the control group farmers and project beneficiaries and the adoption of practices that are relatively little known by farmers. If we compare the percentage of producers that know a certain practice between APSAN-Vale beneficiaries and the control group, we can observe several differences (Figure 9).

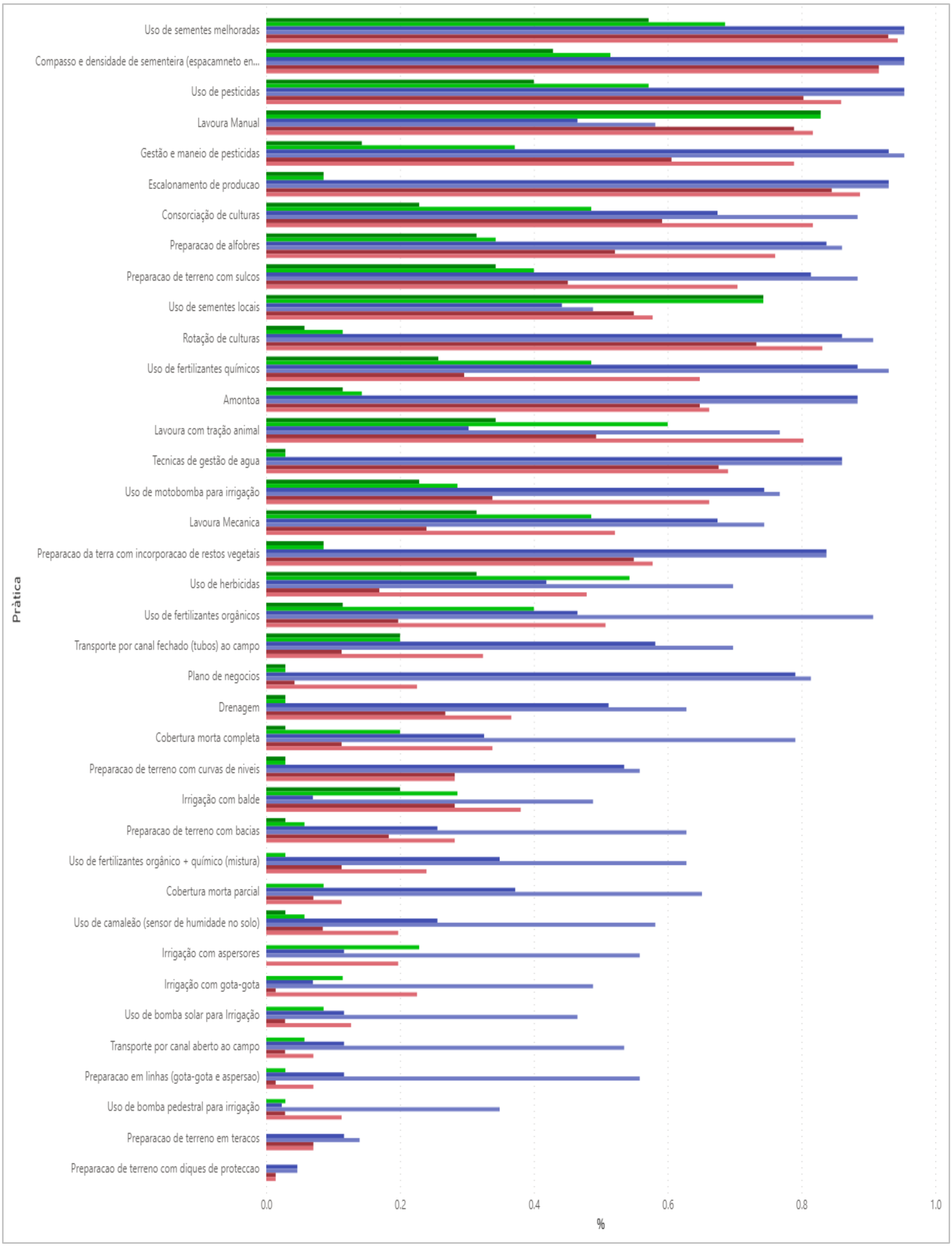

Figure 9. Knowledge of practices and adoption of practices.

Dark green: control group implemented, light green: control group knows, dark blue: PPCs implemented, light blue: PPCs know, dark red: PPEs implemented, light red: PPEs know

The practices of complete mulching and applying organic fertilizer are quite well know, especially amongst PPC farmers, but not applied as much. This is most probably because they require too much effort to apply full field because of the additional resources required.

