SECURING WATER FOR FOOD

FutureWater Evaluation

ThirdEye Project in Mozambique

NOVEMBER 2018

SECURING WATER FOR FOOD: A GRAND CHALLENGE FOR DEVELOPMENT

USAID FROM THE AMERICAN PEOPLE

Government of the Netherlands

Sweden Sverige

science & technology Department: Science and Technology REPUBLIC OF SOUTH AFRICA

Prepared By: Alice Kasznar Feghali
Masters student in Environmental Studies and Sustainability Science (LUMES) at Lund University
Center for Sustainability Studies (LUCSUS)

The Kaizen Company | Contract #: AID-OAA-C-15-00011
www.securingwaterforfood.org | securingwaterforfood@gmail.com

TABLE OF CONTENTS

I. INTRODUCTION 2

II. BACKGROUND 3
1. Gender 4
2. Farm size 5
3. Farmers' experience 5
4. Other occupations or sources of income 5

III. METHODOLOGY 4
1. Sample selection 4
2. Scope of survey and service reach 5
3. Other methodological considerations 5

IV. RESULTS 11
1. Types of information received by farmers from innovation 17
2. Water usage and benefits 24
3. Crop benefits 30
4. Farmers' incomes and income benefits 33
5. Poverty reduction benefits 35
6. Adherence to service 37
7. Gender differences in benefits 38
8. Regional differences 43

V. DISCUSSION 38
1. Crop and water benefits 46
2. Usage/availability 50
3. Innovation affected farm size and general benefits 52
4. Changes in income 53
5. Impact on poverty 54
6. Gender differences 54
7. Affordability of the innovation 55
8. Benefits for Leaders of Farmers' Association 55

VI. CONCLUSION 44

VII. REFERENCES 44

ABSTRACT

FutureWater's ThirdEye was a SWFF-supported infrared flying sensors project that created a group of flying sensors operators equipped with tools to analyze near infrared imagery in order to help farmers to make better decisions concerning the use of their limited resources, such as water, seeds and fertilizers. This report analyses the results obtained by the monitoring and evaluation field intern who conducted an evaluation survey in July and August 2018 in Mozambique, after the project had been active there for 3 years.

A sample of 62 predominantly female smallholder farmers were interviewed out of an estimated total of 2,891 farmers located in the areas where the project was carried out: surroundings of the towns of Xai-Xai and Chokwé, in Gaza province. Farmers were randomly selected through visits to their farms and data was obtained on household income, crop yields, water practices and expenses. Even though it was not possible to quantify changes in water usage, the innovation is seen as having a positive indirect impact over water efficiency in some areas by serving as encouragement for farmers to clean water channels or by providing the necessary justification to have fields leveled.

Even though 59% of farmers increased their yields over the period examined, other factors besides the innovation were identified by farmers as also having an impact over production, explaining why farmers' attitudes towards the innovation varied: 77% of farmers felt that the innovation was beneficial, even if indirectly, but 34%of the farmers felt either unsure or not interested in having the service continue.

I. INTRODUCTION

In Sub-Saharan Africa, where most of the population depends on subsistence farming and have low access to agricultural inputs, decisions concerning resources (such as seeds, water, fertilizers, pesticides, etc.) become challenges that can directly impact on food security and nutrition. In Mozambique, agriculture is the main economic activity, being carried out by small-scale farmers that are responsible for 95% of the country's agricultural production (FAO, 2018). Most of Mozambican farmers practice subsistence agriculture and suffer from extreme weather events, such as floods and droughts (USAID, 2018).

ThirdEye thus intends to increase efficiency in food production by providing farmers with FutureWater, a service that brings relevant information to farmers by setting up a network of flying sensors operators, which can detect crop stress two weeks before the human eye can actually see it (ThirdEye, n.d.). According to the innovator's description of the service, the operators fly sensors over farmland, obtain and analyse imagery and then inform farmers of the current situation in their fields. With this information farmers would be able to improve farm management and make efficient use of resources and inputs by knowing where to use them in their farms (ThirdEye, n.d.).

FutureWater (hereinafter "service" or "innovation") has been implemented in Mozambique, in the surroundings of the towns of Xai-Xai, Chokwé and Moamba and also in Kenya. In Mozambique, which is the focus of this report, the project was carried out from 2014 to 2017, and, according to ThirdEye's website (ThirdEye, n.d.), reached more than 3,500 farmers and 1,600 hectares (the number informed in the innovator's last report available to the evaluator was of 2,892 "active users").

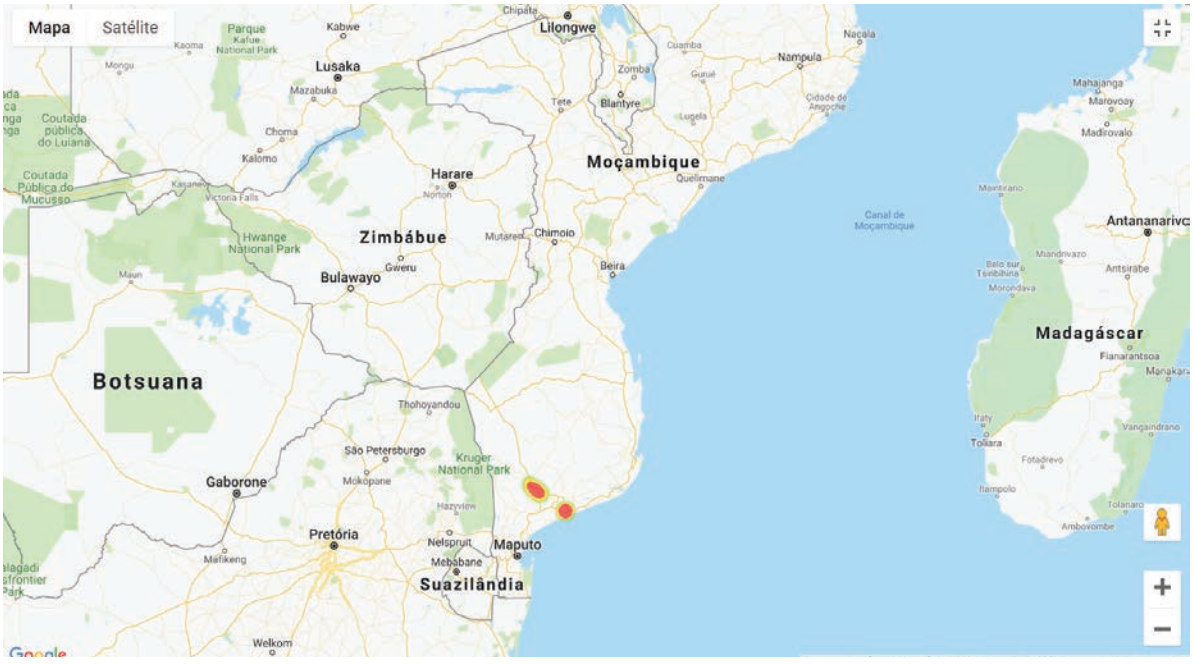
In July and August 2018, an impact assessment was carried out by a SWFF Field Evaluator, who interviewed 63 farmers that stated they had used the ThirdEye service in Mozambique. Farmers were randomly selected through visits to their farms and data was obtained on household income, crop yields, water practices and expenses. The main purpose of the assessment was to understand the benefits, limitations and impacts for farmers using ThirdEye innovation, which will be detailed here.

II. BACKGROUND

In their reports, ThirdEye supported a total of 2,892 active ThirdEye farmers in the third year of the project in Mozambique receiving the service, comprising the regions of Xai-Xai, Chokwè and Moamba (Table 1). Interviews were conducted in-person by the Monitoring and Evaluation field intern with the assistance, when needed, of a translator (as detailed in the Methods section below). The evaluator followed a questionnaire available in the Fulcrum App, comprising approximately 45 questions. Answers were inputted in the mobile-based version of the Fulcrum App during the interviews, which were also recorded with a mobile phone app. After collected, data from the Fulcrum App was processed in Excel.

In this assessment, farmers in Xai-Xai and Chokwè were surveyed. In Xai-Xai farmers work in the Nhampondzoene Association, which is divided in blocks and sub-blocks. In the surroundings of Chokwè, farmers are located around dickes and channels, in different associations or individually. All of the locations covered by the service, as informed in ThirdEye reports provided to the evaluator, were visited by the interviewer, except for Moamba, where there is only one farmer using the service. Since this farmer is not a small scale farmer and only started using the service in 2017 he was not included in the survey.

MAP 1. HEATMAP OF FARMERS INTERVIEWED IN THE SURROUNDINGS OF CHOKWÉ AND XAI-XAI, IN THE GAZA PROVINCE IN MOZAMBIQUE

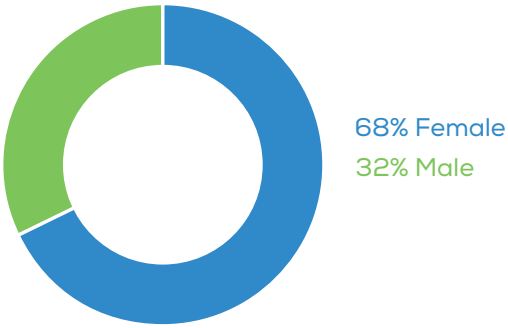


1. GENDER

Approximately 52% of Mozambicans are women in both rural and urban areas. The percentage of women in the Gaza province, where the innovation was active in Mozambique, is of 54% (Instituto Nacional de Estatísticas, 2017). However, subsistence agriculture has become an activity mostly practiced by women, which means that most small-scale farmers are women (Oliveira, 2016). In this survey, women constitute the majority of respondents: 68% (42 out of 62) of them were women and 32% (20 out of 62) of them were men, as illustrated in Graph 1 below.

GRAPH 1. GENDER OF INTERVIEWED FARMERS

n=62



This is also in accordance with the gender distribution previously identified by ThirdEye among the total number of active users of the service (71% women farmers in the third year of the project). It also relates to the general distribution of gender roles in the country, where most of subsistence agriculture is practiced by women, who not only sow and cultivate crops, but are also the ones commercializing their produce informally in urban centers (Oliveira, 2016).

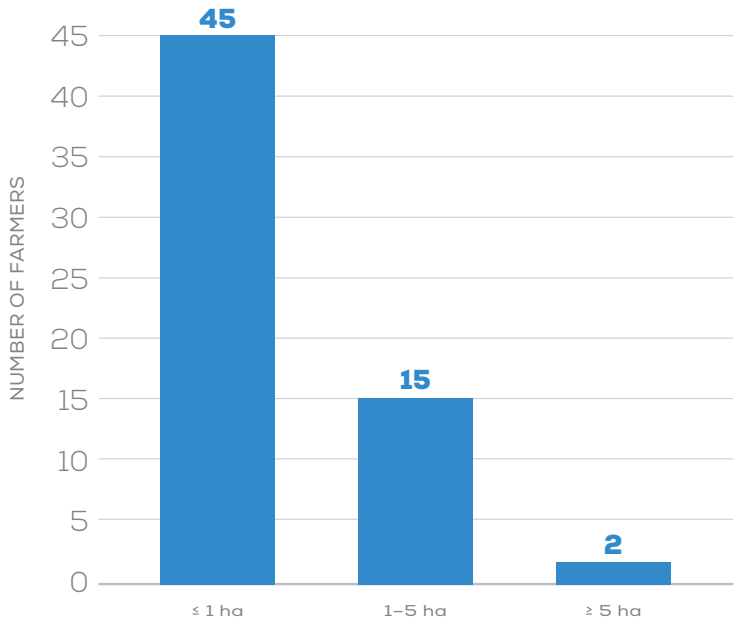
PHOTO 1. Women farmers in Xai-Xai collecting sweet potato leaves.

2. FARM SIZE

Most farmers in the region practice small-scale agriculture, as is clear from Graph 2 below, which presents range of land size owned by respondents. 73% of farms (45 out of 62) are smaller than 1 hectare (10,000 m²), 24% of farmers (15 out of 62) have farms bigger than 1 ha and up to 5 ha, and only 3% (2 out of 62) of farmers own farms with area equal or greater than 5 ha. This is in line with the national context, where 99% of farming units are smaller than 5 hectares (Oliveira, 2016) .

GRAPH 2. RANGE OF LAND SIZE OWNED BY INTERVIEWED FARMERS

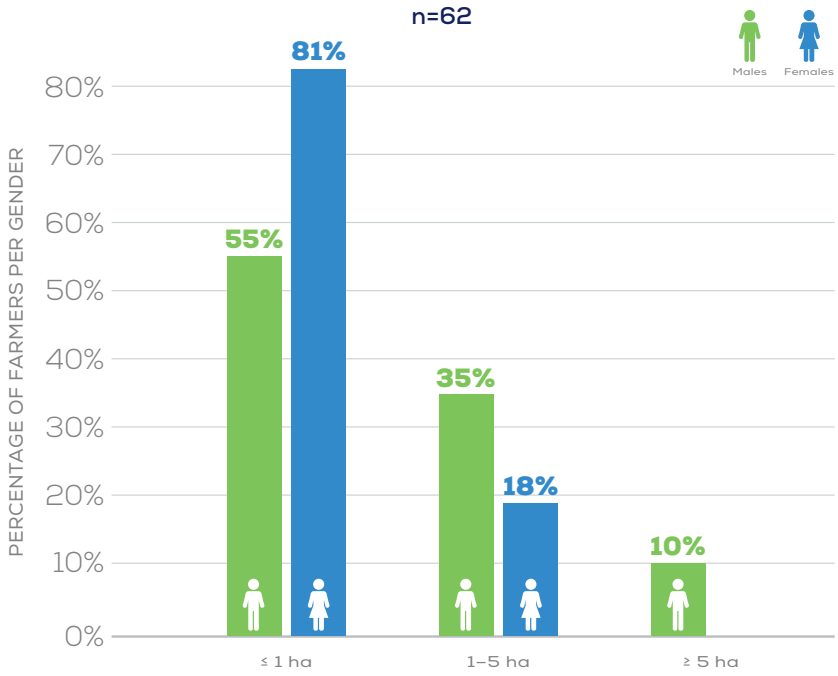
n=62



The average farm size owned by interviewed farmers is of 2.79 ha and the median is 0.5 ha. However, one farmer out of the 62 respondents owns 72 hectares and another farmer owns 15 hectares, which is much above the average. Excluding these larger farmers, the average land size in the sample would be of 0.99 hectares per farmer.

Women respondents own smaller farms than men: 81% of the women (34 out of 42) have farms up to 1 ha, while only 55% of the men have farms up to 1 ha and only men own farms larger than 5 hectares, as shown in Graph 3 below.

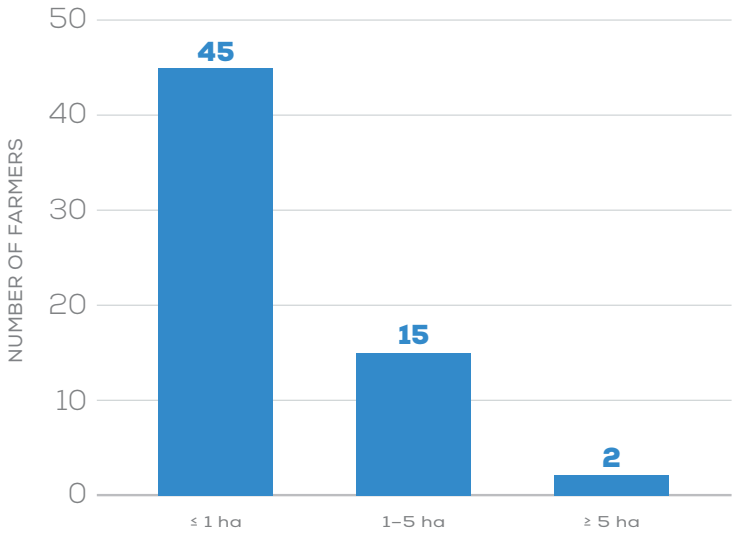
GRAPH 3. SIZE OF FARMS OWNED BY PERCENTAGE OF FARMERS OF EACH GENDER



The area affected by the innovation is smaller than the total area owned by farmers since some farmers have land in areas where the innovation is not active. Including the two larger farmers, the average area affected by innovation per farmer is 1.5 hectares and the median, 0.5 hectares. Excluding the larger farmers, the average area affected by the innovation per farmer is 0.8 hectares. Graph 4 below presents the data on size of innovation affected areas owned by farmers.

