Interventions Impact Analysis: Irrigation Season 2020

APSAN-Vale project

CLIENT Agência de Desenvolvimento do Vale Zambeze (ADVZ)

AUTHORS Jonna van Opstal
Katrien van Krieken
Martijn de klerk
Wouter Beekman

DATE March 2021

Interventions Impact Analysis: Irrigation Season 2020

APSAN-Vale project

Client
Agência de Desenvolvimento do Vale Zambeze (ADVZ)

Authors
Jonna van Opstal (FutureWater) – Water Productivity Expert (j.vanopstal@futurewater.nl)
Katrien van Krieken (Resilience) – Irrigation Expert (katrien@resiliencebv.com)
Martijn de Klerk (FutureWater) – Project manager (m.deklerk@futurewater.nl)
Wouter Beekman (Resilience) – Project manager (wouter@resiliencebv.com)

Date
March 2021

Content

List of Tables

List of Figures

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.

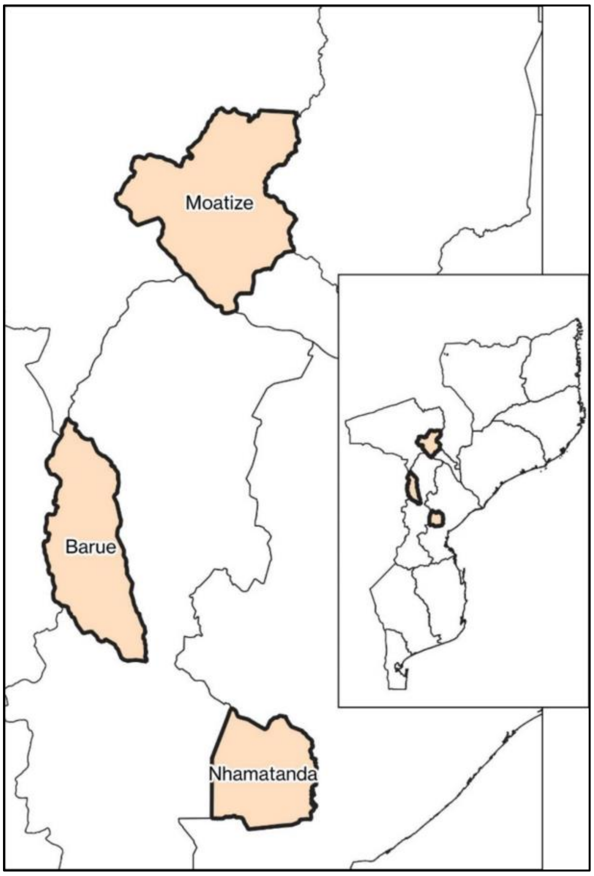


Figure 1 Location districts of APSAN-Vale project activities

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 irrigation season. Chapter 3 provides a description of the methodology for the data collection and the interventions impact analysis. Chapter 4 on the results from adoption of practices, crop yield reports and water productivity. Chapter 5 provides a discussion on the results. Chapter 6 brings the results together on the practices, crop yield, and water productivity, and provides a comparison of the impact of certain practices. Chapter 7 provides some concluding remarks.

2 Field interventions

In the project there are 38 different practices that were trained to and applied by farmers. We analyzed the impact of these practices on adoption, yield and water productivity. These practices can be divided in to three main groups: water management practices, good agricultural practices and market-oriented activities. The list below presents all practices (in *italics*) and how they are grouped.

1. Irrigation and Water Management Practices

1.1 Land preparation for water management and irrigation

1.1.1 Land preparation for irrigated fields

-Sulcos, Basins, In lines

1.1.2 Land preparation for water management

-Bunds, terrasses, dikes, drainage, heaping

1.2 Irrigation methods

-Motor pump, solar pump, foot pump, furrows, tubes, buckets, sprinklers, drip

1.3 Overall water management practices

-Water management practices

1.4 Use of soil sensor

-Soil sensor

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

A clear visualization of all the practices that fall under the groups can be found 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[1]. The practices related to the irrigation season focus on irrigation techniques, practices and technologies.

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

3 Methodology

3.1 Approach

The approach of this analysis can be divided into three steps, as provided in the overview below (Table 1). Firstly, the various practices are placed into categories and sub-groups. The second step is to collect the data on: 1) the adoption of practices, 2) crop yield, and 3) water productivity. Lastly, a scoring system (see section 3.4) 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.

Table 1 Overall approach of analyzing the impact of interventions.

Steps	Description
1	Categorization of practices
2	Collection of seasonal results: Monitoring survey: Adoption of practices and knowledge sharing (Nov 2020) Crop yield reports Water productivity analysis
3	Scoring system: evaluation of impact and effect of the interventions

3.2 Overview input data sources

For the impact analysis, three mean data sources have been used to collect data on adoption of practices, crop yield and water productivities. Table 2 Input Data Sources provides an overview.

Table 2 Input Data Sources

Input data source	Provides data on	Methodology	Comment
Monitoring Survey	- Adoption of Practices - Crop Yield	Structured Survey Farmer-recall method	Surveyed in October 2020 109 Beneficiaries 37 Control Group
In-field production measurement	- Crop Yield	Cut-crop method	Collected September-November 2020 37 PPCs
Flying sensor data	- Crop Yield - Water Productivity	Crop growth modeling Water Productivity modeling	Surveyed from April 2020-October 2020 37 PPCs, 157 fields

3.3 Categorization and grouping of practices

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

The data was collected through the monitoring survey of November 2020. In total 109 beneficiaries being PPE (smallholder farmers) and PPC (small commercial farmers) and 37 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 38 of practices related to irrigation and water management, good agricultural practices and market.
- The log-frame 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[2]). As there is no universal categorization, we focus on the log-frame indicators as the basis for the current intervention analysis.

