Mozambique Sustainable Irrigation Project – PROIRRI

Endline Report

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Summary

Poverty rates have remained stubbornly high in Mozambique despite strong and sustained economic growth between 2005 and 2015. The largest poverty reductions have taken place in urban areas linked to capital intensive and import-dependent sectors, while rural poverty remains entrenched, particularly in Northern and Central provinces. Increasing the productivity of smallholder agriculture has enormous potential to contribute to large-scale poverty alleviation, but is constrained by a number of factors, including low adoption of modern technologies and practices, limited access to financial services and extension support, and poor infrastructure. In response to some of these difficulties, the World Bank and the Ministry of Agriculture and Food Security developed the Mozambique Sustainable Irrigation Project (PROIRRI) between 2011 and 2018, with the primary development objective to raise farm productivity in new or improved irrigation schemes and increase agricultural production marketed in the provinces of Sofala, Manica and Zambézia.

The analysis conducted in this report finds positive trends associated with the construction and rehabilitation the irrigation infrastructure on PROIRRI associations when compared to similar associations that did not directly benefit from improved irrigation systems. At the end of the project, PROIRRI farmer associations had more land under irrigation, produced more cash-crops, cultivated more frequently in the dry season, had higher crop yields, higher revenues from harvested crops and plots, and higher total agricultural revenues. These observations are all linked to the productive utilization of irrigation infrastructure – reducing crop production risk, permitting a second (and third) annual harvest, and increasing yields. Effects were most pronounced in the horticulture and outgrower associations in Manica than on the rice associations in Sofala and Zambézia. This report is unable to establish the causal impact of irrigation on project outcomes, due to farmer association selection not taking place under experimental conditions.

Further research is necessary to ascertain the true impact of irrigation in central Mozambique. One of the primary concerns with irrigation projects such as PROIRRI is the sustainability of investment, which can only generate positive economic returns if the infrastructure is still operational and utilized in the long-term. This requires strong management by water-user associations to maintain and repair the infrastructure following the end of the project. This report is unable to look into these aspects, as the

majority of irrigation scheme construction was finalized so close to the endline survey, which also hindered analysis. Most PROIRRI associations had not experienced an entire year of production under the new irrigation system by the time the endline survey took place. Further long-term monitoring of the associations and their members is required to understand these issues of sustainability. The desire of the new World Bank-financed Smallholder Irrigated Agriculture and Market Access Project (IRRIGA) to continue working with PROIRRI farmer associations provides opportunities in this regard.

1 Context

Poverty rates have remained stubbornly high in Mozambique despite strong and sustained economic growth between 2005 and 2015. The largest poverty reductions have taken place in urban areas linked to capital intensive and import-dependent sectors, while rural poverty remains entrenched, particularly in Northern and Central provinces (Baez and Olinto, 2016). 70% of Mozambicans live in rural areas and 80% of their livelihoods are connected to agriculture (Cunguara and Hanlon, 2010). The agriculture sector is dominated by smallholder production, characterized by low levels of productivity, which is one of the largest determinants of rural poverty (Arndt et al., 2012; Baez and Olinto, 2016). Increasing the productivity of smallholder agriculture has enormous potential to contribute to large-scale poverty alleviation, but is constrained by a number of factors (World Bank, 2017), including low adoption of modern technologies and practices, limited access to financial services and extension support, and poor infrastructure.

Most agricultural production is currently rainfed and precipitation levels are a primary determinant of national staple crop productivity (Cunguara and Kelly, 2009). Sixty to eighty percent of annual precipitation falls during the region's single rainy season (World Bank, 2007). As a result, most agricultural activity is concentrated in the wet season that runs from October to April. Agricultural productivity is related to both crop yields and the number harvest cycles realized by farmers throughout an agricultural season. Through both these channels, increasing the use of irrigation has the potential to substantially improve productivity in Mozambique, particularly given the abundant water resources available throughout large parts of the country. Three million hectares of land have the potential to be irrigated in Mozambique, yet in 2013 only 120,000 hectares were equipped with irrigation infrastructure, and 62,000 hectares were operational (MASA, 2013). Moreover, the current coverage of irrigation infrastructure is concentrated in the southern region, which has the lowest agricultural productivity and irrigation potential (World Bank, 2017).