Practices that are less adopted by the control group farmers than the PPCs and the PPEs are crop rotation, water management and drainage. This indicates that, to adopt these, more knowledge amongst the control group farmers is required.

Manual ploughing and use of local seeds are the only practices that are better known and implemented by the control group. These are more traditional practices, really ‘first level farming’ of farmer who is not exposed to new practices or markets. If we consider the control group farmers as a baseline to the APSAN-Vale project beneficiaries, so the current control group are comparable to the project beneficiaries before the project, this shows the changes and development the APSAN-Vale beneficiaries are going through.

Figure 10 presents relatively unknown practices with a relatively high implementation rates. These practices are: drainage, business planning, preparation of fields through bunds, preparation of field through terrasses and preparation of the field through dikes. This shows that, especially for land preparation practices (1. drainage, 4, preparation in bunds, 5. preparation in terrasses, 7. dikes) farmers are willing to invest and adopt the practices. Because these practices are relatively new, need quite a lot of work and are often for specific locations, farmers are not so much exposed to these practices. It also shows that the project needs to more actively share knowledge on the business planning because this is not something that can be seen ‘over the fence,’ but shows to be adopted when known.

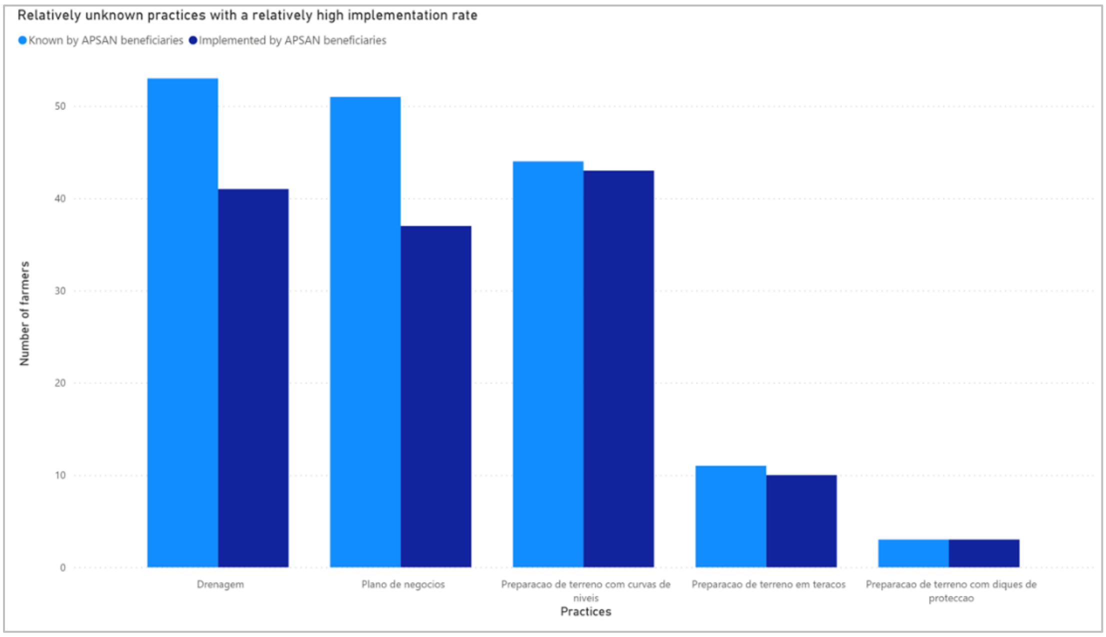

Figure 10. Relatively unknown practices with a relatively high implementation rate.
From left to right: drainage, business planning, preparation of fields through bunds, preparation of field through terrasses and preparation of the field through dikes. Light blue shows known by APSAN-Vale beneficiaries, dark blue shows the implementation in number of farmers

3.2 Crop yield

This section discusses the crop yield of the analyzed farmers, analyzed through the three different methods as described in chapter 2. In all three districts, the two main crops that are accounted for in this analysis are maize and beans.

3.2.1 Comparison with baseline

The crop yields are derived from three methodologies: farmer recall, crop-cut method and crop growth modelling. The results are divided per district (Báruè, Nhamatanda and Moatize) and per crop type grown during the season (maize and beans). Table 3 shows an overview of the crop yield results in ton/ha of 47 fields. For some methodologies there is no data collection available, noted through "N/A" (for "not applicable").
We did not include the beans data because there was limited data available to compare. The bean data was used for the scoring and comparison on adoption of practices.