As a result, all the practices fall under the following three broader options: water and soil management, agronomical practices, and market. The various groups and sub-groups of practices is listed in chapter 2 of this report. All practices are presented in Annex 1.

3.4 Data collection

3.4.1 Adoption of practices and knowledge sharing

<u>Locations</u>

Interviews have been conducted in three districts being the districts of Báruè, Nhamatanda and Moatize (Figure 1). 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.

<u>Structured interviews</u>

During three weeks, 109 project beneficiaries and 37 non-project farmers (control group) have been interviewed.
Data collection tools have been 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 log-frame indicators.

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

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. All results from the monitoring survey can be found in the APSAN-Vale Irrigation Season's 2020 Monitoring Report.[3]

[2] 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.
[3] Gundana C., N. Marula, K. van Krieken, D. Levelt, J. van den Akker. 2020. Monitoring and Evaluation progress and results Production & Implementation of APSAN training topics. APSAN-Vale.

Data analyses

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.

3.4.2 Crop yield

The APSAN-Vale project uses three measurement methods for yield estimation as defined by FAO (2017)[4] to collect data on production: farmer recall, crop-cut method and crop growth modelling.
Farmer recall is an interview methodology, where during the monitoring exercise structured interview are conducted to collect information on production at the season of PPCs and PPEs. This method can be use as auxiliary variable in crop yield estimation.
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 the crop 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 'impact analysis' farmers.

Farmer recall method

In total 109 project beneficiaries (PPE and PPC) and 37 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 used for the PPC's to support hem 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 PPC this approach was used. Through this method there may be intentional over- or underreporting and low accuracy with longer recall periods. In chapter 4 we analyze the different crop yield measurement methodologies.

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.

Crop-cut method

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

[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 Organizsation of the United Nations

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

surveys. Yield samples from the field or production in 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.

Crop growth modelling

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. Flying sensor imagery throughout the growing season 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 the Water Productivity Analysis: Rainfed Season 2019-2020 report[7].

All crop yield measurement methodologies have benefits and disadvantages, and

3.4.3 Water productivity analysis

The water productivity analysis follows two approaches for the calculation of water productivity:

1. At field scale the most detailed information is available regarding crop type and management strategies. At this scale a crop specific water productivity is calculated for the selected crops at the three different districts using crop simulation modelling.
2. At sub-basin and basin scale limited information is available on the spatial distribution of the crop types. At this scale a biomass water productivity is calculated using data from WaPOR, FAO's Open Access Portal with Water Productivity data.

3.5 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 – 1) to indicate if the given crop yield or water productivity value is in the upper range or the lower range compared to the overall values. A score is more understandable than the results in crop yield and water productivity itself. Secondly, a scoring system also enables better comparison between districts and years. Both these aspects are highlighted in the description of the scoring system below.

3.5.1 Min-max method

Below in Figure 19 an example is provided displaying the min-max method of scoring. For each district the minimum and maximum values of either crop yield or water productivity are taken. The minimum value indicates a score of 0 and the maximum value a score of 1. The results in crop yield or water productivity in between the minimum and maximum values are then put on the scale using the equation below.

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

In Figure 3 it shows that the maximum score of 1.0 has different corresponding crop yield and water productivity values. This indicates that the maximum achieved in each district was different.

[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., M. de Klerk, A. Kaune, C. Nolet, J.E. Beard. 2020. Water Productivity Analysis: Irrigation Season 2020. FutureWater Report 218.

Crop yields (average all methods)	Scoring (all yields)	Water productivity	Scoring (WP)
2.0	0.0	0.44	0.0
2.3	0.3	0.44	0.0
2.1	0.4	0.43	0.0
2.6	0.6	0.44	0.0
3.0	0.8	0.51	0.5
2.3	0.0	0.49	0.6
1.5	0.0	0.51	0.7
1.9	0.3	0.51	0.7
2.3	0.5	0.52	0.8
2.6	0.6	0.52	0.9
2.7	0.9	0.52	0.9
2.1	0.4	0.54	1.0
2.6	0.5	0.57	1.0
2.7	0.7	0.53	1.0
3.2	1.0	0.57	1.0
3.2	1.0	0.57	1.0
3.0	1.0		
2.8	1.0		

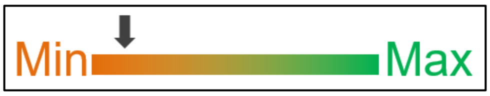


Figure 3 Example of min-max scoring for the crop yield and water productivity values

4 Results

4.1 Adoption of practices and knowledge sharing

It is important to know whether the beneficiaries of the project acknowledge that they acquired knowledge about good agricultural practices (GAP), market and other new information. Table **3** shows that a large majority of the respondents agree on increased knowledge. In addition, the table shows that these farmers share knowledge. We will present the adoption of practices and provide insight on the various ways of knowledge sharing.

4.1.1 Adoption of practices

Figure 4 presents the adoption of practices for the grouped practices as described in Chapter 2 on Field interventions. This allows to compare the adoption of impact analysis farmers, the overall 109 monitored project beneficiaries and the control group.

Almost all grouped practices are implemented by more than 90% of the impact analysis farmers. Only the soil sensor (26%), business planning (73%) and the water management practices in general (85%) are implemented less. 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 business planning, fertilizer use, land preparation for water management and land preparation for irrigation management. Soil sensor had a low adoption rate because it was only provided to a small group of farmers in this phase of the project. Only 31% of the control group farmers apply any form of irrigation techniques.