Access and utilization of irrigation have been identified as crucial to the development of the agricultural sector in Mozambique and are key results in 2 of the 4 pillars Of the Strategic Plan for the Development of Agriculture Sector 2010-2019 (PEDSA).[1] Moreover, the expansion of area under irrigated sustainable land management is the first pillar of the Mozambican Comprehensive Africa Agriculture Development Programme (CAADP). To this end, the National Irrigation Strategy was approved in 2010, resulting in the creation of the National Irrigation Institute (INIR) in 2012 under the Ministry of Agriculture and Food Security (MASA). INIR has legal, technical and administrative autonomy, and a mission to promote the development of an efficient and sustainable irrigation sector.

[1] Pillar I - increasing agricultural production and productivity, and Pillar III - promoting the sustainable use of natural resources

INIR is responsible for the implementation of the National Irrigation Program (approved in 2016), which aims to add 212,500 hectares of new land under irrigation by 2042.

2 The Mozambique Sustainable Irrigation Project

2.1 Overview

The Mozambique Sustainable Irrigation Project (PROIRRI) was launched in 2011 with the primary development objective to raise farm productivity in new or improved irrigation schemes and increase agricultural production marketed in the provinces of Sofala, Manica and Zambézia. The project was structured under four components. The first provided institutional capacity development both within the Ministry of Agriculture and Food Security (MASA) and at the farmer association (FA) level. The second component financed the investment in irrigation systems and supporting infrastructure (such as connecting roads, dykes and electricity). This was the largest component of PROIRRI, which was initially budgeted at $53.1m of the $90m total and planned to cover 5,500 hectares of farmland. This target was revised downwards to 3,000 hectares during the mid-term review of the project. The third component offered cost-sharing grants for market-led production and value chain development. The final component covered project management and coordination.

This endline report provides details on the outcomes among farmers in FAs that received new or rehabilitated irrigation infrastructure as part of component two of the project. It is also important to note that not all members of beneficiary FAs received plots covered by the new or rehabilitated PROIRRI infrastructure. The subsequent analysis takes into account these intra-association differences in member household conditions.

2.2 Implementation

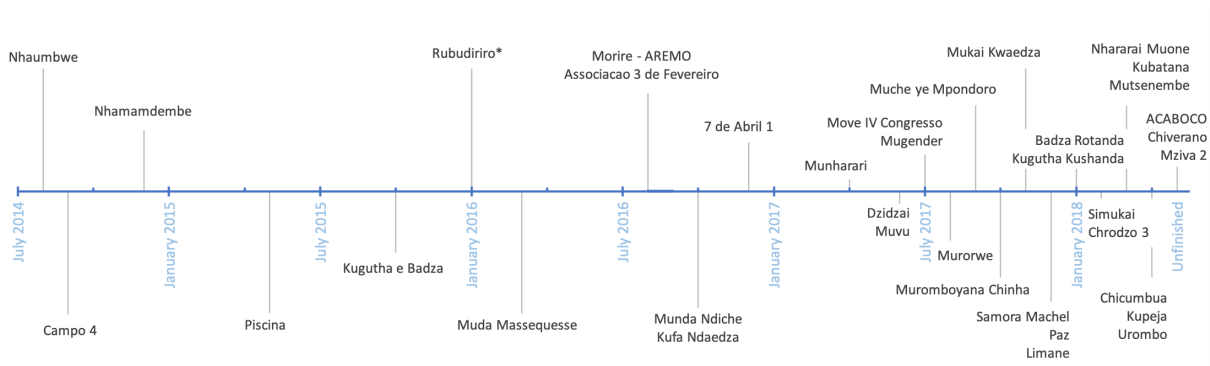
Site selection Beneficiary farmer associations (FA) were selected from a long-list of 95 FAs that were identified by provincial and district level government agencies during project planning stages. Identification was based on either i) their need for rehabilitation of a prior irrigation system, or ii) the potential for construction of a new irrigation system. Farmer groups were not required to be fully legalized associations, but at least have customary access to land suitable for irrigation. Each FA was assigned to a "business-line" based on the current and potential type of agriculture undertaken by the association members, based on three priorities identified by the project: rice, horticulture, and outgrowers. Outgrowers produce under a contract farming arrangement with a commercial entity that supplies inputs and guarantees a market for the production at a fixed price. The development of irrigation schemes for each "business-line" was assigned to a specific service provider.[2]