Table 3. Crop production of maize and beans per district collected for the three different methodologies, compared to the baseline values (a: Van Opstal, 2020[8], b: Food and agriculture data - FAOSTAT).

District	Farmer recall method	Crop-cut method	Crop growth modelling	Average	Baseline value (median)
Maize [ton/ha]					
Báruè	2.19	2.87	2.55	2.56	1.75 [a]
Moatize	1.92	2.33	2.59	2.35	1.34 [a]
Nhamatanda	2.11	2.26	2.25	2.22	1.44 [a]

The figures for maize are also presented in Figure 11. In Báruè, the farmers produce 2.56 ton/ha, 46% higher than the baseline value. For Moatize an average production of 2.35 ton/ha was observed and for Nhamatanda 2.22 ton/ha, which is 76% and 54% higher than the baseline, respectively.

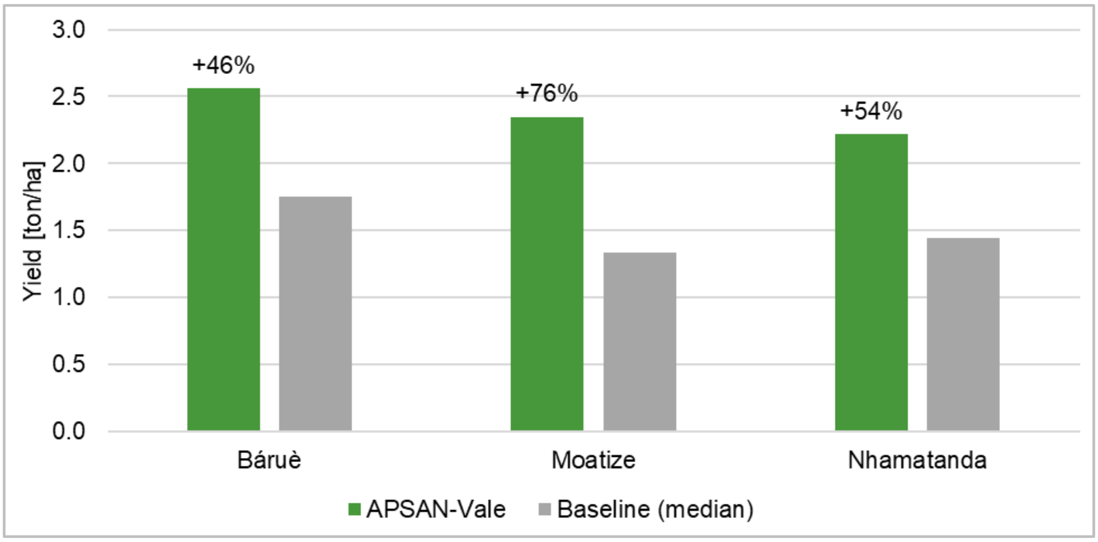

Figure 11. Comparison of maize production of APSAN-Vale beneficiaries (average of all three methods) vs baseline values in all three districts.

3.2.2 Comparison with control group

The data allows varies ways to compare the production of the APSAN-Vale farmers to other farmers, to the baseline and to the production of the rainfed season 2021.

First, we compare the APSAN-Vale beneficiaries production to that of the control group (Figure 12). For all crops that were compared, a substantial increase in production was observed. APSAN-Vale

[8] Van Opstal, J.D., A. Kaune. 2020. Water Productivity Technical Report - Baseline assessment for APSAN-Vale project. FutureWater Report 195.

beneficiaries are producing per hectare 46% more peanuts, 73% more boer beans, 470% more nhemba beans, 85% more sesame, 134% more sorghum and 36% more maize than the control group farmers.