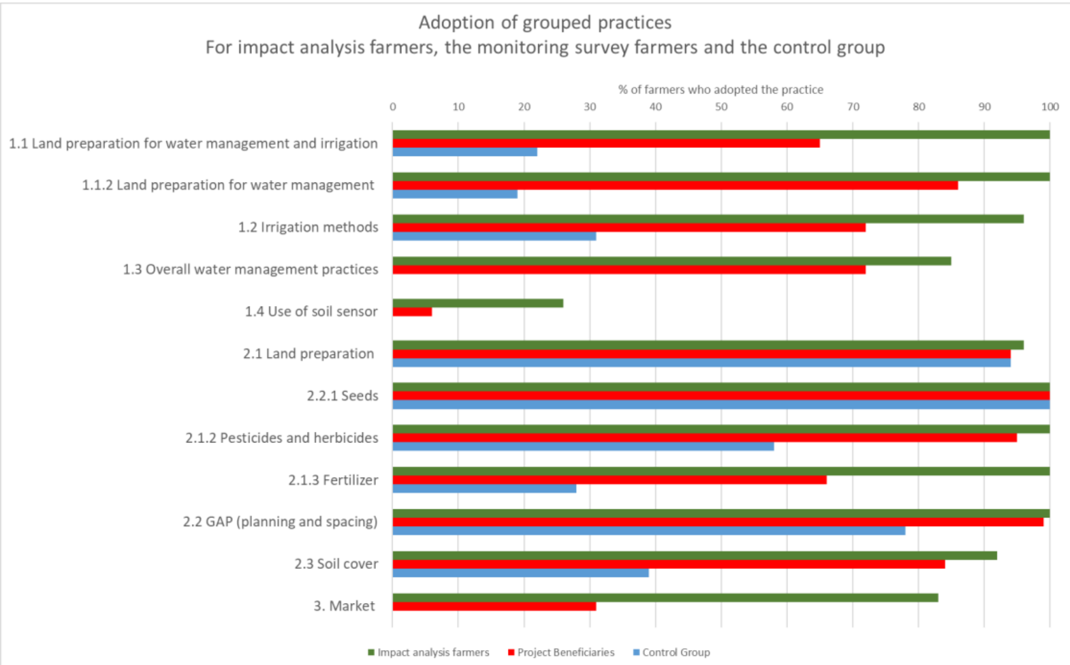


Figure 4 Adoption of grouped practices for impact analysis farmers, the monitoring survey farmers and the control group.

It makes sense that all farmers (100% of all groups) use some form of seeds because this is a grouped practice including local seeds, improved seeds and preparation of seedbeds. Still, almost all farmers use improved seeds for the irrigation season: impact analysis farmer 100%, project beneficiaries 97% and control group 81%. More interestingly, only 57% of the impact analysis farmers use local seeds (Figure 5). This means that almost have of these *only* use improved seeds for their production. Thus, farmers are able and willing to invest into their production system.

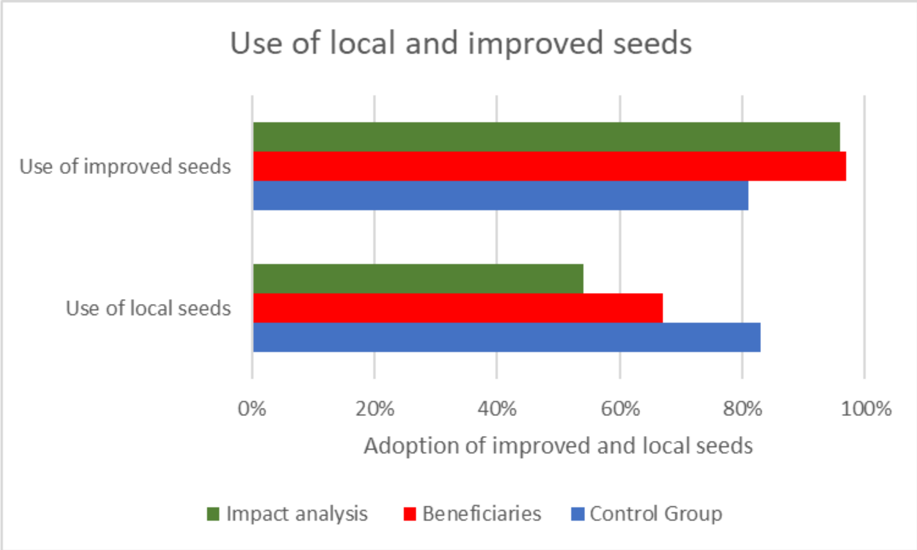
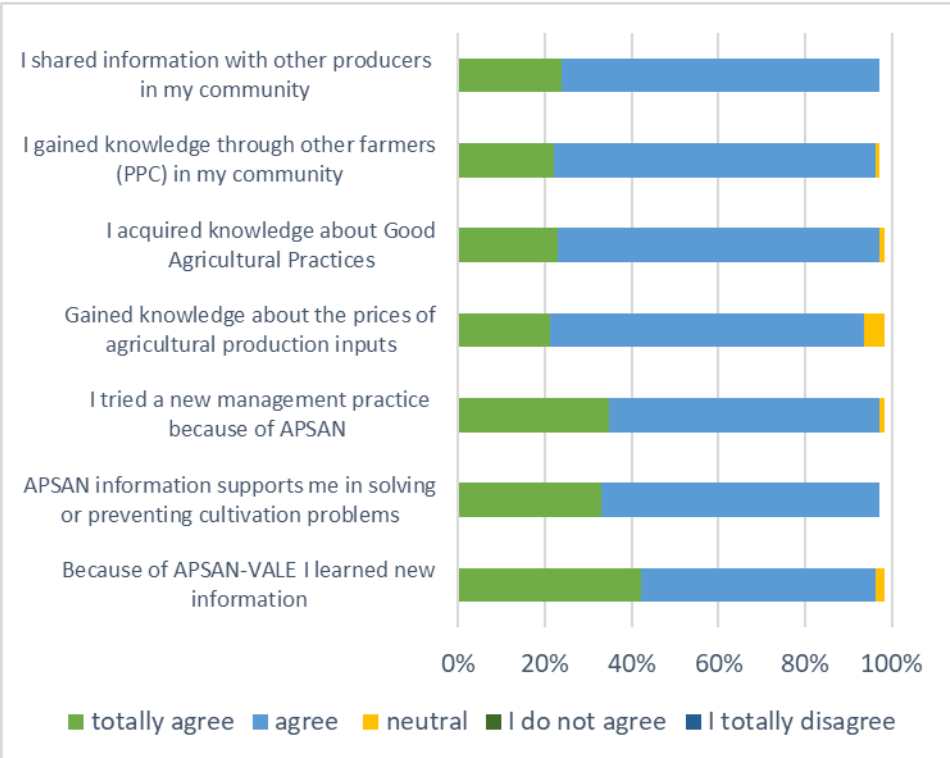