GRAPH 4. SIZE OF INNOVATION AFFECTED AREAS OWNED BY FARMERS

n=62



For the sake of understanding how the innovation impacted local farmers, yields and and information on crops and farming practices, as presented in the following sections, were asked only about areas affected by the innovation.

It is also important to clarify that in Mozambique farmers do not own land, since all land is property of the state. Individuals and organisations are granted the right to use the land and this can either be done informally or though the issuance of an official document (Magin, 2015). For the purpose of this survey, "land owned" is land used by the farmer independent of how he/she has acquired it. In some cases farmers had either borrowed from or lent land to other people and in all these cases no monetary compensation was established between the parties. Use of land was compensated through exchange of services (keeping the land weeded, rotating the soil, borrowing tools).

3. FARMER'S EXPERIENCE

A relevant number of farmers (39% or 24 out of 61 respondents) were not sure when they had started using the service. 61% (37 out of 61 respondents) informed the year they thought they had started using the service, presented in Table 1 below. The high level of uncertainty among farmers may be due to the fact that the innovation is not a product that was acquired by the farmers, did not require a monthly payment or frequent maintenance, but only depended on the visit by a drone operator to the farm, which happened sporadically.

TABLE 1. YEARS INDICATED BY 37 FARMERS THAT COULD INFORM WHEN THEY STARTED USING THE SERVICE

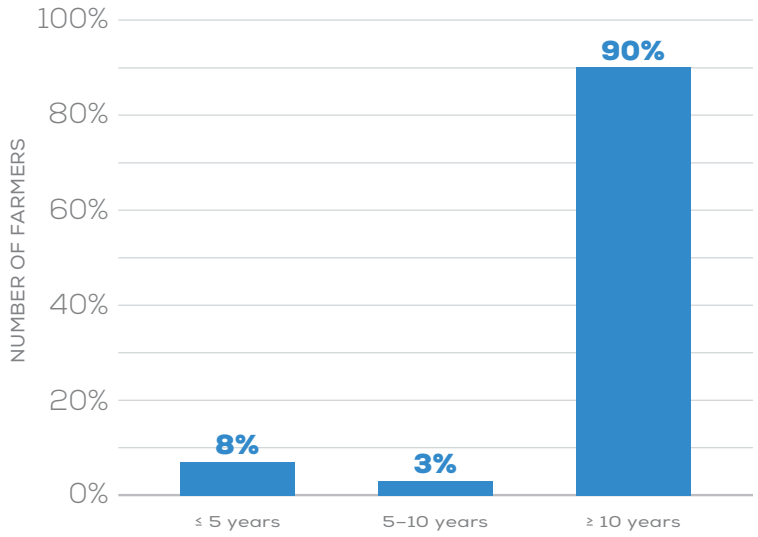
Year	Number of farmers who thought innovation started in this year	Percentage of the sample (N=37)	According to innovator, service started in this year for this percentage of farmers in the sample (according to their locations)
2015	15	40.5%	63%
2016	15	40.5%	37%
2017	17	19%	0

When comparing ThirdEye's reports referring to the year in which the service started in each location with the location of the 37 respondents presented in Table 1 above, there is a difference in timing. 63% (or 20 out of 37) of the respondents were farming in locations that started receiving the service in 2015 and 37% (or 17 out of 37) were located in areas that started receiving the service in 2016, as informed by the innovator. No new locations started receiving the service in 2017. Many reasons could have caused a delay in farmers not receiving the service as soon as it was active in their locations (incompatibility between drone operators' schedule and the farmers') or farmers not remembering the year in which service started correctly.

All the farmers interviewed were working in their farms at least 1 year before the service started so that comparisons could be drawn with farmers' previous yields. 30 farmers out of 57 respondents were precise when informing for how long they had practiced agriculture. 12 other farmers said they had been farming for more than 10 years. From this group of 40 farmers, 8% (3 out of 40) of the farmers had been farming for up to 5 years, 3% (1 out of 40) had been farming between 5 to 10 years, and 90% of the farmers (36 farmers out of 40) had been farming for more than 10 years, as presented in Graph 5 below. The other 17 farmers declared they were farming for at least a certain number of years, but were not precise, thus, were not considered.

GRAPH 5. RESPONDENTS' EXPERIENCE (IN YEARS) IN FARMING

n=40



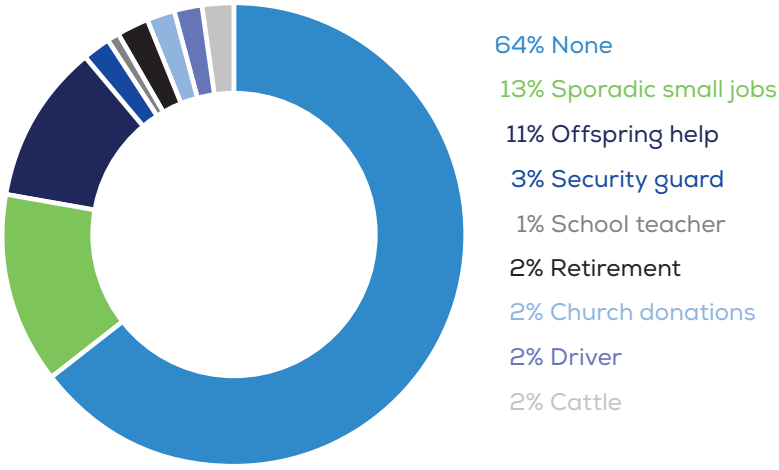
4. OTHER OCCUPATIONS OR SOURCES OF INCOME

Most of the respondents (64% or 40 out of 62) have no other income source in their households besides farming (Graph 6). 3 of these farmers said that besides managing their own farms they also carry out sporadic small jobs for other farmers such as weeding their farms for a daily payment (of around MZN 100), which they use to buy inputs for their farms.

In other sectors of economy, 8 farmers declared to have sporadic income in their households coming from small jobs in the services sector, such as carpentry (1 respondent), collecting straw (1 respondent), sales (1 respondent), construction (2 respondents), and mining (2 respondents). 2 farmers declared that her husbands are security guards and one of these farmers also said that she raises cattle for financial emergencies, selling them when needed. One farmer is a school teacher (in the afternoons) and one farmer is a church leader, that receives church donations, and another farmer declared that her husband is retired. 7 farmers informed that they receive some kind of financial help from their offspring who work.

GRAPH 6. PERCENTAGE OF FARMERS THAT HAVE OTHER SOURCES OF INCOME BESIDES FARMING

n=62



III. METHODOLOGY

1. SAMPLE SELECTION

Sampling was done by visiting the farming areas, walking through the fields spotting farmers working on their land and asking if they had used the innovation. If they responded positively, then an in-person interview was conducted on the spot. Some farmers did not immediately understand about which service we were asking, so a set of introductory questions and explanations was established to help them recall the innovation ("Do you remember the drone that flew here?" "Do you remember when a drone operator/technician came speak to you and show images that the drone had taken of your fields?" or "Did the leader in your association share the drone information with you and other farmers?")

In total, 62 farmers were interviewed out of 2,982 "ThirdEye Active Farmers" (as users were called in the innovator's reports), that were spread around the locations identified in Maps 1 and 2 below. The total number of farmers per location and of interviewees is detailed in Table 2 below.

MAP 2. CLOSER LOOK AT RESPONDENTS'LOCATIONS IN THE SURROUNDINGS OF CHOKWÉ XAI-XAI

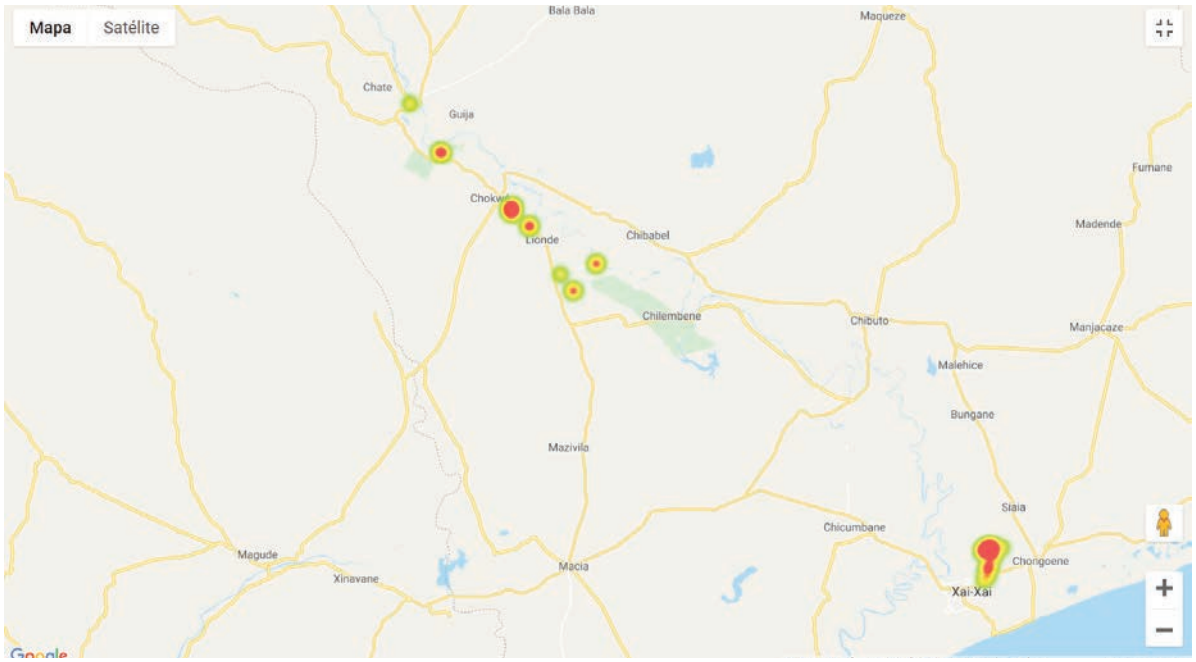


TABLE 2. LOCATION OF "ACTIVE THIRDEYE FARMERS", AS INFORMED BY INNOVATOR AND NUMBER OF INTERVIEWED FARMERS PER LOCATION

Location	Area	Total Active ThirdEye Farmers (in year 3)	Number of interviewed farmers
Xai-Xai	Nhampondzoene Block 1, Subblocks 1-12	498	9
Xai-Xai	Nhampondzoene Block 2, Subblocks 1-12	518	10
Xai-Xai	Nhampondzoene Block 3, Subblocks 1-6	262	7
Xai-Xai	Nhampondzoene Block 4, Subblocks 1-6	103	6
Xai-Xai	***Subtotal***	***1381***	***31***
Chokwè	D5A	103	8
Chokwè	D5B	108	5
Chokwè	Canal Esquerdo	0	0
Chokwè	D6	98	4
Chokwè	D11	296	4
Chokwè	D12	539	3
Chokwè	Macarretane	366	6
Chokwè	***Subtotal***	***1510***	***30***
Moamba	Carthage	1	0
Total		***2892***	***62***

Source: First 3 columns were based on data provided by ThirdEye, fourth column is based on the present survey.

Sampling could not be done based on a contact list of innovator's users since neither the innovator nor the leaders of associations had these lists ready. When speaking to the leader of the Nhampondzoene Association in Xai-Xai he was not sure of the number of farmers that had had access to the innovation. In fact, not using associations as a criteria for organizing the sample proved to be more appropriate since some farmers interviewed in the Chokwè area had used the service and had not been part of an association in their area.

For the chosen sampling method to work, the field intern had to be accompanied by drone operators who knew the farming areas, how their subdivisions (in blocks and dickes) were organized, the roads to reach them and how to walk around in these areas, which are a maze of water channels. To ensure randomness, every morning before entering the field, the evaluator chose a path to walk that would cover a reasonable amount of area for that day and the drone operator was not given the chance to choose beforehand which farmers to visit in the field. Farmers were spotted while the team walked in the fields.

The initial plan was to have the sample in proportion to the number of farmers in each location, which was achieved in Xai-Xai. In the Chokwé region, on the other hand, this was not possible since locations were almost empty when we visited them. For instance, even though the D12 area has the highest number of active ThirdEye farmers, the region is mainly used for rice plantation, which was only going to start in October. The D5A area, on the other hand, has less users, but many users of the service were present when the evaluator came to visit.

PHOTO 2. From left to right, Francisco Manjate (Leader of the Farmers' Association in Xai-Xai), the Field Evaluator and Dércio Chissaque, former drone operator for ThirdEye.

One benefit of this sampling method is that it did not rely on leaders' suggestions or a previous selected list of users, which made the sample free from any possible bias or underlying interests that leaders could have in referencing certain farmers. It also ensured randomness, since the field intern did not know the farmers beforehand or how they were spread out in the fields, or even who would be working on the days she visited the farming areas. It also allowed the evaluator to see farming practices in loco and gather important evidence through observation.

On the other hand, this method brought relevant limitations. First, as interviews were not previously scheduled and farmers were not expecting to stop their work to answer a long survey, this limited how thorough and detailed the interview could be. Also, as interviews were carried outdoors, weather conditions played a relevant role, specially in the first week of interviews in Xai-Xai, which were carried out under heavy rain and low temperatures, which lead the evaluator to reduce the number of follow-up questions. For these reasons, not all interviewees answered all questions, since some questions were prioritized over others and whenever possible, questions were answered through direct observation of evidences in the farm. The number of respondents of each question in informed as "N" in this report.

The drone operators also worked as translators when needed (Picture 2). Some farmers could understand Portuguese as spoken by the Field Evaluator, (who is a national of Brazil), but not all of them had the level of fluency necessary to provide thorough answers for questions that required higher levels of abstraction, especially, making connections between the drone flying over their land, the imagery presented to them and how this could have affected their farming decisions. The fact that the drone operator was present during the interviews does not seem to have affected farmers' disposition to speak honestly. In the one hand, not all farmers knew the operator (since there were different operators working in different regions) and the evaluator made sure to emphasize that it was important that farmers were honest about their thoughts.

It proved quite helpful to have the drone operator in the field since some farmers were mistaking the innovation with SDAE (Serviço Distrital de Atividades Econômicas), a state-run service to instruct farmers on better agricultural techniques. SDAE had been active in the same region as the innovation before the innovation was active and also consisted on a technician coming to speak to farmers about their farming practices in their land. During the interviews then, in many occasions, drone operators had to help farmers distinguish the service we were asking about, by showing their tablets or detailing their routines.

In Chokwé, where one of the drone operators also worked as an SDAE technician, distinguishing the impact of the innovation from that of the SDAE service was a complex task, that was not always possible.

PHOTO 3. Translator greeting a farmer, early morning in Xai-Xai.

2. SCOPE OF SURVEY AND SERVICE REACH

The survey was targeted only at users of the service, so if a farmer answered that he/she had not used the service, the interview was not conducted with him/her. However, after walking in the fields in Xai-Xai for some days asking farmers about ThirdEye's service and receiving many negative answers, concern arose about the actual reach of the service. For instance, in one day walking around Block 3 in Xai-Xai, the evaluator met 6 farmers, besides the 4 interviewed farmers on this day, who said they had never spoken to the drone operator.

As this was not part of the scope of the survey, the total number of farmers identified that had not used the service was not assessed, neither were the reasons for this to happen. However, speaking to drone operators about how the service was offered to farmers and observing the frequency of farmers in their land could help bring some understanding to the reasons why some farmers did not have access to the service or answered negatively.

According to one drone operator in Xai-Xai, the service worked in the following way. Per week, each drone operator had 2 missions. In one mission they flew over 2 sub-blocks and then went to speak with up to 15 farmers from these 2 sub-blocks. In one month, they had to carry out 6 missions, so they flew 12 sub-blocks per month and were expected to speak to 90 farmers in total. The maximum number of drone operators in Xai-Xai working simultaneously was 3, which would lead to a maximum of 270 farmers visited per month in Xai-Xai when all of them were working. ThirdEye, in the document entitled "Appendix 1.1B Breakdown of ThirdEye Farmers" identified 1,381 "active ThirdEye farmers" in Xai-Xai. If the drone operators visited different farmers in every mission, it would have taken them around 5 months to have spoken at least once to all the farmers in Xai-Xai. If operators, for different reasons (such as farmers absence on that day, bad weather, inaccessible areas, etc.), spoke to the same farmers in their missions, this means that a relevant parcel of the farmers identified as ThirdEye "active farmers" were seldom visited by a drone operator.