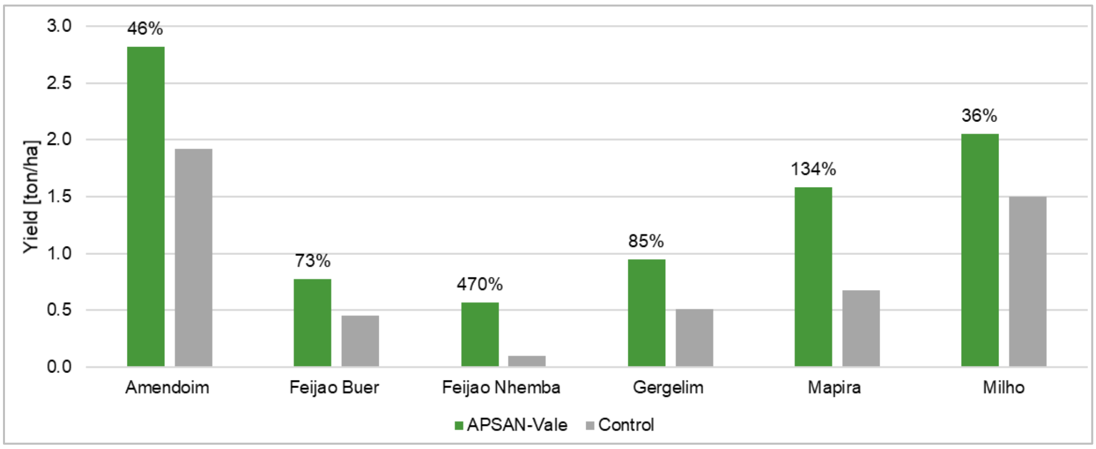

Figure 12. Comparison of crop production of APSAN-Vale beneficiaries vs control group (farmer recall method).

3.3 Farm size

Besides analyzing crop yield, it is also valuable to show that the farmers are increasing their farm size. This means that, although some farmers may have not increased their crop yield per ha, they have increased their overall production. This is influenced by farmer's choices to intensify their production or, expand their production. Monitoring and Evaluation operationalization report (2021)[9]

The average size of agricultural land the producers have access to is 5.52 ha. For APSAN-Vale beneficiaries (10.8 ha for PPC's and 2.9 ha for PPE's) and the average of the control group is 2.33 ha. The average land sizes for the districts are all around 3.5ha per farmer. For PPEs, this is 0.3ha larger than measured during the 6 months before. These farms are much larger than the national average. Smallholder farming is the dominant farming model in Mozambique – the average farm size reported nationally is 1.5 ha, with many farms under one ha (FAO, 2005). When asked in how many parcels (machambas) producers divide their agricultural land, the average for the APSAN-Vale producers was 1.3 and for the control group it was 1.1 plots.

The average number of crops grown on this land in the past rainfed season was 3 for PPC, 2 for PPE and between 2 and 3 for the control group. The results show that farmers cultivate a larger part of available land in rainfed season than in the irrigated season. Farmers in Moatize intend to enlarge their cultivation area the most next year, with 2.3 ha on average. In Báruè this is 0.5 ha and in Nhamatanda no intention to increase on average. Maize is cultivated by almost all farmers (95%).

3.4 Impact of interventions

In the following sections, the impact of agronomic and water management practices are discussed using the crop yield scoring. In addition, the last section reports on the perspectives of the farmers and if they perceived an increase of their production.

[9] Gundana C., N. Marula, K. van Krieken, D. Levelt, J. van den Akker. 2021. Monitoring and Evaluation progress and results Rainy season 2020-2021. Production & Implementation of APSAN training topics. APSAN-Vale

3.4.1 Impact of agronomic and water management practices

A selection of agronomic and water management practices are compared for differences in crop yield scoring, namely: manual ploughing, animal traction, land preparation using drainage, heaping, water management practices and staggering and planning. The crop yield scoring of farmers that applied the practices are compared with those that did not apply the practices. Figure 13 shows the results of this comparison.

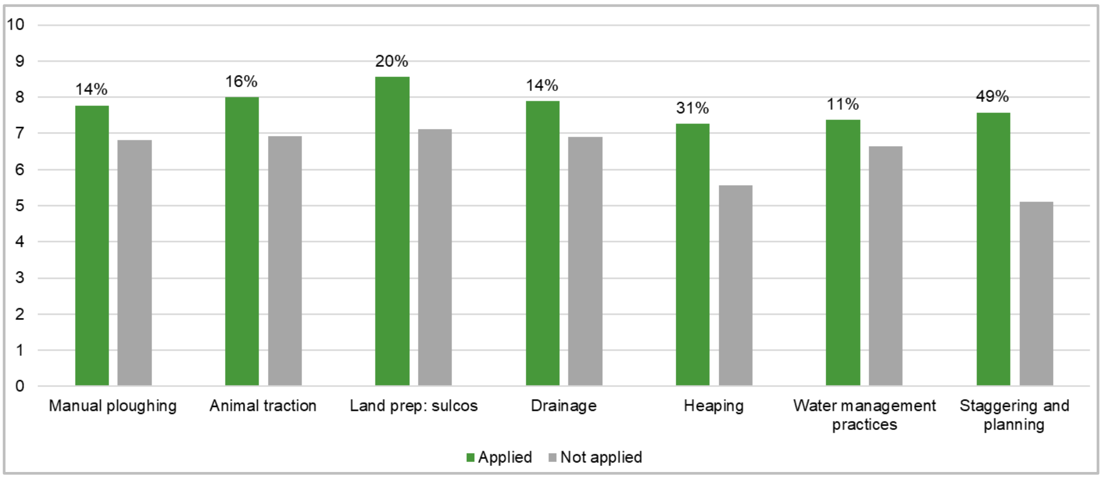

Figure 13. Crop yield score for farmers who applied or did not apply specific agronomic practices, with percentages indicating the difference between the two.