Figure 5 Use of local and improved seeds.

4.1.2 Results on Knowledge sharing

The knowledge sharing is effective to reach to various farmers in the area. Most knowledge is still recognized as being learned by the APSAN-Vale technicians or considered to be 'known.' Letting the technicians introduce new practices to farmers who are capable and willing to adopt new practices, and letting these farmers further spread the knowledge works. A threat might be that the knowledge is limited to the 'neighboring fields' which means that even within a locality, various plots should be taken as demo-plots. Adoption by 'passing by' the field without active training also happens, be-it less frequent and les recorded. The project should focus to continue incentivizing the PPCs to introduce the practices on other production fields, reaching new groups of PPE.

Table 3 **Overview of gained knowledge and implemented practices and knowledge sharing (Source: M&E Monitoring, November 2020)**



4.2 Crop yield

This chapter will discuss the crop yield of the analyzed farmers. Per district, the four main crops that are accounted for are tomato, onions, cabbage and maize. Whilst putting the data together, the project sees that there are discrepancies between the different data collection methodologies. As such, we reflect on data collection methodologies and provide a suggestion to overcome the differences, enabling comparing the different crop yield between the districts and crop types.

4.2.1 Crop yield results

The crop yields are derived from three methodologies: farmer recall, crop-cut method and crop growth modeling. The results are divided per district (Bàrué, Nhamatanda and Moatize) and per crop type grown during the irrigation season (tomato, onions, cabbage and maize). Maize is young maize, locally known as *massaroca*. Table 4 shows an overview of the crop yield results in ton/ha of 114 fields. For some methodologies there is no data collection available, noted through "N/A" (for "not applicable").

Table 4 Results of crop production (ton/ha) per four main crop types per district collected by three different methodologies

District	Farmer recall	Crop-cut method	Crop growth modelling	Average	All district average from Baseline[8]
Tomato [ton/ha]					
Báruè	4.4	9.9	10.2	9.2	7.0-13.8
Nhamatanda	4.4	12.0	12.0	10.7	
Moatize	13.2	11.3	13.8	10.6	
Onions [ton/ha]					
Báruè	3.1	8.0	4.2	5.5	1.5-7.7
Nhamatanda	9.3	10.4	4.4	9.6	
Moatize	1.0	13.4	N/A	8.5	
Cabbage [ton/ha]					
Báruè	4.0	9.7	13.8	9.9	4.0
Nhamatanda	2.0	13.8	14.0	14.4	
Moatize	6.2	14.1	12.1	7.5	
Maize [ton/ha]					
Báruè	N/A	7.7	2.6	6.2	0.9-2.6
Nhamatanda	2.5	0.8	2.8	2.2	
Moatize	2.9	3.7	5.2	4.0	

Báruè has the lowest average production (7.7 ton/ha) and Nhamatanda the highest (9.2 ton/ha). Compared to the baseline crop yields as identified in the Baseline Assessment (2020), there is an increase of production for irrigation season 2021. Although these farmers are PPCs and these farmers have high production, the data still record lower numbers than SDAE averages of 10 ton/ha.

There is a substantial difference in crop yield between the data collection methodologies. The crop growth modelling method shows the smallest range between districts because the crop yield is modeled based on comparable parameters. When the averages are presented, it seems like farmers underestimate the yield for farmer recall. Section 6.2 shows that per individual farmer, there is much less consistency between the methodologies. These differences cannot be explained with a consistent over- or undervaluing. This impacts the opportunity to compare the production of individual farmers and the

[8] Baseline taken from: Kuane, A. Opstal, J. van,. Water Productivity Technical Report; Baseline Assessment for APSAN-Vale project (2020). APSAN-Vale

practices applied. Section 6.2 of this chapter, further discusses the methodologies and mitigation for the next impact analyses.

4.2.2 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 (2020)[9]

Smallholder farming is the dominant farming model in Mozambique – the average farm size reported nationally is 1.5 hectares, with many farms under 1 hectare (FAO, 2005). The average size of the combined production units (*machambas*) of APSAN-Vale beneficiaries was 2.6 hectares.

When asked in how many parcels producers divide their agricultural land, the average for the APSAN-Vale producers was 1.1 versus 0.9 for the control group. The average number of crops grown on this land in the past year was 3 for the APSAN-Vale beneficiaries and 2.1 for the control group. APSAN-Vale farmers have thus more crop diversification.

In general, the results show that the area cultivated in the irrigated season is <50% of a farmer's total available land. Respondents intend to enlarge their cultivation area next year, with 0.7 hectare on average by APSAN-Vale beneficiaries and 0.3 hectare on average by the control group.