Each FA on the long-list received a "quick scan" visit from project engineers to assess their suitability and capacity to receive the project. FAs were assessed on the hydro-ecological conditions and irrigation potential of the land, commercialization opportunities, member cohesion and motivation, and their ability to take advantage of the infrastructure. Favorably evaluated FAs were selected by the project service providers for further technical analysis and a feasibility study before final selection was determined.

[2]The terms "business-line", "value-chain", and "type" are used interchangeably throughout this report to denote these administrative groupings.

Implementation Irrigation systems were developed for thirty-three associations over the seven-year lifetime of the project, covering a total area of around 3,000 hectares. The first set of three irrigation schemes were completed and handed over to the respective FAs in October and November 2014.[3] According to project administrative data, 1,332 hectares were brought under irrigation by April 2017, 2,011 hectares by September 2017, and the remaining 989 hectares finalized by mid-2018. The cost of irrigation infrastructure averaged around 12,000 USD per hectare. Smaller outgrower schemes were more expensive per hectare than larger rice schemes, though they are expected to generate higher levels of profitability.

Figure 1: Timeline of PROIRRI scheme completion



Notes: Irrigation completion dates as recalled by the association leadership. Rubudiriro could not recall the month of completion.

3 Evaluation design and data

This report documents the outcomes among PROIRRI beneficiaries. To provide suggestive evidence of the contributions of the project on their livelihoods, we benchmark these results with a group of non-beneficiaries. It utilizes data collected during the endline survey of the project, which characterizes the situation of participating farmers associations and their members over the final year of the project.

3.1 Evaluation design

A rigorous impact evaluation (IE) aims to isolate the effects that can be directly attributable to an intervention. The objective of an impact evaluation is to understand the difference between what happened to the project beneficiaries and *what would have happened to them in the absence of the intervention.* The key here is in identifying a valid control group with similar characteristics to the beneficiaries (the "treated" group), which provides this counterfactual. To determine the impact of an intervention, one cannot simply compare outcomes of the beneficiaries before and after implementation, nor is it generally sufficient to compare the outcomes of a group that received the intervention and a group that did not. Both of these methods fail take into account other factors that would affect outcomes other than the intervention. In the first case, we would be unable to say whether changes in outcomes would be solely due to the intervention or

[3]These were Nhamandembe, Campo 4 and Nhaumbwe in Vanduzi district, Manica province.

something else entirely, such as the weather, government policies, or other projects. In the second case, inherent differences between the groups from the outset due to targeting criteria would likely cause beneficiaries to not be comparable to non-beneficiaries. The gold standard is to randomize beneficiaries among an eligible group of potential participants, which ensures that a valid counterfactual is generated. Other quasi-experimental methods are often used in cases where randomization was not done or not feasible. These methods have their distinct data requirements.

In the case of PROIRRI we only have data for beneficiaries and relevant non-beneficiaries at the end of the project.[4] Therefore, as described, causal inference of the impact of irrigation under the context of PROIRRI is not advisable. The endline survey was collected among associations that received irrigation infrastructure and the remainder were FAs that were on the initial long-list. However, the farmer associations that did not receive improved irrigation infrastructure from PROIRRI were likely fundamentally different at baseline from those that did because of how the beneficiary selection process was structured. From the long-list of 90 farmer associations, PROIRRI service providers prioritized the development of irrigation on the lands of associations that had i) better prospects for commercialization and integration in value chains, ii) less complex construction processes, iii) more cost-effective benefits (lower cost per hectare or per beneficiary), iv) stronger institutional organization to manage the investment and form a water-user association, among others. Although rigorous impact cannot be effectively ascertained, the analysis will still compare the associations that received the irrigation ("treated") against those that did not ("control"). While the report is able to benchmark the outcomes of the treated and control farmer associations, it is not able to estimate the magnitude of this difference resulting from the irrigation received as part of PROIRRI.