All of the presented agronomic practices show that farmers who applied the practices had a higher crop yield scoring to farmers who did not. The highest increase was found for farmers that applied staggering and planning, which was 49%. Next, the practice of heaping showed a positive difference of 31%.

There are also practices where we saw no or a negative difference between farmers that applied and farmers that did not apply them. On average, the farmers applied 12 out of 26 practices. These practices have a complex influence on the production systems. It is therefore difficult to isolate the effect of one single practice on the production of a farmer. The next section shows that when you group farmers into a typology, you can see a substantial higher scoring. Therefore, it might be interesting to group farmers into a variety of categories in future analyses.

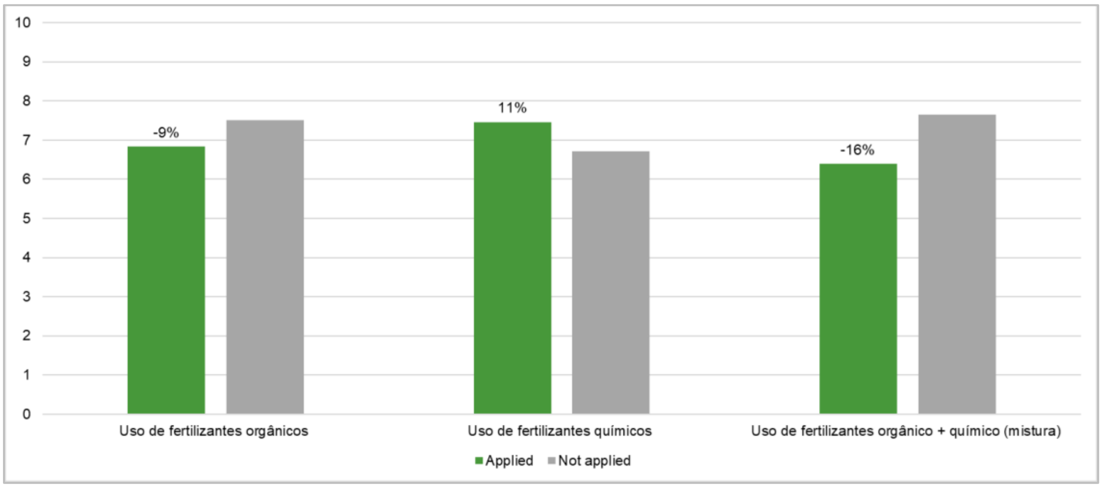

Figure 14. Crop yield score for farmers who applied or did not apply organic fertilizer, chemical fertilizer or a mixture of the two, with percentages indicating the difference between the two.

Figure 14 shows the results of the application on the application of organic fertilizer, chemical fertilizer and a mixture of the two. The figure shows a lower scoring percentage for organic fertilizer and the mixture, but this does not necessarily have to indicate that organic fertilizer has been applied less. The crop yield scoring compares farmers who applied certain types of fertilizer, it is not a comparison between farmers who did or did not apply fertilizer at all. Farmers who did not apply organic fertilizer may have applied chemical fertilizer instead, therefore having a relatively lower crop yield scoring, but an increased crop scoring to those who did not apply at all.