4.3 Water productivity

The water productivity results of the selected farmers for this impact analysis study, is reported in Table 5. An explanation of the methodology and the results is presented in the water productivity report of the irrigation season 2020[10]. A total of 75 fields were analyzed on water productivity using the AquaCrop simulation model and flying sensor imagery. The majority of the fields cultivated tomato and cabbage.

Table 5 indicates the range of the water productivity values found, thus indicating the fields with the lowest and highest water productivity. In addition, the average value is indicated from all the fields. The values that only indicate an average, and not a range, are based on one field and not multiple fields. For example, in Moatize there was only one maize field for the water productivity calculations.

The results show that Moatize has the highest average tomato water productivity, whilst Nhamatanda has the highest productivity for cabbage. For the onion fields the best results were in Báruè, with Moatize not having any onion fields. Lastly, maize and potatoes give varying values and are based on a small number of fields. Potatoes give the highest average water productivity result both in Báruè and Nhamatanda. The water productivity of potato crops are higher in comparison with other crop types, due to harvest index (i.e. harvestable yield compared to total biomass) being higher than the other crop types.

[9] Sanchez, A., Akker, J. van den, Levelt, Dd. Monitroing and Evaluation operationalisation report; Rainfed season 2018-2019, irrigation season 2019. (2020) APSAN-Vale.
[10] Van Opstal, J.D., M. de Klerk, A. Kaune, C. Nolet, J.E. Beard. 2020. Water Productivity Analysis: Irrigation Season 2020. FutureWater Report 218.

Table 5 Overview of water productivity results including range (minimum and maximum) and average (mean) per district and crop type

	Báruè	Moatize	Nhamatanda
Tomato			
Range [kg/m^3]	0.77 – 1.24	1.80 – 2.37	0.83 – 1.61
Average (mean) [kg/m^3]	1.03	2.13	1.32
Cabbage			
Range [kg/m^3]	1.10 – 1.75	1.42 – 1.63	1.36 – 1.69
Average (mean) [kg/m^3]	1.40	1.51	1.58
Onion			
Range [kg/m^3]	0.27 – 0.36	NA	0.36 – 0.73
Average (mean) [kg/m^3]	0.72	NA	0.54
Maize			
Range [kg/m^3]	0.45 – 0.99	NA	0.88 – 1.12
Average (mean) [kg/m^3]	0.32	1.69	1.01
Potato			
Range [kg/m^3]	1.48 – 1.90	NA	NA
Average (mean) [kg/m^3]	1.76	NA	3.01

5 Impact of interventions

For the crop yield results, as reported in Chapter 4, a crop yield score was provided as a value between 0 and 1. This method is described in section 3.4.1 with zero being the lowest crop yield score (the minimum value) and one the highest crop yield score. A crop yield score provides easy comparison between districts, which have differences in environmental conditions. In addition, different crop types can be compared, therefore enlarging the sample size for an analytical comparison between different practices. In the following sections, the impact of agronomic and water management practices are discussed using the crop yield scoring and the water productivity scoring. In addition, the last section reports on the perspectives of the farmers and if they perceived an increase of their production.

5.1 Impact of agronomic practices

A selection of agronomic practices are compared for differences in crop yield scoring, namely: use of herbicides, organic fertilizer, organic and chemical fertilizer, intercropping, mulching, and developing a business plan. The crop yield scoring of farmers that applied the practices are compared with those that did not apply the practices. Figure 6 shows the results of this comparison.

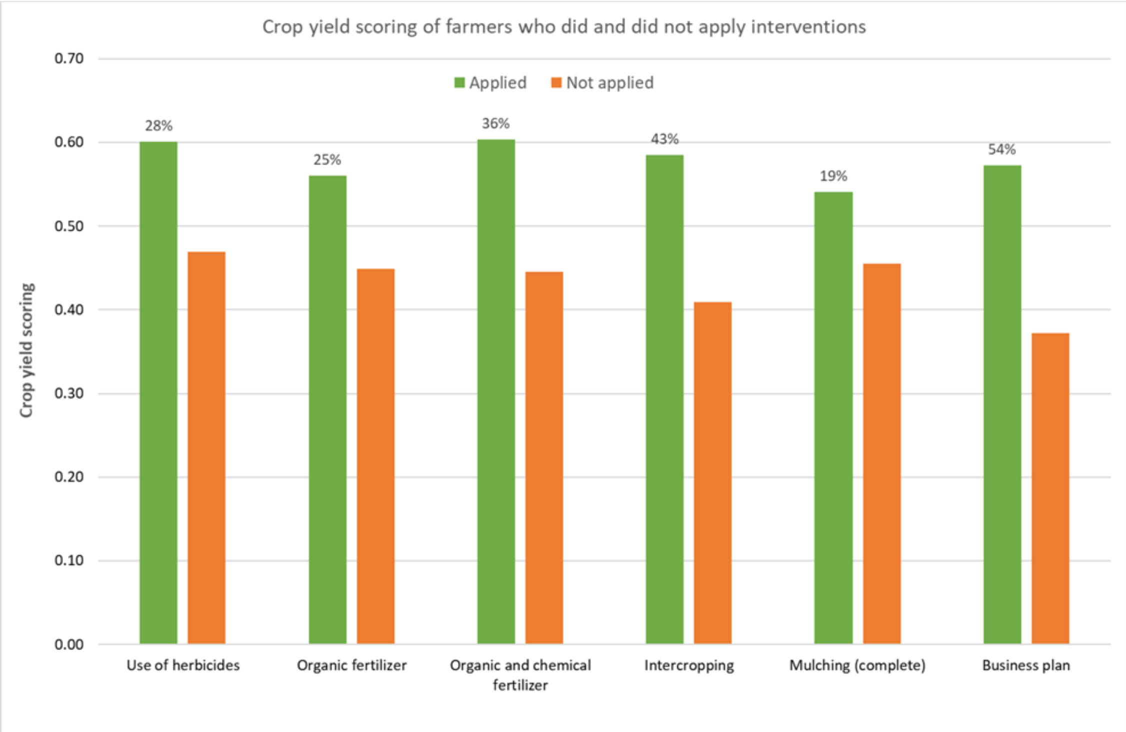


Figure 6 Crop yield score for farmers who applied or did not apply specific agronomic practices, with percentages indicating the difference between the two