Rigorous impact evaluations have been undertaken on several other components of PROIRRI, which look into issues regarding building group cohesion among association members and optimizing water use. The first of these takes advantage of financial literacy training and matching grants offered by the project, which aims to evaluate the degree to which regular follow up visits helped to stimulate savings contributions towards a communal savings goal. The second impact evaluation compares the efficiency of feedback tools for crop water requirements and individual water use information, which finds that the information feedback lead to higher reported and observed water sufficiency, and nearly eliminated water conflicts. This evaluation is documented in Christian et al. (2018). These impact evaluations form part of Development Impact Evaluation's (DIME) agriculture portfolio in Mozambique, which looks into questions of rural transformation and, in particular, the sustainability of rural infrastructure.

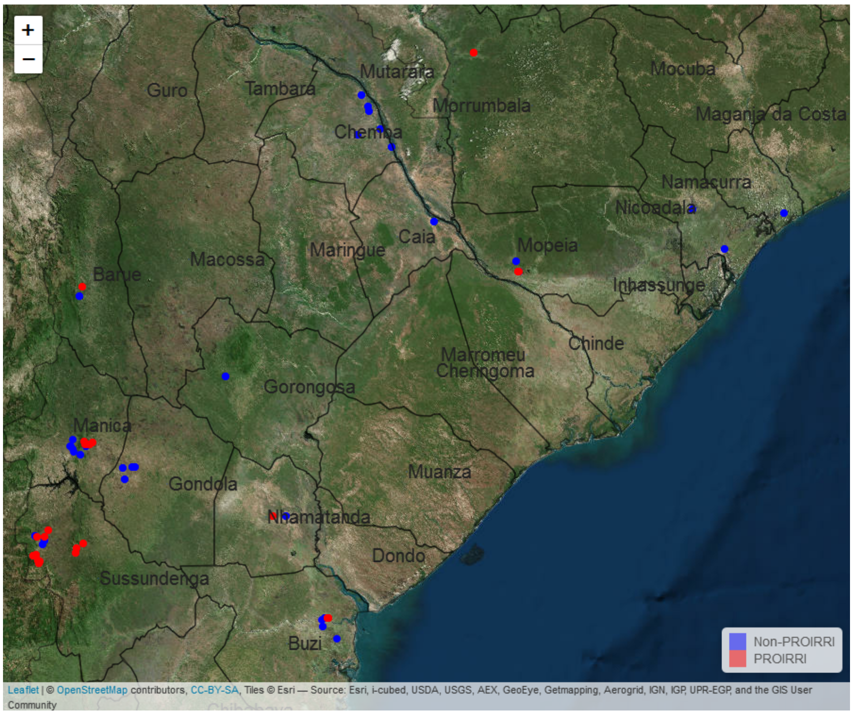
3.2 Sampling

The endline survey sample frame comprised 65 associations – 33 that had received the PROIRRI infrastructure and 32 that had not. These 32 "control" association were selected from the long-list of 90 associations that were considered by the project for rehabilitation during the inception phase. Among the non-selected sites on the long-list, the associations chosen for the survey were those that most closely mirrored the PROIRRI irrigation

[4] The project baseline data was collected among an unrepresentative sample of individuals that lived in communities that were identified as having potential to benefit from the project. However sampling was not necessarily performed based on membership of a farmer group. Instead, the sample was drawn from known farmers in the project provinces.

schemes, matching on district, value-chain and association legalization status. The 65 associations were of varying size and structure. Those in Manica generally have fewer members (45 on average), are smaller in area and produce horticulture crops. Those in Sofala and Zambézia generally cover a larger area, have a greater number of members (111 on average) and primarily cultivate rice. The map in Figure 2 shows the spatial distribution of surveyed farmer associations, denoting *at the time of the survey* whether the association had received finalized irrigation construction as part of PROIRRI. Any incomplete or never-functioning schemes intended for rehabilitation under PROIRRI are classified as non-PROIRRI.[5] The majority of associations were located in the Manica uplands, around the Zambezi delta, or by the Buzi and Muda rivers in Sofala.