On the other hand, there are other possible reasons we could think of for why farmers answered that they had not spoken to a drone operator before, such as: (a) They had just recently started working on that land, (b) They share the land with someone else who comes to the farm more often, (d) They were receiving information through someone else (association leader, for instance) instead of directly speaking to the drone operator, (e) They did not want to speak to the drone operator, etc. However, all these are only hypotheses, since the real reasons were not assessed and would require further research. The evaluator also met 3 farmers during the entire survey who remembered speaking at least once to a drone operator but could not remember anything the operator had told them or what the service was about. These farmers were not interviewed.

3. OTHER METHODOLOGICAL CONSIDERATIONS

The fact that the innovation was considered to be active in the region from a certain year does not necessarily mean that farmers started having access to the service in that year, since this depended on the operator visiting the farm or not. When comparing changes before the innovation was active and after farmers had used the innovation, farmers were asked to provide information on their yields and practices before they started using the service. Some farmers could not tell exactly when this happened and in other cases, dates varied from farmer to farmer even within a same region, since farmers were visited by the drone operator in different moments. Whenever a farmer did not know when he began using the innovation, he was asked to provide information from before the innovation was officially active in his region. When asked to provide information after the use of the innovation (that is, after receiving information from drone operator), preference was given to the most recent yields and practices, in general yields from the end of 2017 or beginning of 2018 (depending on the crop cycle). The assumption here was that once the farmer received information from the drone operator, the effects of the service would be felt in the following yields since it took farmers some time to solve the issues identified by the service or to implement new techniques in the following seasons.

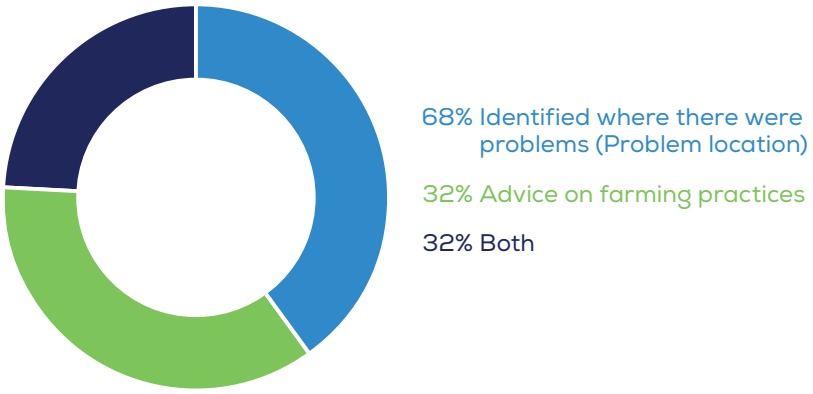
IV. RESULTS: Benefits of Innovation

1. TYPES OF INFORMATION RECEIVED BY FARMERS FROM INNOVATION

The innovation affected farmers and their practices by providing them with information that was brought to them by the drone operators. Among the farmers who remembered to have spoken with a drone operator at least once and were able to explain what kind of information they had received (55 farmers), 40% of them (22 out of 55) said that the drone operator had informed them where certain issues were located in their farms. 36% of the farmers (20 out of 55) declared that the operator had given them some form of advice on farming practices. 24% (13 out of 55) received both types of information combined. These results are summarized in Graph 7 below.

GRAPH 7. TYPES OF INFORMATION RECEIVED FROM DRONE OPERATORS AS RECALLED BY FARMERS

n=55



It is possible to breakdown farmers' description of information they received even further, since 46 (out of the 55) farmers gave detailed answers on the main issues/matters they received information on. For the first category of information (identifying where there were problems in the farm) there were 8 different themes, listed in Table 3 below.

TABLE 3. LIST OF ISSUES THAT FARMERS RECALL WERE IDENTIFIED BY DRONE OPERATOR IN THEIR FARMS AND HOW FREQUENTLY THEY WERE MENTIONED [1]

Issues that farmers recall were identified by drone operator in their farms	Number of farmers that mentioned receiving information on the issue	Percentage of farmers (N=34)
Good/bad soil	16	47%
Pests	9	26%
Clogged channels	8	24%
Crop stress	4	12%
Unlevelled fields	3	9%
Flooding	1	3%
Confirmed what farmer was seeing	1	3%
Where to irrigate	1	3%

When it comes to the second category of information (advice on farming practices), farmers recalled receiving advice on 12 different topics relative to farming practices. The topics that were mentioned the most were related to pests (treating and avoiding them) and methods and techniques to sow and cultivate crops, as presented in Table 4 below.

TABLE 4. LIST OF TOPICS RELATED TO FARMING PRACTICES THAT FARMERS RECALL RECEIVING ADVICE ON BY DRONE OPERATORS AND HOW FREQUENTLY THEY WERE MENTIONED

ITopics related to farming practices that farmers recall receiving advice on by drone operators	Number of farmers that mentioned receiving information on the issue	Percentage (N=31)
How to treat/avoid pests	9	29%
How to sow and cultivate crops	9	29%
Correct crop spacing	8	26%
How to use fertilizer	7	23%
How/when to irrigate	6	16%
Which crop to plant	3	10%
Causes of crop stress	2	6%
Stop burning weed	2	6%
Confirmed or encouraged continuation of good practices	2	6%
Explained crop stress	2	6%
Correct time to plant	1	3%
How to recognize stressed crops	1	3%

1 For the data summarized in Tables 4 and 3, topics were counted as mentions. Farmers mentioned at least one topic, meaning they and can also have mentioned more than one topic for each category of information.

Again pests were a major theme discussed with the drone operators and many farmers who received this type of information (29% or 9 out of the 31) received some kind of advice on how to treat or avoid pests (which pesticide to use, how much to use, when to use it, etc.). The second most common topic was advice on how to sow and cultivate crops: again 9 out of the 31 farmers who received advice on farming practices (or 29%) received advice on these matters. This category also included any general mentions on "how to plant" crops.

In the table above, farmers mentioned "pests" in general, but there is one specific pest that has been a common problem to many farmers and was frequently mentioned throughout the interviews as a main cause for reduced yields or for not producing as much as planned: rats. Out of 62 farmers, 9 farmers (14%) explicitly complained, in some point of the interview, of how rat infestations affected their yields and motivation to farm. 3 of these farmers explicitly said that the drone did not have a positive impact on their work because it is not able to identify or solve the rat infestation in their farms. In fact, while walking around the fields in Xai-Xai the evaluator met a group of boys who were hired to try to eliminate rats in some farms.

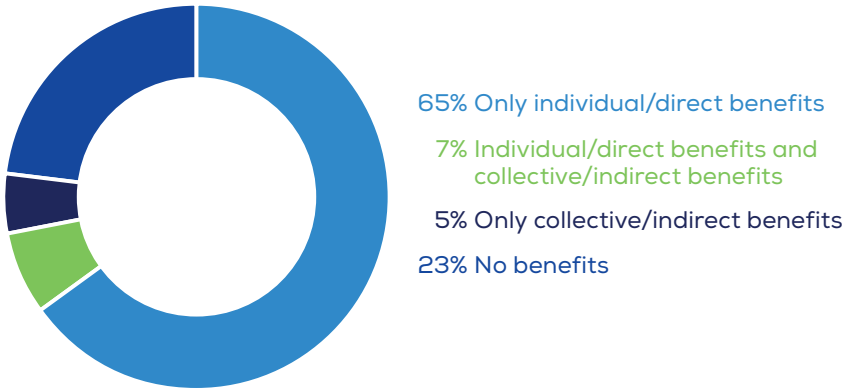
1.1. Perception of general benefits from innovation

Out of the 60 users that spoke about general benefits they perceived from innovation, 77% of them (46 out of 60) felt that there was some kind of benefit (direct/indirect) from the information they received while using the service and 23% of them (14 out of 60) felt that there were no benefits whatsoever. As summarized in Graph 8 below, from the 46 who perceived some kind of benefits,

- 39 farmers (or 65% of the sample of 60 respondents) felt that there was only an individual or direct benefit from the information provided by the service;
- 4 farmers (or 7% of the 60 respondents) thought that there was both an individual/direct benefit and an indirect/collective benefit;
- 3 farmers (or 5% of the 60 respondents) thought that it brought an indirect/collective benefit, even though they did not find any individual/direct benefit from the service.

GRAPH 8. PERCENTAGE OF FARMERS PER TYPE OF BENEFIT PERCEIVED

n=60



3 of 43 farmers that felt an individual/direct benefit from the use of innovation also declared that, besides the information received from the operator, an important benefit of the innovation was that it made them feel more motivated to work after the drone operator visited their farm.

In total, there were 7 farmers (12% of the sample of 60 farmers) that perceived a collective/indirect benefit from the use of the service. The indirect benefits identified by these farmers are listed in Table 5 below. Of these 7 farmers, 3 have leadership positions (2 are leaders in their farmers' associations and 1 is a member of the board in the association). Benefits of the service for leaders will be further discussed in Section IV.8 below.

TABLE 5. LIST OF INDIRECT/COLLECTIVE BENEFITS GENERATED BY USE OF INNOVATION IN THE REGION AS PERCEIVED BY FARMERS

Consequences of the service	Possible Indirect/collective benefit	Number of farmers that mentioned it
Encouraged farmers to clean water channels	Can improve water circulation and availability	2 + 1 Leader
Encouraged farmers to keep their farms clean	Can decrease the spread of pests	2 + 1 Leader
Farmers in general feel ike someone is checking on his/her progress	Can make farmers encouraged/ pressured to work	1
Unlevelled fields	3	9%
Flooding	1	3%
Confirmed what farmer was seeing	1	3%
Where to irrigate	1	3%
Leaders of Association have an overview of the entire farming area and where problems are located	Allowed leaders to speak to farmers and try to help them solve issues or encourage them to work more	
Produced images of the farming area	Leaders of associations could use images to confirm their observations or have more evidence to convince farmers to work	

As mentioned before, 28% of respondents (17 out of 60) did not feel that using the innovation brought them any kind of benefits. The reasons given by these farmers for this negative perception are summarized in Table 6.

TABLE 6. LIST OF INDIRECT/COLLECTIVE BENEFITS GENERATED BY USE OF INNOVATION IN THE REGION AS PERCEIVED BY FARMERS

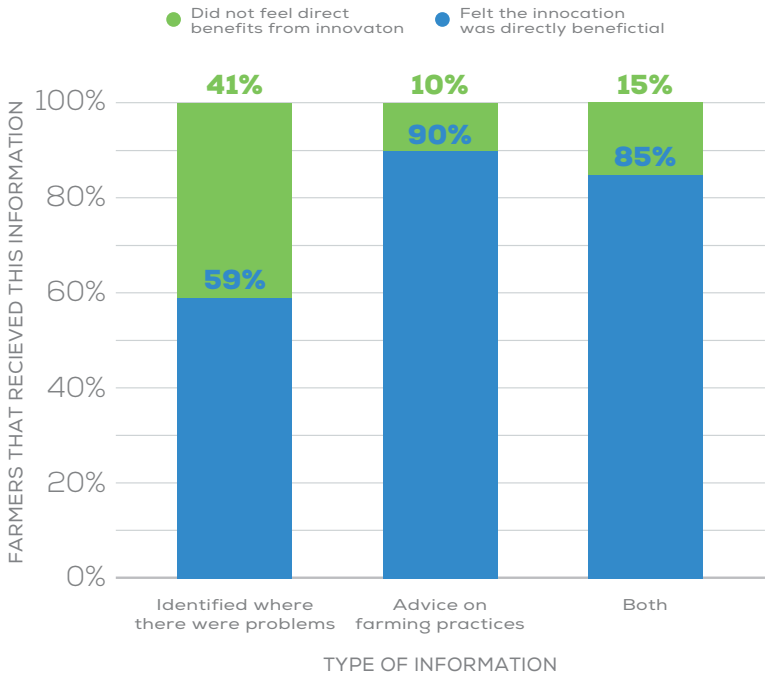
Why no benefit?	Number of farmers that mentioned the reason (N=17)
Could not afford solution	7
Could already see the problem	5
Just identifying where problems are located is not really helpful, drone does not fix the problem	4
Has other factors that impact much more her production (pests, weather) that the drone does not fix	2
Could not understand the images and how they would be helpful	1
Did not know how to fix the problem	1
Already produced well	1

The 3 most common reasons given by farmers are related to the innovation's main purpose, i.e, to inform farmers where problems are located in their farms. This type of information, however, did not bring these farmers positive change either because they could not afford the solution to the problem (normally, buying pesticides or fertilizers), or did not know how to fix the problem or because the innovation in itself does not provide a solution to the problem that had already been identified by the farmer.

On the other hand, when comparing which type of information provided made most farmers perceive benefits, data suggests (Graph 9) that the type of information deemed as most beneficial to farmers was not the main scope of the innovation, but rather advice on farming practices.

GRAPH 9. NUMBER OF FARMERS THAT PERCEIVED BENEFITS FROM USE OF INNOVATION PER TYPE OF INFORMATION FARMERS RECEIVED

n=55



As summarized above, 59% (13 out of 22) of farmers who received information on where a problem was located in his/her farm perceived a benefit from the use of innovation, while 90% (18 out of 20) of those who received advice on farming practices and 85% (11 out of 13) of those who received both types of information felt they benefited from innovation.

This helps explain why when farmers were asked how could the service improve, 56% of respondents (19 out of 34) said that the service would be more effective if it not only identified where problems were located in the farms but also provided means to solve these problems, mostly fertilizers and pesticides. The second most common suggestion was that the innovation should provide farmers with more advice on farming practices. These and the other suggestions given by farmers are listed in Table 7 below. The other suggestions will be approached in the sections that follow whenever appropriate.

TABLE 7. FARMERS' VIEWS ON HOW TO IMPROVE THE INNOVATION

How can the service/innovation be improved?	Number of farmers	Percentage over all farmers that answered about improvements (n=34)
Not just identify problem but provide farm inputs (fertilizers/pesticides) to solve the problem	19	56%
Provide farmers with more knowledge/advice on farming practices	11	32%
Provide farmers with seeds	2	6%
Visit the most people they can	1	3%
Increase frequency of visits	1	3%
Visiting farmers in crucial moments	1 Leader	3%
Focus on solving water drainage issues	1	3%

PHOTO 4. Irrigation by flooding being practiced in the surroundings of Chokwé.

2. WATER USAGE AND BENEFITS

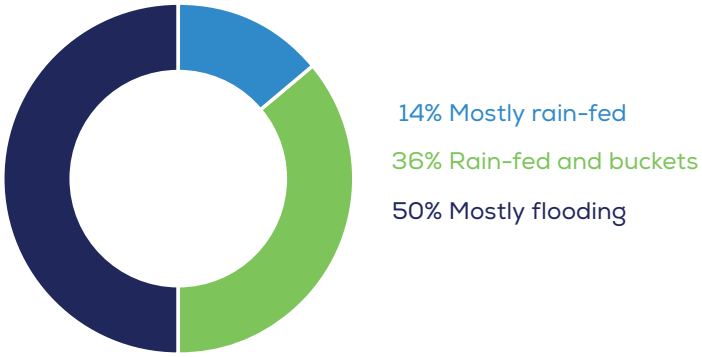
2.1. Irrigation methods

Farmers throughout the sample use different methods of irrigation and, in some cases, a combination of methods (rainf-fed, flooding and manual irrigation with buckets). 48% of farmers (29 out of 61) declared using flooding as primary irrigation method. These are actually all from the region of Chokwé, where flooding techniques are more common and well developed then in the farms visited in Xai-Xai. In Chokwé water comes from rivers (most stemming from the Limpopo River) in the surrounding areas that are channeled to the farms.