All agronomic practices show that an increase in crop yield scoring was perceived. The highest increase was found for farmers that developed a business plan, which was 54%. Next the practice of intercropping showed a positive difference of 43%.
Additional inputs such as herbicides and fertilizers also show a positive impact of the practice. However, these practices required more resources for implementation, thus can be less likely to be adopted.

5.2 Impact of water management practices

The crop yield score and water productivity scores are compared for farmers that adopt different irrigation methods. Surface irrigation is practiced with furrows or buckets, whereas pressurized irrigation is practiced with sprinklers. The results of this comparison are shown in Figure 7.
For crop yield scoring, the highest values are found for furrow and sprinkler irrigation with a score of approximately 0.45. The crop yield score for bucket irrigation is lower than the other methods.
The water productivity score for sprinkler irrigation shows the highest value namely close to 0.7 in score. Both furrow and bucket irrigation were lower. However, both furrow and sprinkler irrigation require more effort for the installation of equipment and digging of furrows. After this effort, it is possible to farm a larger area, in comparison with bucket irrigation, which requires more labor and is not practical for larger fields.

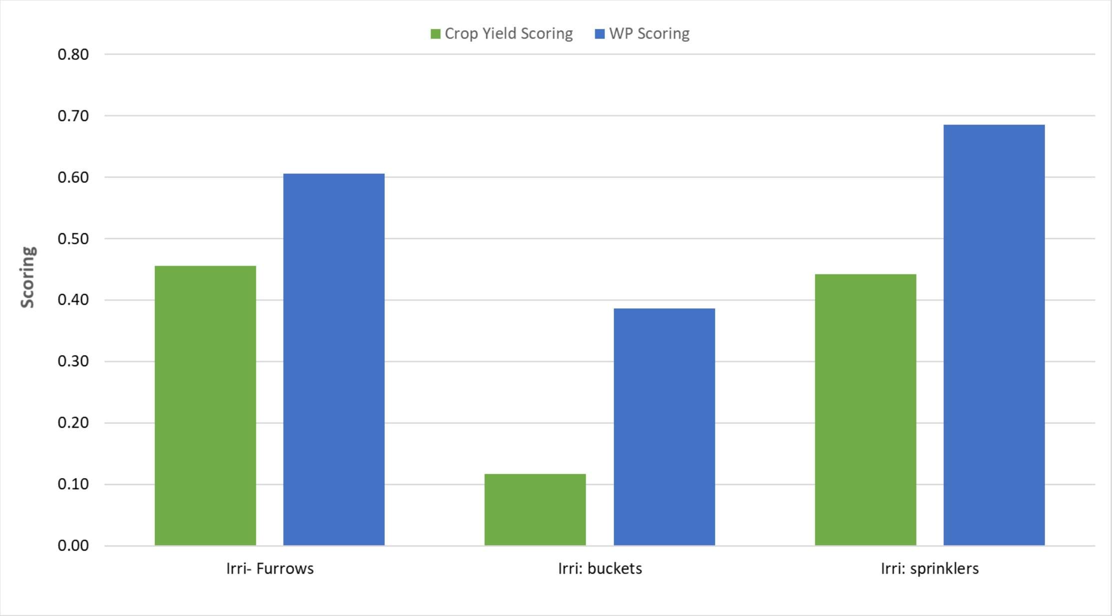


Figure 7 Crop yield score and water productivity (WP) score for different irrigation practices that were applied by APSAN-Vale farmers.

5.3 Perspective of farmers

The images below show farmer's perspective on increased productivity and income, and improved knowledge of irrigation practices. These results derive from the monitoring survey of November 2020 where 109 APSAN-Vale beneficiaries' perception are collected. 98% of the beneficiaries perceived their production increased and 96% of the beneficiaries perceived their income increased. 90% of the beneficiaries state they have improved knowledge of irrigation practices.
In the final impact analysis we will make a comparison of the production of 2019, 2020 and 2021 to quantify the perspectives of the farmers.

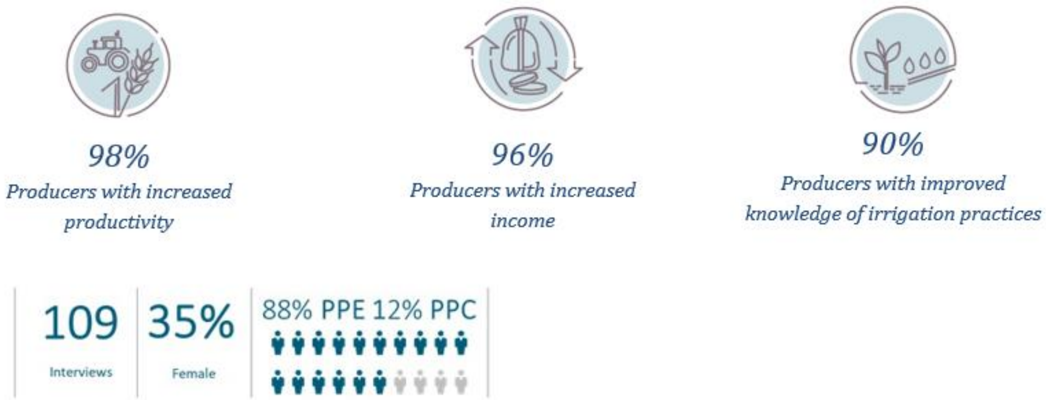


Figure 8 Results from farmers perspectives on production increases

6 Discussion

6.1 Adoption of practices and knowledge sharing

In the following paragraphs, we will provide an overview of adopted water management practices. A thorough analysis on the adoption of practices can be found in a separate report by Resilience[11]. In this report, qualitative and quantitative analyses have been done to identify the differences in adoption of practices and the most common and effective ways through which knowledge sharing happens.