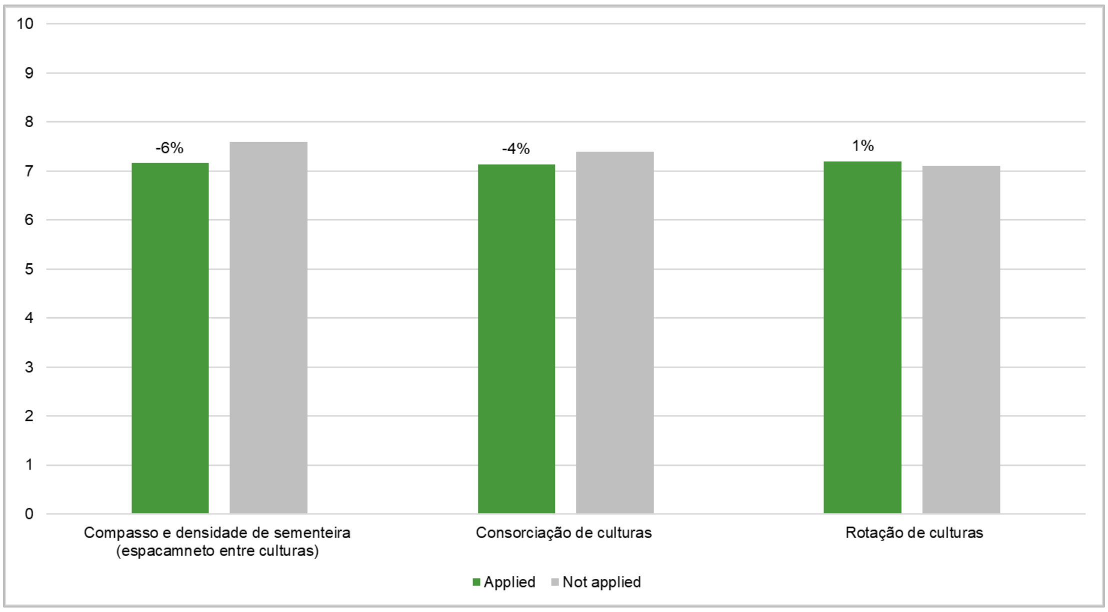

Figure 15. Crop yield score for farmers who applied or did not apply crop spacing, intercropping and crop rotation with percentages indicating the difference between the two.

The figure above shows that low-cost but labour intensive practices are often applied, but appear to be less beneficial when compared to farmers who did not apply the practices. Again, this could possibly be because the scoring system indirectly compares farmers to each other, instead of to a baseline value of practices applied or not applied. When comparing between farmers, the difference between applied and not applied will appear lower in a large group of farmers than in a small group of farmers. When comparing to a baseline value, a certain practice could be scoring higher than shown in the comparison between farmers. In sum, it is not unbeneficial for the production system.

3.4.2 Impact of farmers who irrigate

Even though irrigation is not used often in the rainfed season, some farmers did apply irrigation to their farm field. To be precise four farmers cultivating beans and maize applied some form of irrigation, while 41 farmers growing beans and maize did not.

Figure 16 shows the impact of the use of irrigation the scores of beans and maize farmers in all districts. As can be seen, farmers who did apply irrigation scored an average of 8.9, which is substantially higher than the farmers who did not apply any form of irrigation. Those farmers scored an average of 7.1.

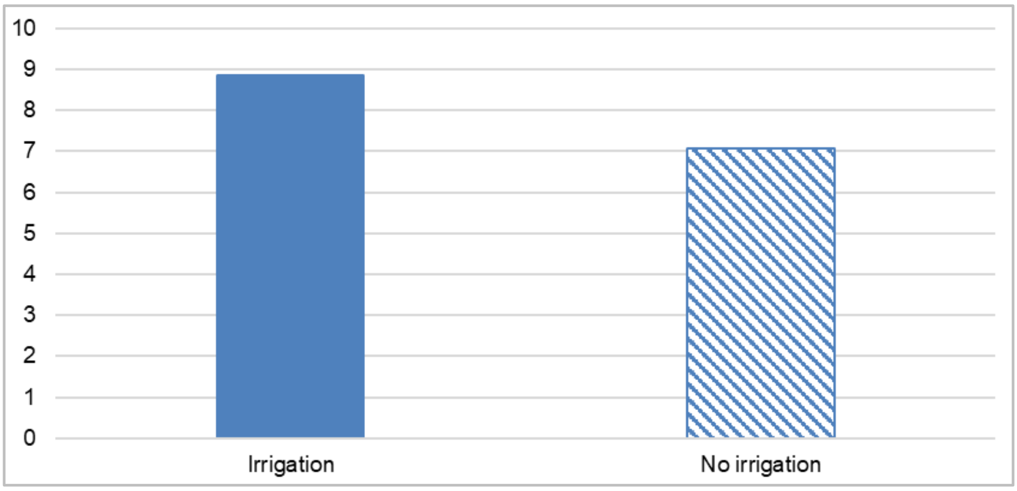

Figure 16. Impact of irrigation on scores for beans and maize farmers in all districts.

3.4.3 Impact from the farmers' perspective

The project asked farmer whether they have increased productivity and income, and improved knowledge of irrigation practices. These results were derived from the monitoring survey of July 2021 where the perception of 117 APSAN-Vale beneficiaries was collected.