All farmers from Xai-Xai (32 out of 61) have rain as primary source for water, which leads them to plant mostly maize. 69% (22 out of 32) of the farmers in Xai-Xai also mentioned using manual methods of irrigation (buckets and 1 farmer used a spray system) for irrigating vegetables, that are normally planted beside the maize plantations (mostly cale, sweet potatoes, lettuce and onions). Graph 10 below presents results for irrigation methods with percentages over the total amount of respondents for these questions (n=61).

GRAPH 10. DISTRIBUTION OF IRRIGATION METHODS AMONG FARMERS

n=61

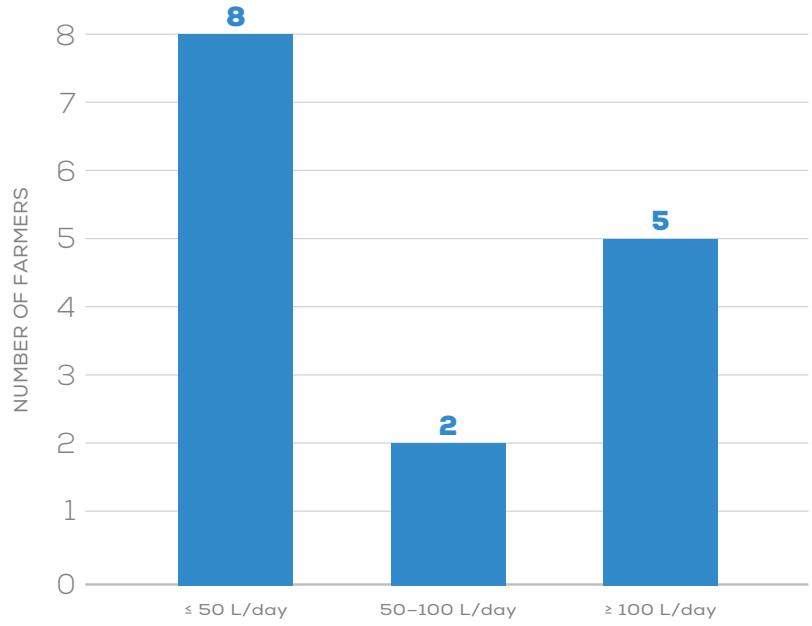


It was not possible to establish precise amounts of water used by farmers, either in Xai-Xai or Chokwé. In Xai-Xai, there were no measuring systems tracking water usage in the Nhampodzoene Association. When contacted, the regadio responsible for the area confirmed that they did not have information available on water flow and usage in the area. There also seemed to be very little consistency on frequency of irrigation by farmers or quantity of water used for each irrigation since farmers were very reliant on rain, adapting irrigation frequency to weather conditions (how dry or wet it is), amount and types of vegetables planted (which varies from season to season depending on quality, availability and accessibility of seeds).

To have a general idea of water consumption, farmers who use manual methods of irrigation (buckets) were asked to inform irrigation specifications for a warm day considering the average amount of vegetables they would have in their farms. The average of the amounts informed by 15 out of the 19 farmers who used buckets was of 69 liters per day. In warm and dry seasons farmers said they watered vegetables everyday. Graph 11 below summarizes the ranges of water usage among farmers in Xai-Xai that used buckets for irrigating vegetables. As described in the graph, 53% of these farmers (8 out of 15) use 50L/day of water or less in their vegetable gardens, 13% of farmers (2 out of 15) use more than 50L/day but less than 100L/day and 33% (5 out of 15) use 100L/day or more.

GRAPH 11. RANGE OF WATER USAGE IN MANUAL IRRIGATION IN XAI-XAI

n=15



Also, unlike farmers in Chokwé, farmers in Xai-Xai do not pay a fee for water. The channels in the association in Xai-Xai (Nhampodzoene Association) are classified as primary, secondary and tertiary (from bigger to smaller) and the regadio is responsible for cleaning primary channels, while farmers are responsible for the secondary and tertiary channels, which are the smaller channels stemming from the primary ones. As observed during field visits, many channels (primary, secondary and tertiary) were frequently clogged with dirt, grasses or weeds, probably having an impact on water distribution and drainage in the region. In fact, as detailed in Section III.3 below, farmers complained of the negative impacts that floods had on their yields.

PHOTO 4. Irrigation by flooding being practiced in the surroundings of Chokwé.

As in Xai-Xai, there were no measuring systems in place for assessing water usage in the different farming locations in the surroundings of Chokwé. 6 (out of 29) farmers in the surroundings of Chokwè informed that they were using a motor pump to bring water to their farms: one is a large-scale farmer that owns 2 pumps for his own farm, 4 are small-scale farmers in Macarretane that share their association's motor pump and individually pay for the fuel whenever they use it for irrigation, 1 is a farmer in the D11 location that uses the pump from his association. Questions were asked to these farmers to try to quantify amount of water used (pump's capacity/output, model, for how long pump was on, etc.) but farmers were not able to answer these questions precisely, so amount of water was not quantified.

In the different areas where the innovation was active around Chokwé, all farmers except two pay a fee for using water. One was excused by her association to pay for water since she owned only 0.25 ha of land and the other one did not pay because she used only underground water (the local association charges only for surface water). Associations in the region use different criteria to define the price charged from farmers for water (type of crop planted, season of the year, size of land owned/planted), so fees varied in between areas, as summarized in Table 8 below (which provides values for 0.5 ha as a common criteria for the sake of comparison). In farms in D5A, D5B and D6, farmers paid a flat fee for water based on amount of land used for production, which did not change if a farmer was more efficient in irrigation or not. In Macarretane farmers paid for the fuel used by the motor pump to bring water to their farms, which allowed them to save money (and consequently use less water) if they adopted more efficient irrigation techniques or improved their farming practices.

TABLE 8. FEES OR COSTS INVOLVED IN IRRIGATION FOR THE FARMERS LOCATED IN THE SURROUNDINGS OF CHOKWÈ

Location	Cost/Fee (calculated per 0.5 ha)	Number of farmers interviewed
D5A, D5B, D6	400 MZN for rice 200 MZN for maize	17
D12	500 MZN for rice	3
Macarretane association (to use motor pump)	200 MZN in the winter 400 MZN in the summer	3
Macarretane area (to use motor pump)	1000 MZN	1 (large-scale farmer)
D11	different fees informed: 400 MZN 250 MZN for rice 750 MZN (summer), 250MZN (winter)	1 1 1

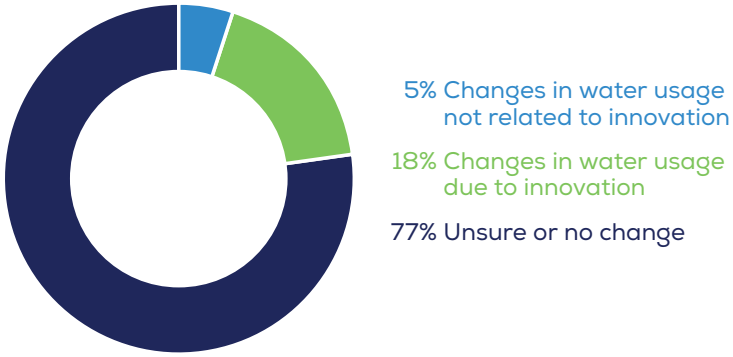
2.2. Water benefits

For the reasons explained above, it was not possible to quantify water usage in Xai-Xai and Chokwè in order to assess if innovation helped decrease water consumption in the region as a whole. However, the innovation brought some water benefits that were identified by farmers. None of the farmers interviewed, in the two regions, changed their irrigation methods over the period while the innovation was active in Mozambique.

When asked specifically if they had observed changes in amount of water used since the innovation was active, 77% (48 out of 62) of farmers were not sure or did not think that they had changed the amount of water used in their farms since the innovation was implemented in the region (Graph 12 below). 23% of farmers (14 out of 62) answered that they experienced some change in water usage when compared to amounts of water used before the innovation was active. Of these 23%, 3 farmers (5% of the 62 respondents), experienced changes that were not directly linked to the use of innovation: 2 farmers were using less water due to problems with water drainage in the area (mainly due to clogged channels) and 1 farmer was being able to use more water due to cleaning of channels.

GRAPH 12. PERCENTAGE OF FARMERS THAT EXPERIENCED CHANGES IN WATER USAGE IN THEIR FARMS AFTER THE INNOVATION WAS INTRODUCED

n=62



The other 11 farmers (18% of the sample of 62 farmers) justified this change as being connected (either directly or indirectly) to the use of the innovation and their explanations for this change are summarized in Table 9 below. Of these 11 farmers, 4 farmers said that the drone operator advised them to decrease amount of water for irrigation, as this could alleviate the crop stress they were seeing in their farms. 1 farmer explained that he was using less water to irrigate because since the drone operator had explained him how to use straw to cover the soil, the soil had been able to retain humidity for longer periods. One farmer explained that she is using less water since she started using fertilizers, which was encouraged by the drone operator (before doing this, she thought that the plants were weak and would water them more to make them stronger).

TABLE 9. CHANGES IN WATER USAGE AS EXPLAINED BY FARMERS THAT EXPERIENCED A DECREASE IN WATER USAGE DUE TO THE INNOVATION

Impact	Change as perceived by farmers	Due to	Number of farmers that mentioned impact
Direct	Decreased water usage	Operator's advice on farming practices	6
Indirect	More efficient use of water	Levelling of the fields	5

Five of these 11 farmers noticed that the recent levelling of the fields in their farming areas improved water usage, avoiding floods and crop stress due to unleveled fields. This improvement is not a direct consequence of the innovation, but the leader of this association, already knowing that the fields needed to be levelled, used images provided by the service to reinforce his argument to local authorities that they needed to level the fields in that area. The leader of the association explained how the levelling makes water usage more efficient:

"If the fields are not levelled we produce less. Water does not flow correctly, so we end up using the incorrect amount of water, which in some areas causes hydric stress."

Besides the benefits listed above, that were explained by farmers when they were specifically asked to explain if they saw any impacts of the innovation on their use of water, there are other other benefits that the innovation could have caused in terms of water usage. As mentioned before, in Section III.1, farmers received information from drone operators that consisted either on identifying where problems were located or on advice on how to improve farming practices. In both these categories, different topics were approached by the drone operator that could have lead to a positive impact on water usage, either directly or indirectly. Some information and advice received were more related to water usage (such as identifying clogged channels, unlevelled fields, flooding areas, where to irrigate, etc.) but, improving farming practices in general (for instance by following correct crop spacing, or learning about fertilizer and pesticide use) can also improve efficiency of water use. Also in Section III.1 above, 3 farmers mentioned that the innovation could have an indirect benefit on water circulation in their areas since it encouraged farmers to clean the water channels around their farms.

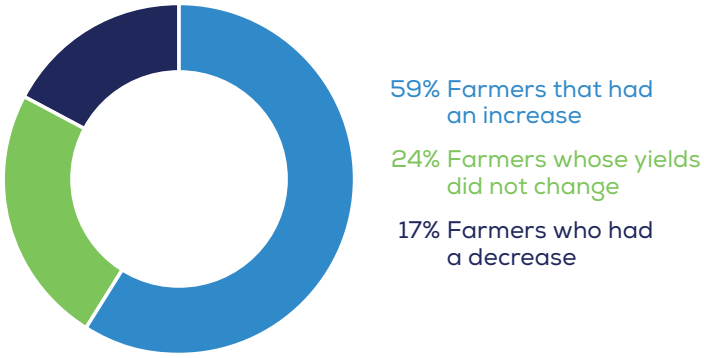
PHOTO 6. Beans harvested by female farmers in D5B, surroundings of Chokwè.

3. CROP BENEFITS

During the period that the innovation was active, many farmers saw changes in their yields (Graph 13). When comparing farmers' last yields with average yields before using the innovation[2], 59% (35 out of 59) of the farmers had an increase in yields. The average increase in yields was of 89% and the median increase was of 50%. 24% (14 out of 59) of farmers saw no change in their yields and 17% (10 out of 59) farmers saw their yields decrease over this time. The average decrease was of 70% and the median decrease was of 75% of the original yield.

GRAPH 13. CHANGES IN YIELDS, WHEN COMPARING BEFORE AND AFTER THE INNOVATION WAS ACTIVE

n=59

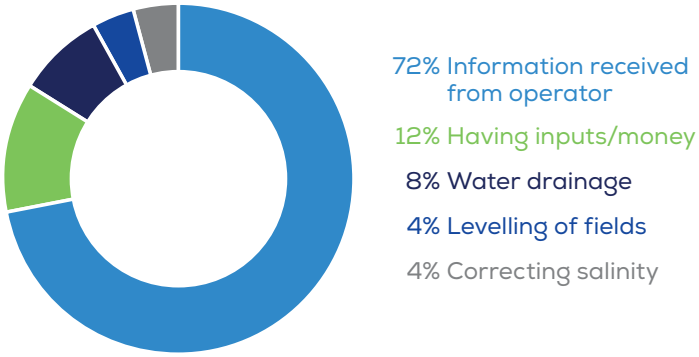


2 Changes to crop yields were compared between farmers' average yield in one season before use of innovation and the yield in the most recent season, after having used the innovation. Only farmers' main crop was used for comparison. For instance, if farmer plants mainly maize but sporadically plants vegetables or plants very few vegetables beside the maize, only maize was taken into consideration. In case a farmer planted different crops but the farmer felt that the innovation only had an impact on one specific crop, this crop was taken in consideration and not the others. In the region of Chokwè, where many farmers worked in a rotation system (rotating between beans, maize and rice) preference was given to comparing one season of rice since this crop was the main source of income of most of the farmers, unless stated otherwise or innovation had affected another crop.

But not all farmers who increased their yields made an explicit direct connection between this change and the use of the innovation. Among the 35 farmers who had an increase in yields, 19 of them (54% of those who had an increase) established a connection between this change and the innovation: 18 of these farmers think that the information they received from the drone operator had a positive impact on their production, and 1 farmer highlighted that the levelling of fields in his association (a process that used drone images as visual support) had an impact on his production, also increasing yields. This means that 32% of all respondents (or 19 out of 59) established an explicit direct connection between the increase in their yields over the period analyzed and the use of the innovation. Other factors that were highlighted by farmers while explaining the increase in their yields were: being able to buy/have access to agricultural inputs such as fertilizers, pesticides or seeds (3 mentions), improving water drainage in their farms or surroundings (2 mentions) and fixing salinity of soils (1 mention), as summarized in Graph 14.

GRAPH 14. FACTORS THAT POSITIVELY IMPACTED YIELDS AND HOW FREQUENTLY THEY WERE MENTIONED BY FARMERS[3]

n=24



Percentages calculated for each mention over a total of 25 mentions.

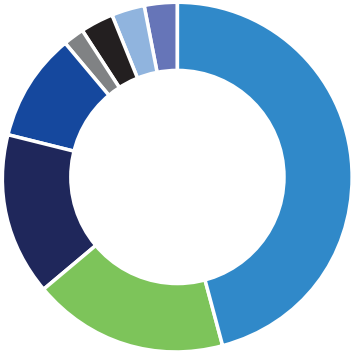
On the other hand, 23 farmers (out of the 59 respondents) gave detailed explanations as to why they did not see a change in yields, produced less or did not produce as much as planned (even for those who had an increase). The following factors were mentioned as negatively impacting production: pests (18 mentions), floods (7 mentions), weather (6 mentions), not having farming inputs such as fertilizers, pesticides or seeds (4 mentions), insufficient workforce to share the workload with (1 mention), salinity of soils (1 mention), low quality of seeds (1 mention), lack of knowledge about agricultural techniques (1 mention), as summarized in Graph 15 below.

At least 6 of these mentions to pests are referent to rats. As explained before, rat infestations were common in both Xai-Xai and Chokwé farms and farmers perceived them as having a negative impact on yields since rats ate most of the produce (maize, sweet potatoes). This also also impacted seed availability for the following season, decreasing yields.

3 It is important to observe that both Graphs 14 and 15 refer to the frequency in which a factor was mentioned compared to all mentioned factors and that some farmers mentioned more than one factor.

GRAPH 15. FACTORS THAT NEGATIVELY IMPACTED YIELDS AND HOW FREQUENTLY THEY WERE MENTIONED BY FARMERS

n=23



46% Pests
18% Floods
15% Weather
10% Not having inputs
3% Sailinity
3% Low quality of seeds
3% Little knowledge on farming
2% Insufficient workforce

Percentages calculated for each mention over a total of 39 mentions.