There are several factors related to the adoptability of practices: costs, urgency, effect on production system, labour requirements, access to additional requirements and the location. Adoption of practices is influenced by the demand and effects on the production system as a whole. The level of the risk of the production (irrigation vs. rainfed) influences the farmers willingness to adopt a practice.
In the APSAN Vale approach we provide the farmers the tools and the understanding of practices that farmers may apply in their field to improve their production and income, but it is up to the farmer to actually choose which practice to adopt and apply of his/her field. Half of the practices (19/38) are adopted by 80-100% of the farmers. The transfer of knowledge is done in such a way that farmer understand and accept the practices and the adoption is based on the *capacity* and *choice* of the farmer.

Table 6 Overview of factors that influence adoption and examples of practices

Characteristics of easily adopted practices	Example of easily adopted practice	Characteristics of less adoptable practices	Example of less adopted practices
No-cost practices	Planting with a correct spacing (for irrigation), knowing when to irrigate, crop rotation	**High-cost practices**	Fertilizer and improved seeds for the rainy season, use of herbicides, use of certain irrigation materials
Practices that highly influence the production (urgency)	Land preparation and control of pest and diseases	**Practices that not clearly/directly show the added value**	Terrasses, dikes, drainage
Low labour requirements,	Preparing seedling beds	**High labour requirements**	Planting with the correct compass (during rainfed season)
Practices for a small area with more control on production	Buying improved seeds for irrigated production	**Practices for a larger area with less control on production**	Buying improved seeds for rainfed production
Easily access to additional requirements	Incorporating plant rests in the soil during weeding, manual ploughing	**Challenging access to additional requirements**	The grass for mulching, ploughing with tractor
Location dependent	Improved seeds	**Location dependent**	Construction of dikes or terrasses, types of irrigation materials

The farmers who have benefitted with the project strongly show that these farmers implement more complex and higher resources demanding practices than the control group. This shows that the methodology works because the project has identified potential farmers and is improving farmers' production systems.

[11] K. van Krieken, J. van den Akker. 2020. Analysis of adoption of practices in APSAN-Vale: Adoption and knowledge sharing of APSAN training topics. APSAN-Vale. December 2020

Low hanging fruit practices are heaping and staggering. These practices require knowledge but few extra resource and are highly adopted once encountered by the farmers; the practices are largely adopted by the APSAN-Vale farmers (heaping: 68%, staggering:78%) but barely implemented by the control group (heaping: 14%, staggering 2%). These practices could be shared with farmers as an entry point in future projects, to gain trust and credibility, after which the project can further share more complex and demanding practices.

> "The adoption is based on the ***capacity*** and ***choice*** of the farmer"

Although understanding the practice's effect of the production system may lead to a higher willingness to adopt a practice, in general practices are most likely to be adopted when a clear benefit on the production (in terms of quantity and quality) can be seen by the farmer. The increase of the production should thus be key to the training and demo-plot methodology. Focusing on training practices that are more likely to be adopted is also important to the project's methodology.

Important to reflect is that farmers are more willing to invest in practices in the production system in which they have more control, i.e. the irrigation season. It should be advisable to investigate low-cost and low-effort measures that increase control over rainfed production (such as water harvesting), which may lead to further willingness to invest in- and adopt practices. The African Union Framework for Irrigation Development and Agricultural Water Management[12], where the first pathway is agricultural water management, serves as a guide for policy makers and project implementation.

In the upcoming seasons, results should also show how understanding of knowledge transfers allow for forms to upscale the APSAN Vale approach.

6.2 Crop yield

<u>Crop yield data methodologies</u>

In our analysis we have encountered differences between the production results of the different methodologies. Table 7 shows the advantages and disadvantages of these methodologies and provides an explanation for these discrepancies.

Table 7 Overview of advantages and disadvantages of applied crop yield estimates methodologies

Methodology	Advantages	Disadvantages
Farmer recall	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 (FAO 66 publication)	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).

[12] https://au.int/en/documents/20200601/framework-irrigation-development-and-agricultural-water-management-africa

Crop yield data results of different methodologies

We have attempted to identify a consistency between the different methodologies to determine whether one methodology always reports lower yields than the other. With the correlation for all districts being below R=0.2, this did not seem to be the case. Figure 9 shows an example that there no consistent difference between the methodologies.