Practically all of the interviewed producers (97.2%) report an increased income compared to last year's income. For the control group farmers 20% indicates to have increased productivity compared to previous season. Most of the APSAN-Vale beneficiaries (92.7%) report increased productivity compared to last year income, whereas 86.7% of the control group indicates that their income compared to previous year not has improved.

4 Discussion

4.1 Crop yield data collection methods

The APSAN-Vale project uses three measurement methods for yield estimation to collect data on production: farmer recall method, crop-cut method and crop growth modelling. In our analysis we have encountered differences between the production results of the different methodologies. Table 4 shows the advantages and disadvantages of these methodologies and provides an explanation for differences.

Table 4. Overview of advantages and disadvantages of applied crop yield estimates methodologies.

Method	Advantages	Disadvantages
Farmer recall method	Simple data collection, data quickly available, less expensive to implement	Shortcomings are (i) subjective; (ii) non-standard harvest units; (iii) intentional over- or underreporting; (iv) low accuracy with longer recall periods; (v) poor quality responses in lengthy interviews; (vi) insufficient supervision; and (vii) illiteracy
Crop-cut method	Reliable and objective; Productivity of parcels, sub-parcels or fields can be determined without knowledge of their size	Only biological yield not taking into account harvests losses thus not economic yield. Time consuming, labor intensive
Crop growth modelling	Predict crop yield in specific conditions or range of conditions. Reduce labor and resources required for data collection.	Crop models cannot be used to predict crop yield accurately for great variation in field conditions and unique situations (such as pest invasion).

Figure 17 shows the average crop yield for maize farmers for the three different data collection methods for all three districts. The error bars indicate the standard deviation of the dataset, which shows the dispersion of a dataset relative to its mean.

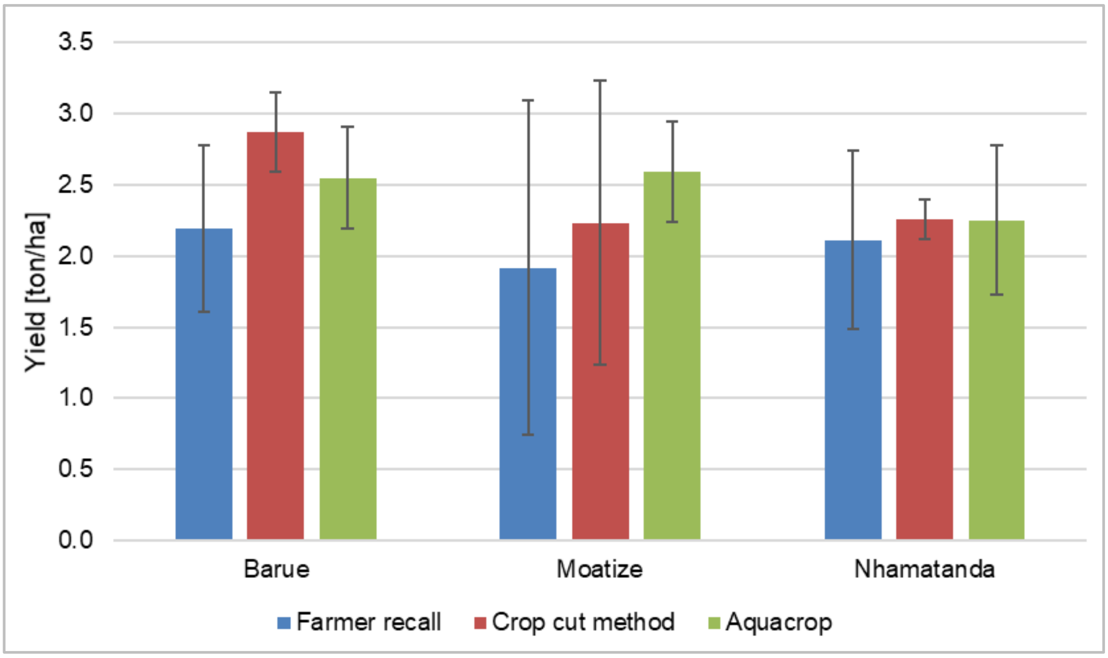

Figure 17. Average maize yield according to the three different crop yield data collection methods for the three different districts (error bars indicate standard deviation).