Regarding possible increases in crop survival rates or in crop quality, these questions were not asked to farmers who had a decrease or no change in their yields. All those who had an increase in yields (59% or 35 out of 59 farmers) thought that either crop survival or quality had increased. Farmers expressed that they could see the improve in quality of their crops through expressions like "yes, fat pretty beans", "yes, clearly improved quality", "yes, better beans" and "I was marveled at the quality of the corn after using pesticides".

4. FARMERS' INCOMES AND INCOME BENEFITS

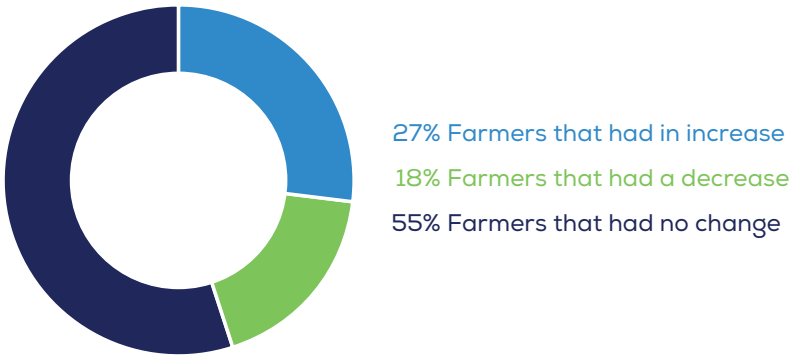
As many of the farmers interviewed did not keep track of their yearly incomes or were not able to remember yearly incomes from previous years as far as 2015 or 2014 with accuracy, to have an overview of farmers' income this report considered data based on revenues for one season's harvest. That is, change in income was assessed by comparing how much farmers used to earn, in average, by selling their yields before the innovation was active in their region and how much they earned by selling their yields after using the innovation. Regarding income after using the innovation, farmers were asked to focus on the most recent season for the sake of comparison. Income was considered per season of the farmers' main crop (or the crop affected by the innovation in case this was not the same), that is, how much money a farmer earned by selling one harvest (or a part of it) of his/her main crop. 51 farmers were able to provide data on their revenues from selling crops and other data relevant to this section on income and on the next section, on poverty reduction.

Before innovation was active, 53% (27 out of 51) of the farmers were selling their yields and had an average revenue of 21,800 MZN per harvest. The other 47% (24 out of 51) of the farmers practiced subsistence agriculture, meaning that they did not use to sell their yields, which were consumed mostly within their households. After having the innovation active in Mozambique, 55% (28 out of 51) farmers, sold their yields and this time the average income of was of 33,466 MZN, meaning an increase of 54% in income.

But not all farmers had an increase in income and not all farmers who were selling before continued selling after the innovation. 4 out of the 28 farmers who were selling before did not sell their yields recently and 5 farmers who were not selling before, sold their yields recently. In fact, data shows, as illustrated in Graph 16 below, that 55% (28 out of 51) of the farmers had no changes in income, while 27% (14 out of 51) of the farmers had an increase in income and 18% (9 out of 51) had a decrease in income. The decreases in income were preceded by decreases in yields, except in 2 (out of the 9) cases, where decrease in income was due to the fact that farmers were too late to sell their yields. All the farmers who saw an increase in income also had an increase in yields.

GRAPH 16. CHANGES IN INCOME EXPERIENCED BY FARMERS COMPARING INCOMES AFTER THE INNOVATION WAS ACTIVE WITH BEFORE THE INNOVATION WAS INTRODUCED

n=51

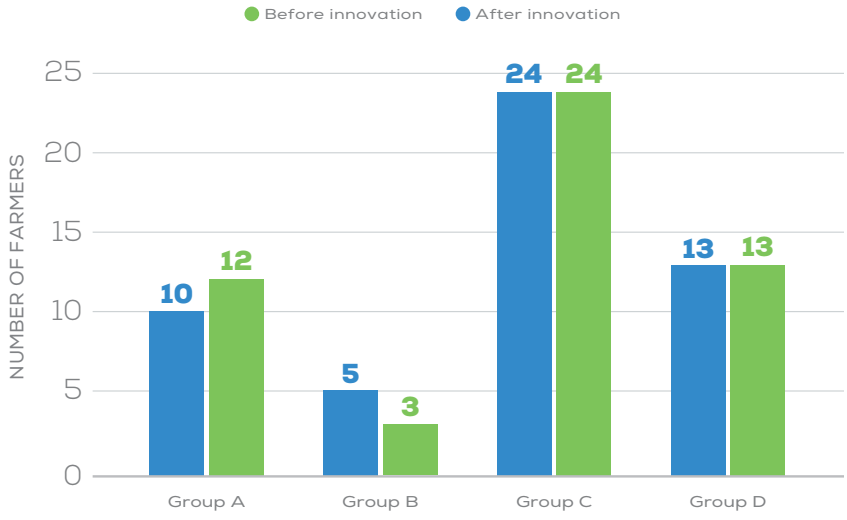


By using farmers' data on their incomes before and after the innovation was active, it was possible to classify them into income groups and compare the distribution of farmers per income groups before and after the innovation was active, as presented in Graph 17 below. Group D corresponds to the poorest group of farmers, i.e., farmers who in that period (either before or after innovation was active) had no other source of income and practiced subsistence agriculture. Group C corresponds to farmers who when selling their yields (either before or after the innovation was active) did not obtain incomes greater than 5,000 MZN or another source of income that would provide them with same amount in one season. Group B corresponds to farmers who, when selling their yields (either before or after the innovation was active), earned more than 5,000 MZN but did not obtain incomes greater than 10,000 MZN, also considering other income sources. Group A corresponds to farmers who, when selling their yields (either before or after the innovation was active), obtained incomes greater than 10,000 MZN, also considering other income sources.

When looking at the individual progress that farmers had, as detailed above, we see that 14 (out of 51) farmers had an increase in their income, outnumbering farmers who had a decrease (9 out of 51). However, if we look at the sample as a whole, Graph 17 shows that there was actually little change for the entire sample and within income groups. Comparing income groups before and after the innovation was active, the only visible change for the entire sample was that the number of farmers in Group B decreased because 2 farmers were able to improve their classifications, moving from Group B to Group A.

GRAPH 17. INCOME RANGE OF FARMERS BEFORE AND AFTER INNOVATION WAS ACTIVE IN THEIR FARMS

n=51



5. POVERTY REDUCTION BENEFITS

According to the international poverty line standards, 62.2% of Mozambicans were living with less than USD 1.90 in 2014 (World Bank, 2018). Even though this survey did not focus on collecting specific data to analyse poverty trends and that time constraints limited amount of observations and data collection that could help assess farmers' poverty levels, poverty will be assessed based on combination of answers to different questions of the survey. We will look at data from 51 respondents who provided enough information on the relevant questions (concerning income, yields, adherence to innovation and perception of benefits).

As mentioned in the previous section, before the innovation was active, 47% (24 out of 51) of the farmers practiced subsistence agriculture, meaning that they did not use to sell their yields, which were consumed mostly within their households. 11 of these farmers (or 22% of the sample of 51 farmers) had no other source of income, depending entirely on subsistence farming or on very sporadic commercialization of very small amounts of their produce. This not only sets them below the international poverty line but sets them as the poorest farmers in the sample.

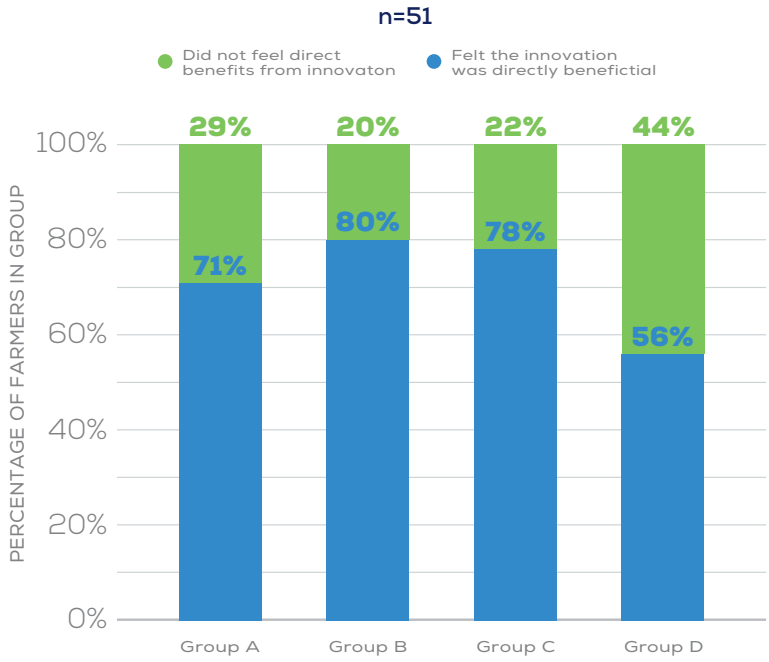
From this set of poorest farmers, 3 out of 11 or 27% of the poorest farmers started selling some of their yields after the innovation was introduced, and their average income was of 13,500 MZN in their last harvest. None of these 3 farmers, however made an explicit connection between the use of the innovation and their increase in yields and in income.

On the other hand, 8 out of 11 or 73% of the poorest farmers had no changes in their situation. 3 farmers recently joined the group of poorest farmers after the innovation was introduced since they did not have any other source of income and did not sell their harvest recently, keeping the number of poorest farmers still at 11. In the case of these 3 farmers, the decrease in income is connected to a decrease in yields and as discussed above, in Section III.3, different factors could have influenced this change.

Using the same income group classification as in Section III.4 above (but adapting it accordingly[4]), it was possible to compare farmers' perception of benefits per income group, as presented in Graph 18 below.

4 In Section 4, farmers were classified per income group for the period before innovation was active and then classified again, according to their incomes before innovation was active. For this graph in Section 5, change over time was not being assessed, so farmers were classified only once according to their highest income, according to values established for each income group in Section 4.

GRAPH 18. FARMERS' PERCEPTION OF GENERAL BENEFITS PER INCOME GROUP



As information provided by 51 respondents show, less farmers from Group D, i.e., the poorest group of farmers, felt that the innovation brought a direct benefit to them as compared to farmers that fall into Groups A, B and C. Seventy-one percent (10 out of 14) of the farmers in Group A, 80% (4 out of 5) of the farmers in Group B, and 78% (18 out of 23) of the farmers in Group C felt the innovation was directly beneficial to them, while only 56% (5 out of 9) of the farmers in Group D felt that way.

6. ADHERENCE TO SERVICE

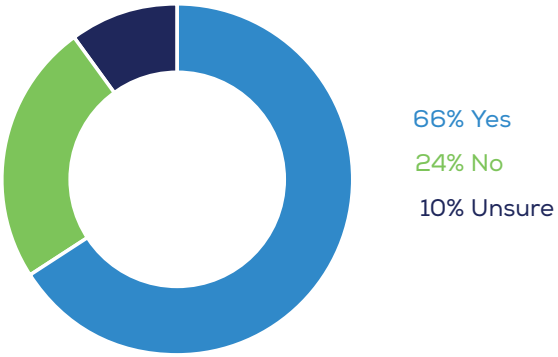
To have the service active in a certain region was not an individual decision, since this decision was either made collectively by the farmers' association or by the innovator, who chose an area to work in. These factors impacted how farmers answered questions regarding if they would like to continue with the service and if they would be willing to pay for it, since most of the farmers would first explain that this did not depend on them individually and that they had never paid for it and were not sure of which price they could afford.

When asked if they would like the service to continue, 66% (41 out of 62) of the farmers said yes, 24% (15 out of 62) said no, and 10% (6 out of 62) said they were unsure about it, as illustrated in Graph 19 below. Of the 6 farmers who were unsure, 4 of them explained that they were not sure if the innovation was really beneficial to them or if it would continue being. The farmers who answered that they did not want the service to continue and justified their answers, gave the following reasons for it:

- The innovation has no real impact for the farmer (9 farmers)
- He cannot afford it (1 farmer)
- There are no problems in his farm so help is not needed (1 farmer)
- She does not understand how the service worked (1 farmer)

GRAPH 19. FARMERS' ANSWERS WHEN ASKED IF THEY WOULD LIKE THE SERVICE TO CONTINUE

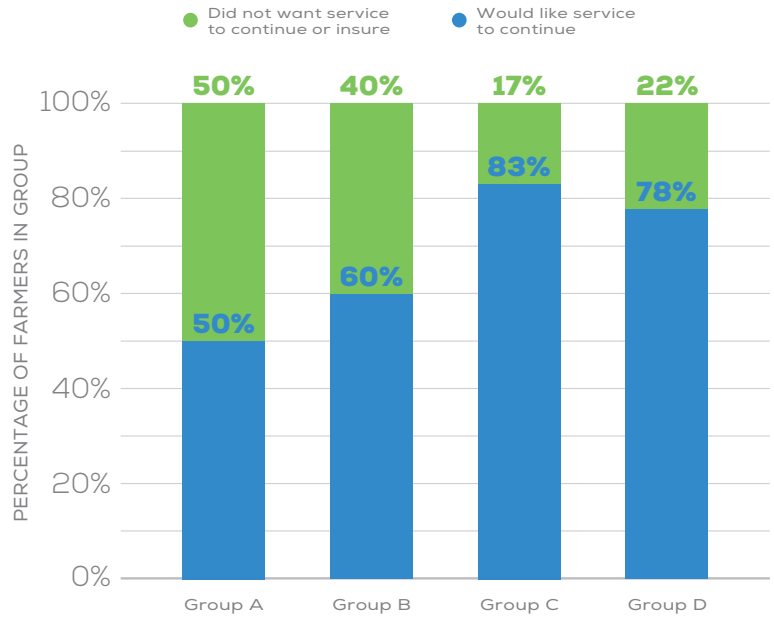
n=62



When it comes to adherence per income group, it is interesting that, despite the fact that more farmers from higher income groups perceived direct benefits from innovation, when farmers were asked if they wanted the service to continue, more farmers from the lower income groups (Groups D and C) were positive about having the service continue, as detailed in Graph 20 below. 50% (7 out of 14) of the farmers in Group A and 60% (3 out of 5) of the farmers in group B stated that they did not want the service to continue, while 83% (19 out of 23) of the farmers in Group C and 78% (7 out of 9) of the farmers in Group D stated that they would like the service to continue. Possible reasons for these trends will be discussed in Section IV below.

GRAPH 20. FARMERS' ADHERENCE TO THE INNOVATION PER INCOME GROUP

n=51

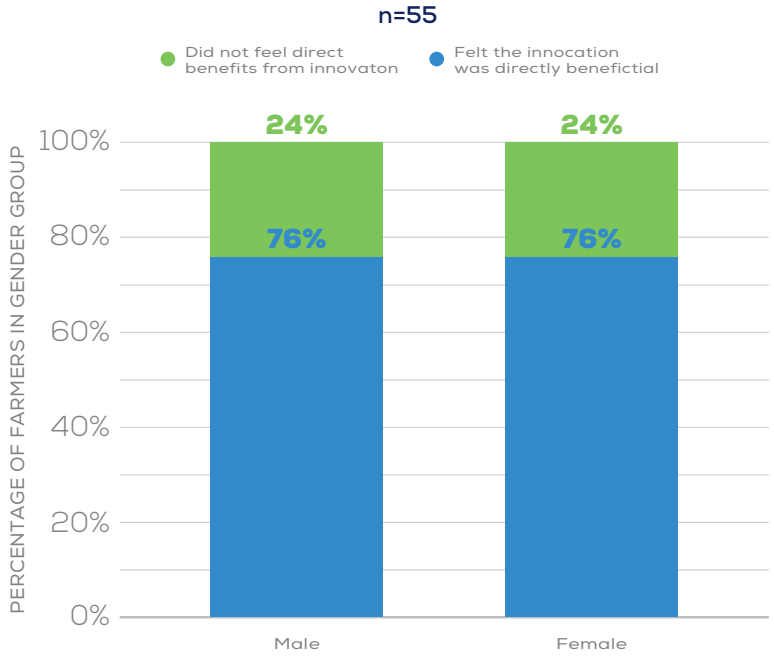


7. GENDER DIFFERENCES IN BENEFITS

7.1. Gender and general perception of benefits by type of information received

In terms of perceived benefits, as detailed in Section III.1.1 above, 77% of farmers perceived that the innovation was beneficial to them (either directly or indirectly). This same proportion was kept within female and male farmers (Graph 20): 76% of the female farmers (29 out of 38) felt they benefited (either directly or indirectly) from the use of the innovation as did 76% of the male farmers (13 out of 17).