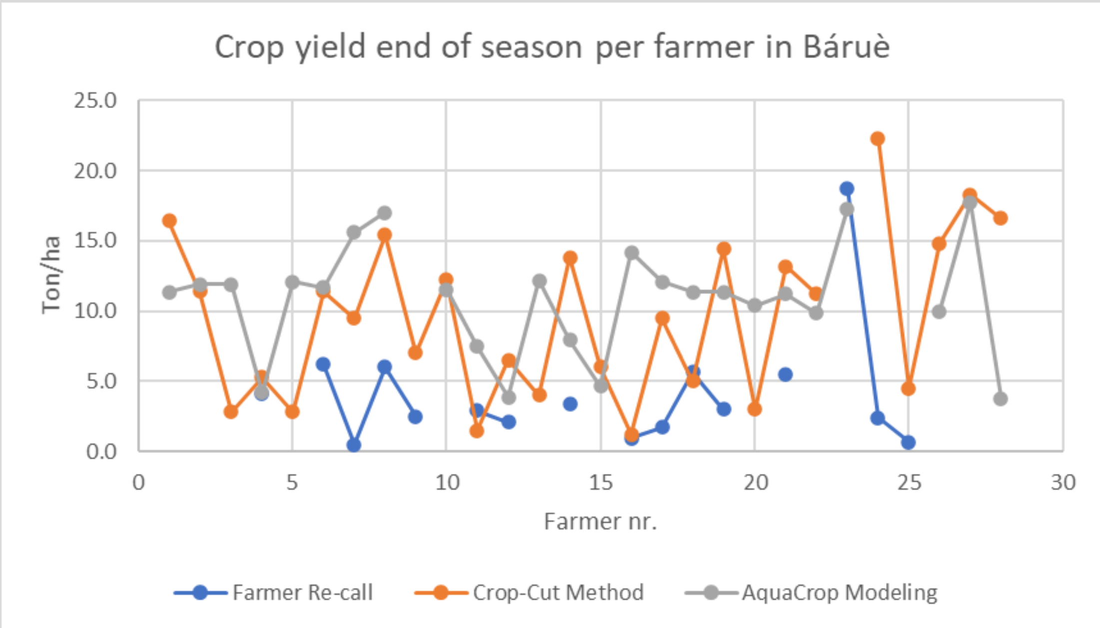


Figure 9 Crop yield data of selected crops in Báruè for all methodologies.

There is a discrepancy and no consistency between the different crop yield data collection methodologies. Our 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.

Lessons learned on crop yield data collection

For the upcoming production cycles (rainfed season 2020-2021, irrigation season 2021), the project will ensure the cut-crop method will be implemented carefully In addition, the project will put emphasis that the farmers fill out their farmer field books, to validate information through the crop diary methodology. This is in particular on the same plots that are measured with the drones to be able to validate the modeling results and compare them to the crop cut method so we can extrapolate the date for all the farmers..

6.3 Water productivity

The water productivity values show the range of the PPC farmers active in the APSAN-Vale project. These values are higher than the baseline analysis with an overall average of 33%, as reported in the Water Productivity Irrigation Season report[13]. The ranking of the water productivity results is best performed by comparing with the baseline or the average reported by the district office (SDAE).
In this analysis, a comparison between the crop yield and water productivity results was limited due to the inconsistencies between the various yield reports, as discussed in section 4.3. A logical trend between yield and water productivity could not be reported. In the continuation of this project, the comparison can be performed solely with the AquaCrop yield results, or alternatively include yield reports when the data is more consistent.

[13] Van Opstal, J.D., M. de Klerk, A. Kaune, C. Nolet, J.E. Beard. 2020. Water Productivity Analysis: Irrigation Season 2020. FutureWater Report 218.

6.4 Overall methodology

We are comparing the specific impact analysis PPCs. These farmers are already considered successful farmers. Then, we are scoring from one farmer to another. This might lead to a 'low' scoring, although compared to district averages the PPC has a high production. For the next impact analysis we suggest to compare the farmers to baseline crop production and water productivity instead comparing farmers amongst one-another.

We are working to improve production and income of all farmers, meaning the farmer has the option to implement 38 different practices. We promote a complete package of practices, suitable for the farmer. The impact analysis farmers 20 practices on average, and a minimum of 15 practices. As such, it is difficult to formulate an unambiguous conclusion on specific single practices. Furthermore, it seems outside the scope of the project to analysis the impact of a specific practice.

7 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. Both the lessons learned on the adoption and the achieved increases in productivity 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 37 PPC's and a total of 157 fields, which were monitored during the irrigation season of 2020. The main crop types in this impact assessment are tomato, cabbage, onion, potato, and maize. The data presented on crop yield, water productivity, and adoption of practices have been detailed in other project reports.

There is a discrepancy and no consistency between the different crop yield data collection methodologies. Our 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.
For the upcoming production cycles (rainfed season 2020-2021, irrigation season 2021), the project will ensure the cut-crop method will be implemented carefully In addition, the project will put emphasis that the farmers fill out their farmer field books, to validate information through the crop diary methodology. This is in particular on the same plots that are measured with the drones to be able to validate the modeling results and compare them to the crop cut method so we can extrapolate the date for all the farmers..

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

- A high percentage of the farmers adopt practices piloted by APSAN-Vale
- The adoption depends on a trade-off between effort required and expected outcome
- Several agronomic practices lead to higher crop yield score
- Sprinkler irrigation gave a higher water productivity score when compared to furrows and buckets

The impact analysis will proceed in the upcoming growing seasons of the project: rain season 2020-2021 and irrigation season 2021. Some lessons learned that will assist the upcoming growing seasons and further activities are:

- Case studies of specific farmers can be added to explain different trends of the analysis in higher crop yield or water productivity, or a selected practice
- Improved comparison between crop yield results and water productivity
- The crop yield results can be elaborated with values from PPE and the community to show the range of high and low productivity in the region. The scoring system will then be more indicative, with higher yields having a higher score.
- Improvements in the data collection and additional quality assessment of the data can assist in improving the analysis
- More business practices can be included in the piloted practices
- The economic aspect of practices can be included
- Field interventions can be distinguished between irrigated and rainfed agricultural 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							
1.1.2Land 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
21	22	23	24	25	26	27	28	29	35
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 plan	

Annex 2 Adoption of practices ungrouped