As can be seen, the averages do not differ from each other by more than 20%, roughly. No significant differences are observed between the datasets, which indicates the values from all three datasets are within the same range, once the average of several farmers is taken. These results show how complicated is it to collect reliable and consistent production data from the field. It should be a lesson to other projects to reflect on their data collection methods.

5 Concluding remarks

APSAN-Vale is a project with the aim to pilot innovative practices that improve productivity. The analysis on the impact that the piloted interventions have, is central to determining the effectiveness of the practices. The lessons learned on the adoption of practices, the achieved increases in productivity, sharing of knowledge and the relation between adoption of practices and production are valuable key findings for this project and assist follow-up activities. The analysis of this report therefore contributes to the overall assessment of the piloted practices.

In summary, the report presents findings from 114 project beneficiaries and 35 control group farmers, with specific data analysis of 27 PPC's and a total of 117 fields, who monitored during the rainfed season of 2021. The main crop types in this impact assessment are maize and beans. The data presented on crop yield, adoption and knowledge of practices. Water productivity data has been presented in other reports.

It has proven useful to use different methods to collect production data, being the farmer recall method, crop-cut method and crop growth modelling. As explained in section 4.1 'Crop yield data collection methods', each method has its advantages and disadvantages. By using multiple methods, we have been able to compare the different methods and results, allowing us to validate the data retrieved. Furthermore, by including the baseline values in the current scoring system, we have not only compared farmer's results relative to each other but also included a definition of what values are perceived to represent 0%.

In this report, the comparison of the results with the practices gave some key messages namely:

- A high percentage of the farmers adopt practices by APSAN-Vale, especially good agricultural practices (94%), land preparation with water management practices (94%) and land preparation (89%);
- Farmers are willing to invest labor in the field, although practices and technologies that require more financial investment continue to be challenging;
- Farmer produced higher than the 75% baseline values and substantially higher than control group farmers;
- Practices with the highest rate of adoption have been drainage (+49%) and heaping (+31%);
- The practices of manual ploughing, animal traction, land preparation with furrows, drainage, heaping, water management practices and staggering and planning lead to higher crop yield scores;
- Practices such as the application of fertilizer and land preparation show lower crop yield scoring. A possible explanation for this is because the methodology compares different types of fertilizer and land preparation and not to an absolute absence of fertilization or land preparation;
- Crop rotation, correct spacing and intercropping seem to not have a significant effect on crop yield, but this might be influenced by the high adoption rate where the scoring system indirectly compares farmers to each other, instead of to a baseline value of practices applied or not applied;
- Many farmers state that they have increase in income and production compared to the previous years. APSAN-Vale beneficiaries report a 92.7% increased productivity compared to last year's income versus 13.3% of the control group farmers.

Lessons learned:

- Practices that the project could focus on to further introduce to new farmers are crop rotation, water management and drainage because of a high adoption rate when known by PPCs and PPEs and are little known by control group farmers;
- More business practices need to be included in the monitored practices;

- It is useful to identify typologies of farmers, like irrigating and non-irrigating farmers, to analyze production scores alongside the analysis of individual practices.

Overall, the results provide valuable insight and display an effective methodology for the analysis of the impact achieved with field interventions.

Annex 1: Grouped practices

1. Water management practices							
1.1 Land preparation							
1.1.2 Land preparation: irrigation			1.1.3 Land preparation: WRM				
Land prep: sulcos	Land prep: Basin	Land prep: in lines	Land prep: bunds	Land prep: terrasses	Land prep: dikes	Drainage	Heaping

1. Water management practices									
1.2 Irrigation methods								1.3 overall water man practices	1.4 use of soil sensor
Irri: motor pump	Irri: solar pump	Irri: footpump	Irri: furrows	Irri: tubes	Irri: buckets	Irri: sprinklers	Irri: drip	Water management practices	Soil sensor

2. Good agricultural practices											
2.1 Land preparation methods			2.2 Use of inputs								
			2.1.1 Seeds			2.1.2 Use of inputs (pesticides and herbicides)			2.1.3 Fertilizer use		
Mechanical ploughing	Animal traction	Manual ploughing	Local seeds	Improved seeds	Seedbeds	Use of herbicides	Use of pesticides	Management of pesticides	Organic fertilizer	Chemical fertilizer	Organic and chemical fertilizer

2. Good agricultural practices							**3. Market**
2.3 GAP (planning and spacing)				2.4 Soil cover			
Crop spacing	Intercropping	Crop rotation	Staggering and planning	Incorporating plant rests	Mulching (complete)	Mulching (partitial)	Business planning

Annex 2: Adoption of practices ungrouped