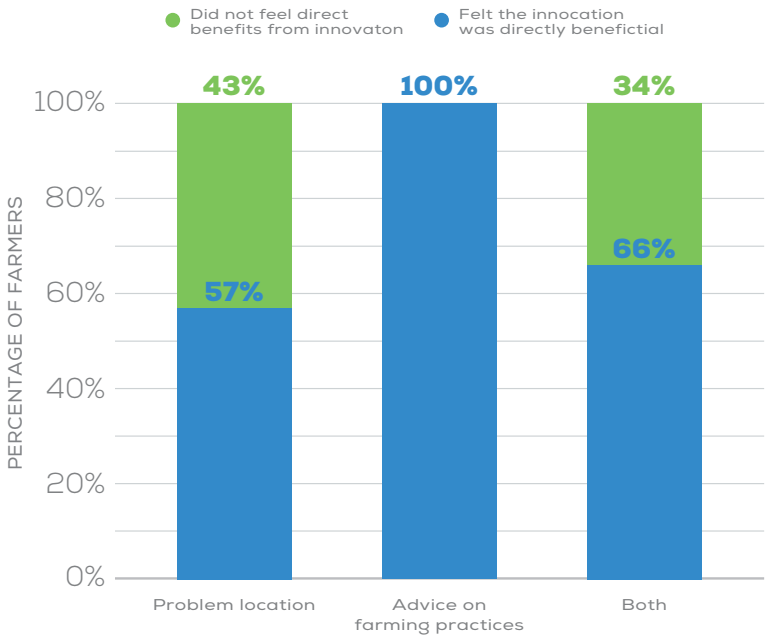
GRAPH 21. COMPARISON BETWEEN FEMALE AND MALE FARMERS' PERCEPTION ON GENERAL BENEFITS PROVIDED BY THE INNOVATION



There were small differences regarding benefits when comparing the type of information received by farmers from drone operators, as it is clear by comparing Graphs 22 and 23 below. However, both men and women felt that the innovation was less beneficial when they received only information identifying where problems were located in their farms: 60% (9 out of 15) of the women felt that was beneficial as did 57% (4 out of 7) of the men. More men felt the innovation was beneficial when they received advice on farming practices: 100% (7 out of 7) of the male farmers who received this type of information thought the innovation was beneficial, compared to 67% (2 out of 3), who received both types of information. Women, on the other hand, felt the innovation was beneficial when they received both types of information combined (identification of where problem is located and advice on farming practices): 90% of the women who received the combination felt the innovation was beneficial, compared to 85% (11 out of 13) who received only advice on farming practices.

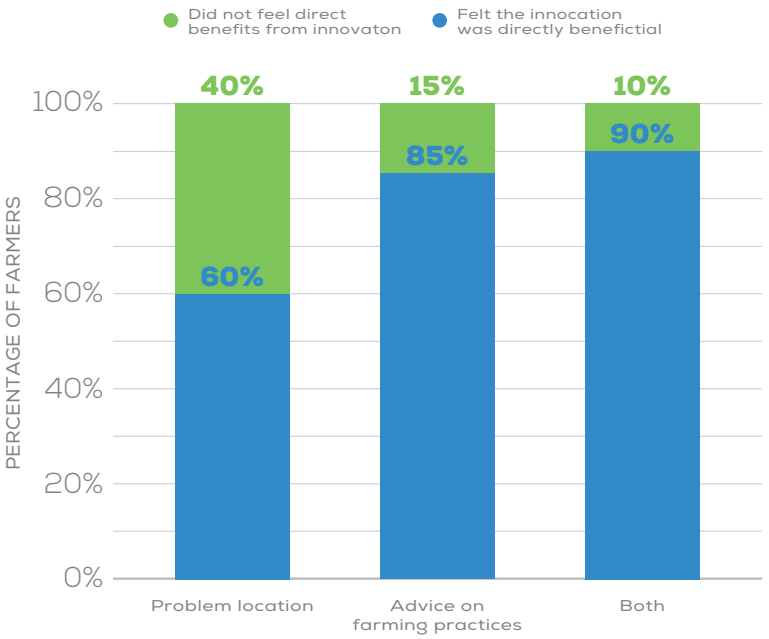
GRAPH 22. PERCEPTION OF GENERAL BENEFITS BY MALE FARMERS PER TYPE OF INFORMATION RECEIVED

n=17



GRAPH 23. PERCEPTION OF GENERAL BENEFITS BY FEMALE FARMERS PER TYPE OF INFORMATION RECEIVED

n=38



Women also seem to have found an indirect benefit in the innovation that was not mentioned by any men: 3 women mentioned how the fact that the drone operator came visit their farms gave them extra motivation to work. One female farmer also said that after her husband passed away, having the drone operator come visit her gave her motivation to keep working by herself.

PHOTO 7. Farmer preparing beans in Macarretane, surroundings of Chokwé.

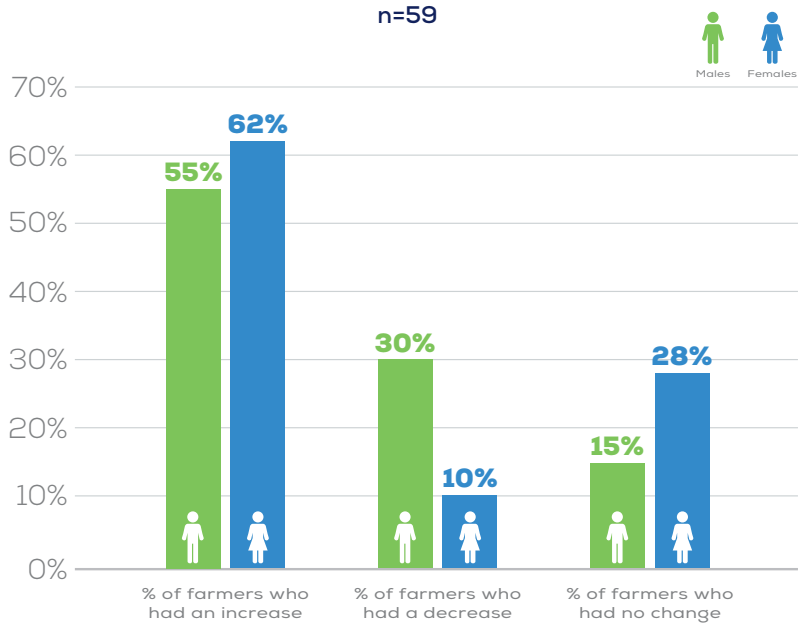
7.2. Gender and changes in yields

Compared to men, female farmers, in average, had a lower increase in yields when comparing their last yields with those before the innovation was active in Mozambique. The average increase of the 20 female farmers who provided information on yields was of 66%, compared to an average increase of 136% for the 10 male farmers who provided this information. If we consider both increases and decreases in yields within gender groups, male farmers still had a better average: 63% of net increase (based on answers by 15 male farmers) compared to 47% of net increase for women (based on answers by 24 female farmers).

However, more women saw their yields increase over the time the innovation was active (Graph 24). 62% (24 out of 39) of the female farmers had an increase in their yields, compared to 55% (11 out of 20) of the male farmers. And more male farmers, 30% (6 out of 20), saw their yields decrease, when compared to female farmers, 10% (4 out of 39). 28% (11 out of 39) of the female farmers and 15% (3 out of 20) of the male farmers saw no change in yields.

Also, more women that had an increase in yields established a connection between their change in yields and the use of the innovation: 58% (14 out of 24) women compared to 45% (5 out of 11) men.

GRAPH 24. CHANGES IN YIELDS PER GENDER, COMPARING AVERAGE YIELDS BEFORE INNOVATION WAS ACTIVE WITH YIELDS AFTER FARMERS USED THE INNOVATION (MOST RECENT YIELDS)

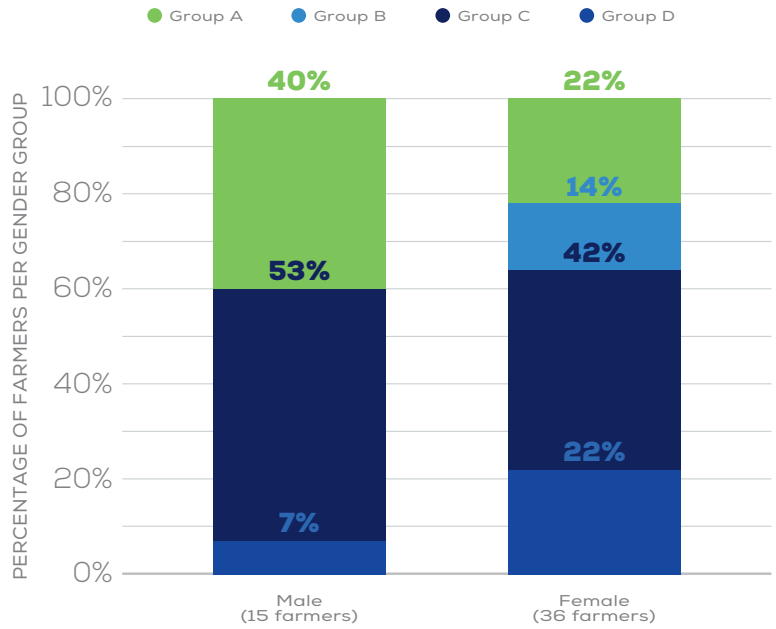


7.3. Gender and income

Data also shows that, besides owning more land, male farmers are wealthier than female farmers (Graph 25). 40% of male farmers (6 out of 15) are classified in Group A, compared to 22% female farmers (8 out of 36). In fact When adding the number of female farmers in the wealthiest groups (Group A and B), it is still proportionately less than male farmers only in Group A: 36% (12 farmers in Group A and 4 farmers in Group B). There were no male farmers in Group B, and there are more male farmers in Group C than female farmers: 53% (7 out of 15) compared to 42% (16 out of 36). However, there were more female farmers in Group D than male farmers: 22% (8 out of 36) compared to 7% (1 out of 15).

GRAPH 25. INCOME DISTRIBUTION BETWEEN MALE AND FEMALE FARMERS

n=51

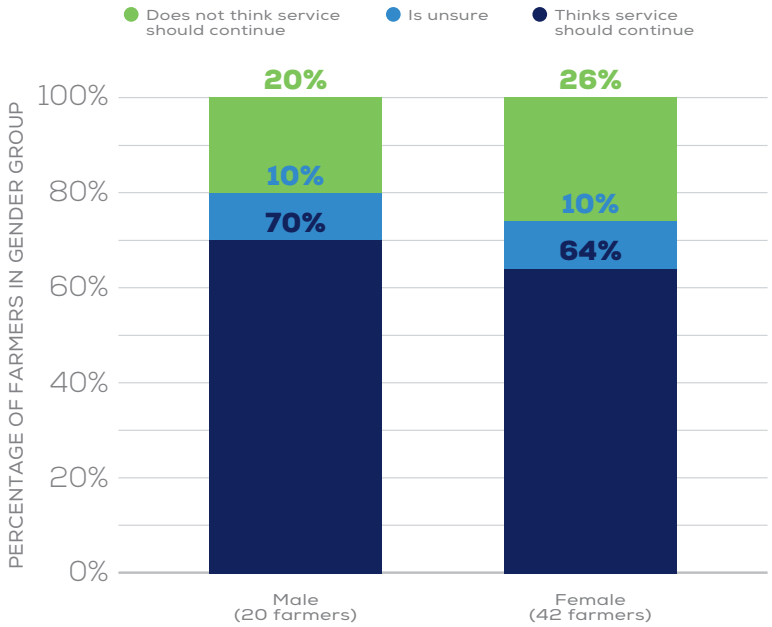


7.4. Gender and adherence to service

Even though farmers' perception of benefits between gender groups was the same (with slight differences according to type of information provided), less women had a positive answer when asked if the service should continue active in their region, when compared to men (Graph 26).

GRAPH 26. ADHERENCE TO SERVICE PER GENDER

n=62

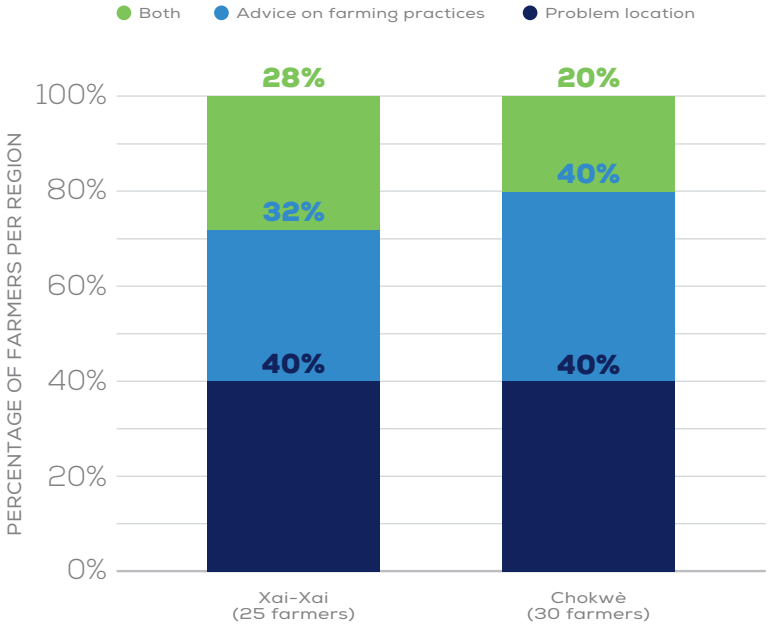


8. REGIONAL DIFFERENCES

After conducting the survey in the two regions where innovation was active, Xai-Xai and Chokwé, it was clear that there were differences between the two, specially in terms of benefits perceived by farmers. Even though the same type of information was given to approximately the same number of farmers (Graph 27 below), less farmers' in Xai-Xai perceived a direct benefit from the innovation (Graph 28).