Figure 2: Geographical distribution of surveyed farmer associations



As a first step of the endline survey, a member listing was conducted to obtain a sampling frame for the household survey. The association listing exercise yielded 4,748 total members in these 65 associations, from which 2,638 households were sampled – 1,051 from 34 associations in Manica, 1,153 from 20 associations in Sofala, and 434 from 11 associations in Zambézia. An average of around 40 households were sampled in each association. The sampling rules were as follows:

1. All association members that participated in the PROIRRI matching grant scheme were sampled, so that this could be fully evaluated.

2. All remaining association presidents and treasurers were sampled.

3. If an association has fewer than (or equal to) 26 members, all remaining members were sampled.

[5] The leadership of the following associations reported that the intended PROIRRI infrastructure had not been completed at the time of the survey: ACABOCO, Chiverano, and Mziva 2 (AMUCEMA).

4. If an association has more than 26 members, all remaining (after steps 1 and 2) members are randomly sampled to reach 26, then 20% of the remainder are also added to the sample.

The size and structure (proportional oversampling of smaller associations) of the endline sample frame ensures that there is sufficient statistical power to identify differences in outcome variables over the groups of interest. We use sampling weights in the analysis to compensate for the difference in sampling probability across FAs.

In total 1,159 replacements were made to the sample throughout the household data collection. Replacements occurred when a listed association member could not be interviewed, with the most common reasons being due to the member belonging to a household that has already been interviewed, the member being unknown, or difficulties locating the member. The majority of replacements were in Sofala (71%), with 70% of these coming from three large associations, where the association leaders and guides were unable to locate or did not know a substantial proportion of their members.

3.3 Data collection

The endline data collection was performed between April and August 2018 over 15 districts in the project provinces of Manica, Sofala and Zambézia. The household survey data primarily refers to agricultural activities performed by member households in participating farmer associations over the 12 months prior to the survey – specifically covering the principal harvest (rainy season) of the 2017/18 agricultural campaign, and the secondary harvest (dry season) of the 2016/17 agricultural campaign. The field work took place part over two phases. First, an association-level survey was performed with the association leadership, a list of members was recorded, and the association land and irrigated area was mapped. Secondly, the field teams returned to perform household-level surveys with sampled member-households in each association.

Data quality was assured through robust methods of data collection and verification. Surveys were performed on tablet devices running SurveyCTO Collect data collection software. This ODK-based application verifies data quality through a series of hard checks (e.g. all relevant questions must have an answer, age has to be between 0 and 120 years) and soft checks (e.g. enumerators are warned if plot areas are more than 5 hectares) on question responses in order to avoid invalid responses and typos. Electronic data capture also permits immediate checks on the data quality.[6] Questions in each survey were subjected to tests that flagged potentially inconsistent responses, which were then sent back to the field teams for final verification (with the household members if necessary). As a final measure, a small verification survey (*backcheck*) was applied to a random sample of 10% of household surveys that covers principal survey topics in order to verify enumerator accuracy and integrity. Cases in which responses of core questions were not aligned (such as the number of plots) were re-interviewed.

4 Results

The primary objective of PROIRRI was to increase marketed production and increase productivity on the irrigation schemes. In this section the project results are broken

[6] Including, for example, flags for if a household had no plots, extreme values for crop prices and yields, extreme values for labor services and payment, large plot sizes, crop sales larger than total production.

down and viewed under seven main themes to characterize the performance of the irrigation schemes. Firstly, we look into the expansion of irrigated areas that members of PROIRRI farmer associations have access to, then into the types of crops produced given the changing means of productions. Following this we look into how the schemes are being cultivated throughout the year and then discuss evidence on crop yields. Finally, estimates of crop revenues, cropping intensity and household revenues are presented to gain perspective on the overall impact of the irrigation infrastructure on the well-being of the project beneficiaries.