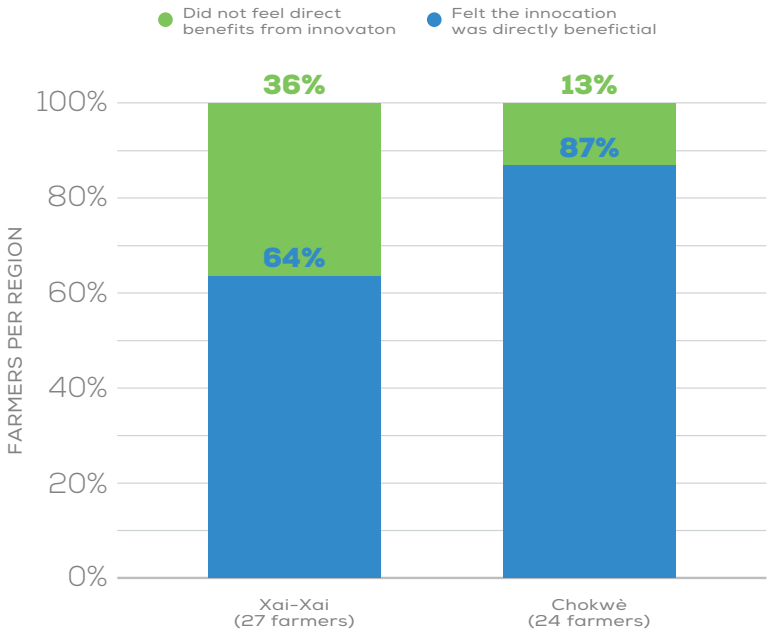
GRAPH 27. DISTRIBUTION OF TYPES OF INFORMATION RECEIVED BY FARMERS PER REGION WHERE INNOVATION WAS ACTIVE

n=62



GRAPH 28. FARMERS' PERCEPTION OF DIRECT BENEFITS IN EACH LOCATION WHERE INNOVATION WAS ACTIVE

n=55

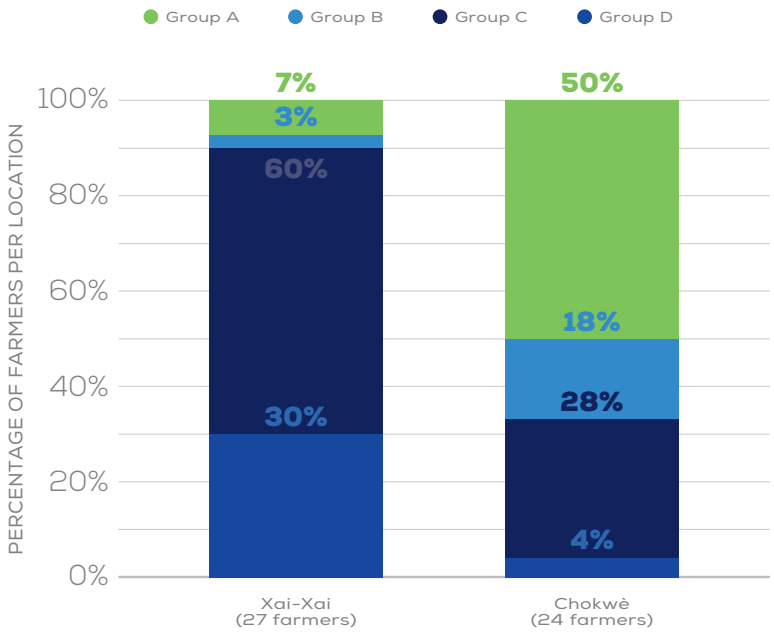


It goes beyond the scope of this survey to thoroughly understand all the reasons that could explain this regional difference, but looking at some of the farmers' comments about their experience with the innovation could bring some insights. For instance, in Xai-Xai most of the farmers that did not perceive a benefit in the innovation complained that they could not afford the solutions for the problems identified or to buy the inputs suggested by the drone operator. In some farms in Chokwé, on the other hand, the drone operator suggested cheap solutions to problems identified, which made farmers very positive about the innovation. Solutions and advice like these were not mentioned by farmers in Xai-Xai.

It should also be considered that farmers' situation differ from one region to the other. Just as an example, Xai-Xai farmers are poorer (Graph 29) and own smaller farms than farmers in Chokwé, but there are other differences that will not be assessed here. While 89% (24 out of 27) of farmers in Xai-Xai classified in the poorest income groups (Group D and C), only 33% (8 out of 24) of the farmers in Chokwé fell in these income groups. Actually, 50% (12 out of 24) of the farmers in Chokwé were in Group A, the wealthiest group of farmers, compared to 7% (2 out of 27) of the farmers in Xai-Xai.

GRAPH 29. INCOME DISTRIBUTION PER GROUPS IN BOTH LOCATIONS WHERE INNOVATION WAS ACTIVE

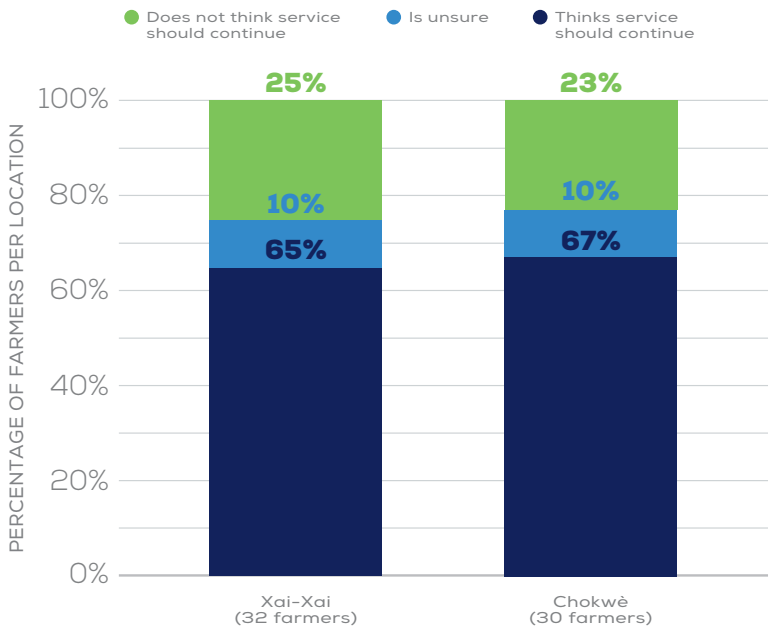
n=51



When it comes to size of farms, Xai-Xai farmers own in average 0.7 hectares, while farmers in Chokwé own 1.4 hectares, excluding the two larger farmers (who own 72 and 15 hectares each), which is twice the average area owned by farmers in Xai-Xai. Including the large-scale farmers, the average in Chokwé increases to 4.2 hectares. The median for farm size in Xai-Xai is 0.5 hectares, compared to 1.0 in Chokwé.

On the other hand, despite the differences in benefit perception, when farmers were asked if they wanted the service to continue, there were almost no differences in farmers answers between these two regions (Graph 30).

GRAPH 30. FARMERS' ANSWERS TO THE QUESTION "WOULD YOU LIKE SERVICE TO CONTINUE ACTIVE?" IN EACH REGION
n=62



V. DISCUSSION

1. CROP AND WATER BENEFITS

1.1. Crop benefits

As detailed in Section III.3 above, 59% (35 out of 59) farmers saw their yields increase over the period the innovation was active in Mozambique. All of those who had increases felt that there was better quality or improved survival rates of their crops. However, only 32% (or 19 out of 59) of all respondents established an explicit direct connection between the increase in their yields over the period analyzed and the use of the innovation. Many other factors besides the innovation played a critical role on crop survival rates and farmers' results. The many factors that farmers perceived as causes for increasing or decreasing yields were also presented in Section III.3 above.

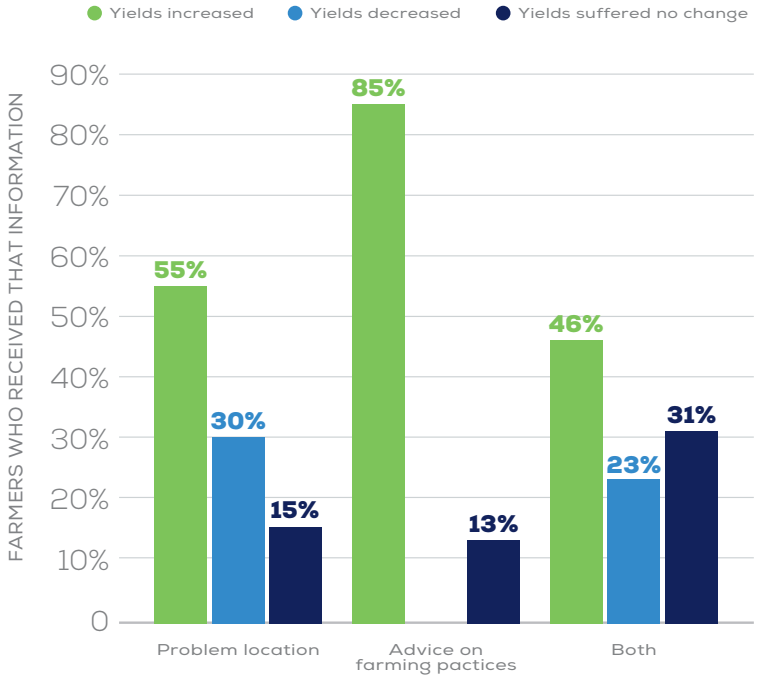
Among the main factors that were seen as hindering production, rat infestations and extreme weather conditions were highlighted as problems that the innovation is not able to solve or provide a useful solution to, therefore not having a significant impact on yields. In fact, Mozambique is well known for suffering from extreme weather events and variability, such as droughts and floods that have direct consequences on agriculture (World Bank, 2011). These results thus raise the question as to what extent the innovation has been able to impact crop survival and yields in unfavourable scenarios such as the one found in Mozambique.

PHOTO 8. Farmer in the surroundings of Chokwé who thought the innovation was beneficial because it helped improve her farming techniques and increased her yields.

Data also shows that farmers who received advice on farming practices or this type of information combined with the location of problems in their farms obtained better yields then those who only received information on the location of problems (Graph 31 below). 85% of the farmers who received advice on farming practices (17 out of 20) had an increase in their yields, while 15% (3 out of 20) saw no change in yields. This was a much better result than that experienced by farmers who received only information on location of problems in their farms: 55% of them (11 out of 20) had an increase in yields, but 30% (6 out of 20) saw their yields decrease and 15% (3 out of 20) saw no change. 46% of farmers who received both types of information (6 out of 13) saw their yields increase, while 31% (4 out of 13) saw no changes and 23% (3 out of 13) saw yields decrease.

GRAPH 31. CHANGES IN YIELDS COMPARED TO TYPE OF INFORMATION THAT FARMER RECALLED RECEIVING FROM DRONE OPERATOR

n=62



In this sense, data shows that it is possible that innovation benefited crop yields more through advising farmers on farming practices than by only showing them imagery to help them locate where an issue was occuring in their farms. Farming knowledge is highly valued and requested by many of the farmers interviewed. Providing farmers with more knowledge on farming practices and techniques was the second most common suggestion that farmers gave when asked about how the service could be improved, as detailed in Table 7, Section III.1.1 above.

And even though the most common suggestion was that innovation should provide farmers with the inputs to solve the problems in their farms rather than just identify their location, farming knowledge played an important role in giving farmers access to farming inputs. In Chokwé, for instance, this

relation was very clear and led to positive results for satisfied and enthusiastic farmers. Drone operators in this region, when advising farmers' on farming practices, gave them suggestions on how to improve soil quality through techniques that are cheaper and easier to access then commercial fertilizers, bringing to light the important relation between knowledge of farming techniques, using resources efficiently and having access to farming inputs. The following quotes, from 3 different farmers in the surroundings of Chokwé, all benefited from learning about how to use straw, weed and manure as fertilizers in their farms:

"Operator told me to keep weeding the fields and cleaning the channels to find out where the water was coming through. She confirmed that what I had planted was good and that the soil had good quality, but also ***explained me that weeds could be used to fertilize the soil for better rice production***. I used to burn weeds before. Now I produce more rice."

"We produced more because operator came and explained the spacing in between crops (maize, cabbage and green pepper). She told us that ***for soil to be fertile we should cover it with straw***. I saw productivity increase."

"The operator told me to keep weeding. He told me that my crops were good and that I could use manure in my fields instead of fertilizer, so I decided to try it. I had done it years before but I had seen everybody using the commercial fertilizer so I had switched to fertilizer. ***After speaking to drone operator I decided to try to use manure together with fertilizer on my rice plantation.*** And yes, it improved quality of the crops."

If providing farming advice to farmers was not the original intent and is not the future plan of ThirdEye, it would probably make the service more effective if it is implemented in regions where farmers have good knowledge of farming techniques or are being advised by local services, like the SDAE in Mozambique.

Finally, if the original purpose of the service was not to provide farmers with advice on farming practices, but ended up expanding to include this, it is also worth questioning if drone operators had the adequate training to provide farmers with this type of service (and even if they were being rewarded by the extra work delivered).

1.2. Water benefits

When it comes to water benefits, even though it was not possible to entirely measure water flows and quantify usage in the locations evaluated, there are different ways in which innovation could have affected water efficiency in the region, depending on the kind of information that the drone operator provided to farmers.

Informing farmers about the location of problems in their farms (Table 3 above) could have had an indirect impact on water usage, as explained by farmers and detailed in Section III.2.2 above. Specifically, drone operators told farmers where channels were clogged and encouraged them to keep the channels surrounding their farms clean, which could have impacted water drainage and flow in these areas. In the location called D5A in Chokwé, images provided by the innovation were used to support the local farmers' association request to have their fields levelled, which also has an impact on how water is used.

Advising farmers on better farming techniques, as detailed in Section III.1 above (Table 4), allowed farmers to make better use of water resources. Some of the advice offered focused on water use specifically (explaining how and when to irrigate) but the fact that farmers improved their farming techniques in general (sowing, crop spacing, use of fertilizers and pesticides, when to plant, etc.) can also have had an indirect positive impact on water usage. One farmers' comment makes this relation very clear:

PHOTO 9. Farmers in Xai-Xai cleaning the channel close to their farm.

"After I started using fertilizers (as suggested by the drone operator), I use less water on my plants. Before I thought that they were looking weak and I thought it was because they needed more water, now they are strong so I don't water them that much."

2. USAGE/AVAILABILITY

2.1. Usage of innovation

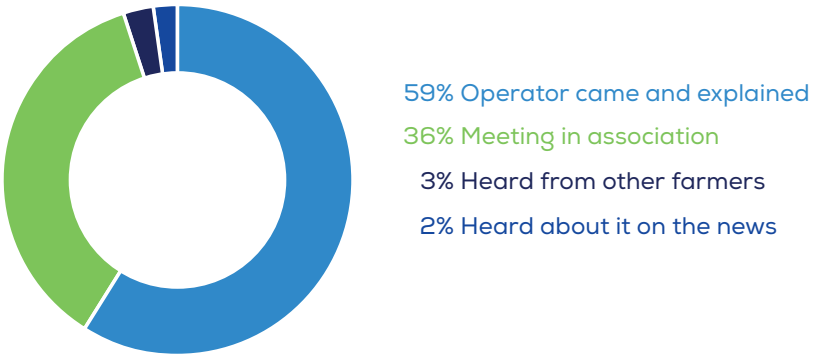
Only 3% (2 out of 62) of the farmers said they had problems understanding the service. These were two female farmers who said they were not able to understand the images the drone operators showed them. From the 97% who did not declare to have any problems in understanding the innovation, 11% (7 out of 62) commented that the drone operators were able to explain very well the information they were presenting. 5 out of these 7 farmers were women and 2 were men.

2.2. Decision to start using innovation

When it comes to farmers' usage of the innovation, it is important to clarify that it was not decided by the the farmer individually to use the innovation, it was a decision made by farmers' associations (in most of the regions). In other places, like in D11 (in the surroundings of Chokwé), some farmers were not aware of why the service began to be offered there.

As summarized in Graph 32 below, 59% (34 out of 58) of farmers first heard about the innovation because the drone operator came speak to them, 36% (21 out of 58) because they went to a meeting in their farmers association where the innovation was presented and explained to them, 3% (2 out of 58) first heard about the innovation from other farmers and 2% (1 out of 58) heard about the innovation on the news (radio).

GRAPH 32. WAYS IN WHICH FARMERS FIRST HEARD ABOUT THE INNOVATION
n=58



2.3. Frequency and timing of use

Regarding frequency of use of innovation (i.e., deciding when to obtain drone information), this was not a users' choice either. It depended on the drone operator coming to farms and presenting the information to farmers (which also depended on farmers being present on that day), which was done according to the operators' working schedule. From what two operators explained, operators' working schedule and farm visits were not necessarily decided together with farmers or previously informed to them. This could have had an impact on issues related to both (i) the frequency in which farmers were offered information about their farms and (ii) the relevance of the moment this information was provided.

As detailed in Section II.2 above, if drone operators in Xai-Xai, for instance, visited all of the "active ThirdEye users" in the region as identified by the innovator, it would take around 8 months for a farmer to receive a drone operator in his farm. If by any chance this farmer was absent on the day of the operator's visit, it would take even longer for the farmer to receive information from the drone operator.

Also, even if a farmer is visited a few times during the year, further consideration should be taken on the possibility of synchronizing visits with crucial moments in the farming cycle. One association leader pointed out that (even though he was satisfied with the service in general) there are specific moments during the year that information on soil quality and crop stress is more crucial than in other moments, such as just before the harvest or when farmers are preparing the soil to sow.

This is very important in terms of effectivity of the service. The main purpose of the innovation was to provide spatial information to farmers allowing them to see where crop stress is happening before it would be visible to the human eye (which would be 2 weeks according to innovator's website) (ThirdEye, n.d.) or, at least, in an adequate time frame to allow them to make decisions concerning their resources. This would allow farmers to "make decisions based on facts" and "see when and where they should apply their limited resources" (ThirdEye,n.d.). If farms are only being visited around once or twice per year, it is questionable to what extent the information provided by the innovation was given as early as possible so as to to allow farmers to anticipate their decisions, fulfilling the main benefit promised by the innovator.

In some cases, however, even if problems were spotted in advance by the innovation, this would not automatically translate into a concrete benefit to farmers for two main reasons: some farmers could not afford the necessary solutions to fix their problems and improve their yields, or farmers were not well informed of farming practices and techniques that would have allowed them to solve their problems.

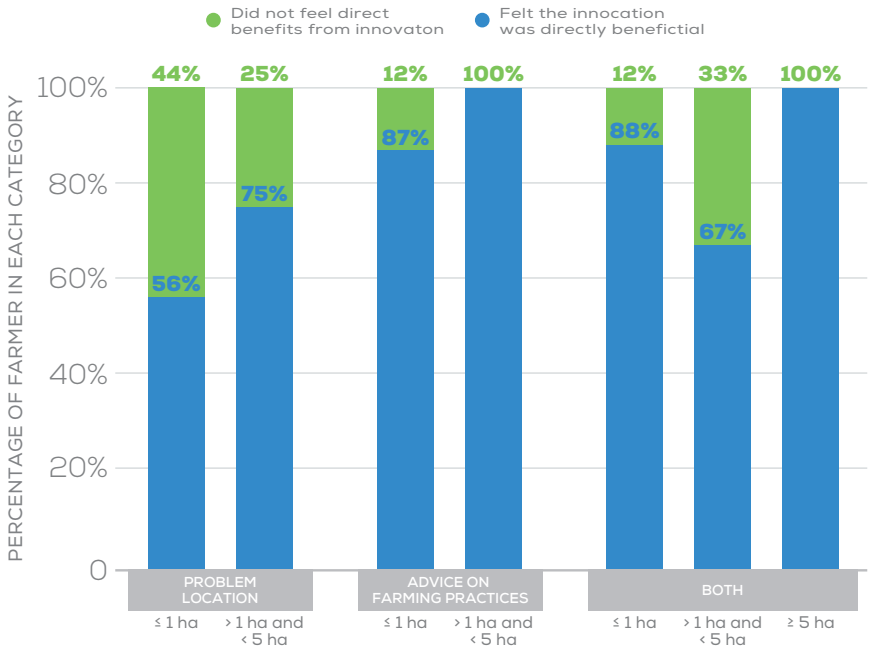
3. INNOVATION AFFECTED FARM SIZE AND GENERAL BENEFITS

If innovation is not providing information before farmers can spot problems with their own eyes, it could still be useful by bringing information about areas that farmers cannot reach or are too far. However, the average size of farm area affected by the innovation is of 0.8 hectares (excluding the 2 larger farmers, who own 27 and 15 hectares affected by innovation, each). This means that most of the farmers can easily walk around their farms and spot main issues when they are already visible.

In fact, data shows that farmers owning smaller farms were the ones that less perceived direct benefits from the innovation when they were provided with only information about where problems were located in their farms, as presented in Graph 33 below.

GRAPH 33. FARMERS' PERCEPTION OF BENEFITS PER FARM SIZE (AFFECTED BY THE INNOVATION) AND TYPE OF INFORMATION RECEIVED FROM DRONE OPERATOR

n=55



56% (10 out of 18) of farmers owning farms with an area equal or smaller to 1 hectare perceived direct benefits from innovation, while 75% (3 out of 4) of farmers owning farms between 1 hectare and 5 hectares perceived benefits. Farmers owning farms with an area of 5 hectares or more did not mention receiving only this type of information, so their perception of benefits from this type of information could not be assessed.

Farmers with larger farms also perceived more benefits than smaller farmers when they received advice on farming practices and techniques: 87% (13 out of 15) of farmers owning 1 hectare or less found direct benefits when the service provided them with this type of information, compared to 100% (3 out of 3) of the farmers who own farms with areas between 1 and 5 hectares. Farmers owning farms with an area of 5 hectares or more did not mention receiving only this type of information, so their perception of benefits from this type of information could not be assessed.

Farmers with farms with an area of 5 hectares or more were the ones who felt more direct benefits from receiving both types of information (problem location and advice on farming practices) combined: 100% (2 out of 2) of them, compared to 88% (7 out of 8) of the farmers owning 1 hectare or less and 67% (2 out of 3) of the farmers owning between 1 and 5 hectares.

4. CHANGES IN INCOME

Even though there was a slight increase in the number of farmers selling their yields after the innovation was active and an increase of 53% of the average revenue obtained by these farmers, as detailed in Section III.4 above, there are other factors, besides the innovation, that had an impact on income changes experienced by farmers, such as price fluctuations, access to markets, timing of harvest, etc. One of the main reasons for farmers being able to sell more of their produce was an increase in yields. But, if we look solely into increase in yields, for instance, only 7 out of the 14 farmers who had increases in income made an explicit connection between their increase in yields and the use of the innovation.

It is also important to consider that many farmers were advised by the drone operators on farming practices, such as how to use fertilizers or pesticides, which could probably have had an impact on how much they spend with farming inputs, affecting farming incomes. This change in investment on farming inputs was not included in the scope of the survey. But as discussed in Section IV.1.1 above, farmers that received advice from drone operators on how to use and have access to cheap/non-commercial forms of fertilizers not only were able to solve their issues, but were able to save on other inputs (such as water) and had a very positive attitude towards the innovation.

5. IMPACT ON POVERTY

As presented in Section III.5 above, the innovation had small impact on poverty alleviation since the number of poorest farmers after the innovation was introduced continued the same, even though some farmers improved their incomes. In fact, data shows that after innovation was active, the number of wealthier farmers slightly increased but the overall number of farmers in the lower income groups (Groups C and D) remained the same. On the other hand, the average earnings of farmers who were selling their yields increased, which can also be seen as beneficial.

This is in line with the fact that less farmers among the poorest felt the innovation brought direct benefits to them, while more farmers from the higher income groups felt direct benefits. It is interesting however, that more farmers from the lower income groups (Group C and D) were more interested when asked if the service should continue. It was not possible to evaluate all the reasons behind this trend, but one reason could be, as explained by one farmer in Group D, that he is "so poor that any help or service is welcome". Another farmer from Group D, when asked if he wanted the innovation to continue even without producing any direct benefits to him explained that he would be interested if in the future the innovation could help him. Also, a wealthy farmer from Group A said that the innovation was beneficial to him (he learned how to solve the issue with his beans from drone operator) but now he has no other problems, so he does not need the innovation anymore.

6. GENDER DIFFERENCES

As detailed in Section II above, women are the majority of farmers both in Mozambique and in the sample as small-scale agriculture has become a gendered activity where women are seen as the main responsible for farming (even though they not always have final decision over financial gains, as noted by Oliveira, 2016). Female farmers interviewed are are poorer (Graph 24 above) and own smaller farms (Graph 3 above) than the interviewed male farmers.

Even though men had higher average yield increases and overall net changes in yields, which is line with the national tendency of female small-scale farmers being less productive than men due to inequalities in education and access to farming inputs (Ministério do Género Criança e Acção Social de Moçambique, 2016) a higher proportion of women than men saw their yields increase while the innovation was active in Mozambique.

However, when asked if the service should continue active, less women responded positively, when compared to men (see Section IV.7 below). It is not clear what could be the exact reasons for this, especially when we see that, as detailed in Section III above, the same proportion of men and women perceived direct benefits from innovation.

However, more women felt the innovation was beneficial when they received both types of information (location of problems and advice on farming practices). It was not the scope of this survey to evaluate gender disparities in knowledge of farming practices and techniques, but further research on this could help better understand how effective the innovation could be to women depending on their previous knowledge or how to tailor it specifically for female farmers' needs.

Also, as previously described, a few women also stated that the innovation brought them more motivation to continue farming (since someone was "checking" or "helping" them), which is an indirect benefit that could also be better researched to bring more benefits to women. For instance, one question that was not asked in this survey is if the farmer works alone (many women were widows) or with spouse/husband and how does this affect their will to farm.

7. AFFORDABILITY OF THE INNOVATION

Because of limitations of time, the affordability of the innovation was not thoroughly assessed. But, when answering that they would like the service to continue, 29% (12 out of 41) of these farmers immediately continued the answer by saying that they cannot afford the service, even before a hypothetical price was mentioned.

In fact, 15% of the entire sample of farmers (9 out of 62) do not invest any money in farming inputs. They use seeds they stored from previous seasons and do not apply commercial fertilizers or pesticides. In Xai-Xai, specifically, farmers used to receive seeds for free as part of a government subsidy programme. Having to store or buy seeds now has put an extra pressure on farmers in this region. The leader of the farmers' association in Xai-Xai informed us that they were discussing with the board of the association if they should include the service in the fee that they are planning to start charging farmers in this area.

However, as detailed in Section III.6 above, many farmers had a positive attitude towards the innovation and would like it to continue active.

8. BENEFITS FOR LEADERS OF FARMERS' ASSOCIATION

As mentioned in sections above, leaders of farmers associations benefited from the innovation in different ways. 3 leaders were interviewed: the leader from the Nhampondzoene Association in Xai-Xai, and from the D5B and D5A locations in the surroundings of Chokwè. All of the 3 leaders interviewed stated that besides being beneficial to them as farmers, the innovation was useful to their work as leaders of farmers associations, as summarized in Table 10 below.

TABLE 10. BENEFITS PERCEIVED BY LEADERS OF FARMERS ASSOCIATIONS

Benefits from the service	Possible Indirect/collective benefit	Number of leaders that mentioned it
Allows leaders to have an overview of the farming area and where problems are located	Allowed leaders to speak to farmers and try to help them solve issues or encourage them to work more	3 Leaders
Produced images of the farming area	Leaders of associations could use images to confirm their observations or have evidence to convince farmers to improve their work	3 Leaders

For instance, the leader of association in D5B, (surroundings of Chokwè), explained that the innovation allows her to know which fields are facing problems and get in contact with these farmers to try to solve their issues:

> **"As a leader, the innovation helps me to know which fields in this association are problematic. So I go and speak to farmers to tell them what I saw in the images and I tell them where to find pesticides for them to improve their work."**

The leader of the association in D5A (surroundings of Chokwè) used the images provided by the innovation to support his demand to local authorities that fields in their region had to be levelled, besides showing where issues are located:

> **"As leader of the association, the innovation helped us to see where problems were located in peoples' farms, where the soil needed fertilizer, for example, or where there was too much salinity. It also confirmed where the soil was not levelled and we were able to take the images to the authorities to request the levelling. When soils are not levelled we produce less, water does not flow correctly, we use the incorrect amount of water, which causes hydric stress."**

Despite the positive uptake of the innovation among the interviewed leaders, it is also important to mention that while walking around the locations where the innovation was supposed to be active, we met the leader of Armalug, in Macarretane (surroundings of Chokwè), who had spoken to the drone operator at least once and seen the drone fly over his farm. However, he told us that "there was no need for new technology to identify where problems are if they won't explain them what the problem is and how to solve it". He was very negative about the service and did not want to speak in details about it stating that he had not used it.

VI. CONCLUSION

FutureWater's ThirdEye was a SWFF-supported infrared flying sensors project that intended to help farmers make better decisions concerning the use of their limited resources, such as water, seeds and fertilizers, by providing them with timely information about where issues were happening in their farms. This report analysed the results obtained by the monitoring and evaluation field intern who conducted an evaluation survey in July and August 2018 in Mozambique, after the project had been active there for 3 years.

Most of the farmers interviewed are small-scale (owning up to 1 hectare of land) female farmers that depend on rain-fed and flooding irrigation techniques. The service had an impact over water usage, crops, yields and farmers' income through information provided by drone operators, which were of two types: (i) problem location, meaning they they were informed of where a certain problem was occuring in their farms (crop stress, soil salinity, flooding, clogged water channels) and (ii) advice on farming practices: they were advised on farming techniques and skills, either confirming or improving their knowledge of farming. 40% of the farmers (N=55) received the first type of information, 36% of the farmers received the second type and 24% received both types of information.

77% of the respondents (N=60) felt that there was some kind of (direct/indirect) benefit from the information they received while using the service and all leaders of association thought that the innovation made their work easier for different reasons. Even though it was not possible to quantify changes in water usage, the innovation is seen as having a positive indirect impact over water efficiency in some areas by serving as encouragement for farmers to clean water channels or by providing the necessary justification to have fields leveled. As the innovation also provided advice on farming practices it can also indirectly have led to better use of water and other resources in farming. When it comes to benefits to crops, even though 60% of farmers increased their yields over the period examined, other factors besides the innovation were identified by farmers as also having an impact over production.

When it comes to farmers' perceived benefits from innovation, the type of information deemed as most beneficial to farmers was not the main scope of the innovation (identifying in advance where problems were occuring), but rather advice on farming practices. 56% of respondents (N=34) said that the service would be more effective if it not only identified where problems were located in the farms but also provided means to solve these problems, mostly fertilizers and pesticides. The second most common suggestion was that the innovation should provide farmers with more advice on farming practices.

This report also discussed to what extent the innovation's main purpose (to inform farmers in advance about the location of problems in their farms) was actually occurring considering drone operators' working schedule and the total number of users, and how beneficial can the innovation be to farmers who own, in average, not more than 1 hectare of land and cannot afford much farming inputs. In fact, data shows that farmers who owned smaller farms or that were classified in the poorest income groups were the ones that less perceived benefits from innovation. And data also showed that innovation had very little impact on poverty reduction when looking at the entire sample.

When asked if they would like the service to continue, 66% (N= 62) of the farmers said yes, while the rest was not sure or not interested in continuing with the service.

VII. REFERENCES

Instituto Nacional de Estatística de Moçambique. (2017). Mulheres e Homens em Moçambique 2016. Retrieved on December 23, 2018 from http://www.ine.gov.mz/estatisticas/publicacoes/mulheres-e-homens/mulheres-e-homens-em-mocambique-2017/at_download/file

FAO. (2018). Mozambique at a glance. Retrieved on December 23, 2018 from http://www.fao.org/mozambique/fao-in-mozambique/mozambique-at-a-glance/en/

Magin, P. (2015). Rule of Law for Whom? Questioning the Beneficiaries of Mozambican Land and Resource Rights. (Master's Thesis), Lund University, Retrieved from http://lup.lub.lu.se/luur/download?func=downloadFile&recordOId=5463382&fileOId=5463415

Ministério do Género Criança e Acção Social de Moçambique (Ministry of Gender, Infancy and Social Action of Mozambique). (2016). Perfil de Género de Moçambique. Maputo, Moçambique. Retrieved from: http://www.mgcas.gov.mz/st/FileControl/Site/Doc/4021perfil_de_genero_de_mocambique.pdf

Oliveira, P. (2016). Agricultura familiar, cultura e economia em Moçambique. Cadernos CERU, 27(2), 156-170. Retrieved from http://www.revistas.usp.br/ceru/article/view/125090/122144

ThirdEye. (n.d.). ThirdEye: Flying Sensors to Support Farmers' Decision Making. Retrieved on December 23, 2018 from https://www.futurewater.eu/projects/third-eye/

USAID. (2018). Agriculture and Food Security. Retrieved on December 23, 2018 from https://www.usaid.gov/mozambique/agriculture-and-food-security

World Bank. (2011). Climate Risk and Adaptation Country Profile - Vulnerability, Risk Reduction, and Adaptation to Climate Change in Mozambique. Washington DC, USA. Retrieved from: http://sdwebx.worldbank.org/climateportal/countryprofile/doc/GFDRRCountryProfiles/wb_gfdrr_climate_change_country_profile_for_MOZ.pdf

World Bank. (2018). Shared Prosperity 2018 - Piecing Together the Poverty Puzzle. Washington DC, USA. Retrieved from: https://openknowledge.worldbank.org/bitstream/handle/10986/30418/9781464813306.pdf

SECURING
WATER
FOR FOOD:
A GRAND CHALLENGE
FOR DEVELOPMENT

Securing Water for Food has sourced and invested in a portfolio of innovative solutions that aim to help farmers use water more efficiently and effectively, improve water storage for lean times, and remove salt from water to make more food. Our cohort of innovators are helping people in 35 low-resource countries with tools they need to produce more food with less water.

To learn more about Securing Water for Food,
visit www.securingwaterforfood.org.