There are several groups compared throughout the analysis. As previously described, the primary strategy will be to look at outcomes between associations (and association members) of associations that received PROIRRI infrastructure and those that did not. Within this divide, we also acknowledge important differences between plots of farmers from PROIRRI associations that are irrigated (i.e. on the scheme) and those that are not. Therefore, wherever informative and practical we differentiate between both i) PROIRRI association members with and without any irrigated plots, and ii) the irrigated and non-irrigated plots of PROIRRI members with irrigated plots.

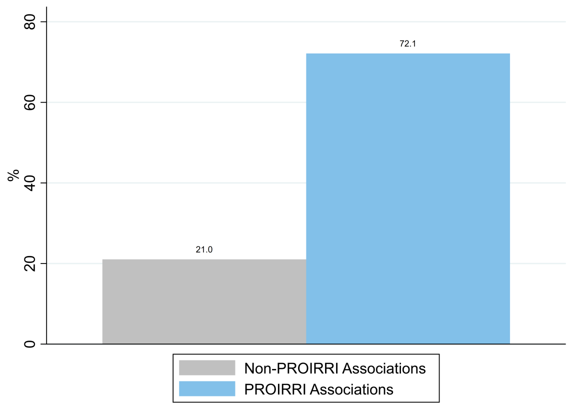
Survey data shows that farmers reported that construction/rehabilitation of only 10 schemes was finalized before 2017 (3 being rice-focused associations), with 18 schemes being finalized *during* the period the survey production data covers (between May 2017 and April 2018). As the majority of farmer associations were not operating PROIRRI irrigation infrastructure for the entire duration that the endline survey covers, the data described here will not be able to completely capture the impact of the irrigation infrastructure on the selected indicators. This issue is addressed during the discussion of crop yield estimates.

4.1 Areas under irrigation

Associations that received PROIRRI irrigation infrastructure investment have substantially higher rates of access to irrigation and larger irrigated plots, as depicted in Figures 3 and 4. The data shows that 72% of households in PROIRRI associations had access to an irrigated plot, while just 21% of members in other viable associations had access to an irrigated plot. The figure for PROIRRI associations is less than 100% for several reasons. First, there were several associations unfinished (or plots were not allocated) at the time the household survey took place, and second, there are some formal members of finalized PROIRRI farmer associations that were not allocated a plot connected to the irrigation system upon scheme completion.

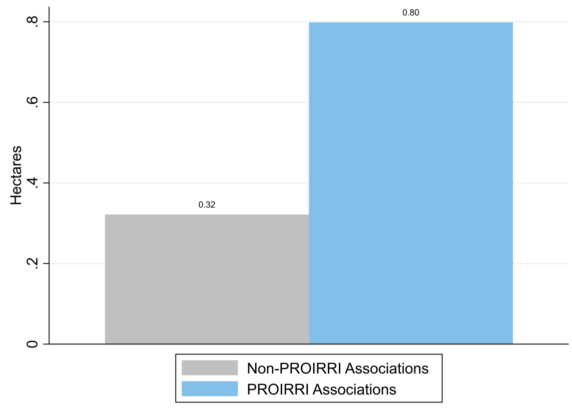
Farmer association members with access to irrigation on PROIRRI schemes have 0.8 hectares of irrigated farmland on average, while on the non-PROIRRI associations the average irrigated area per household is 0.32 hectares. This corresponds to households from PROIRRI schemes having an average of 23.4% of all their farmland with access to irrigation, while non-PROIRRI scheme households had access to irrigation on an average of 7.3% of their total landholdings.

Figure 3: Percentage of association members that have irrigation on at least one plot



Notes: Sampling weights applied.

Figure 4: Average area equipped with irrigation per household (hectares)



Notes: Sampling weights applied.

4.2 Crop production

Irrigation provides a steady source of water throughout the year. As a result, farmers can extend cultivation into the dry season and also switch to crops that require stable water supply. Farmers with effective irrigation systems are able to adopt more "risky" crops than otherwise – particularly crops with high water demand such as soybean or sugarcane, or more water sensitive crops such as lettuce and other horticulture crops. Furthermore, reducing the risk of crop losses should promote the production of cash crops over more drought-resilient staple crops. In theory, farmers with irrigation should have the capacity to meet the optimal water requirements throughout the crop production cycle.

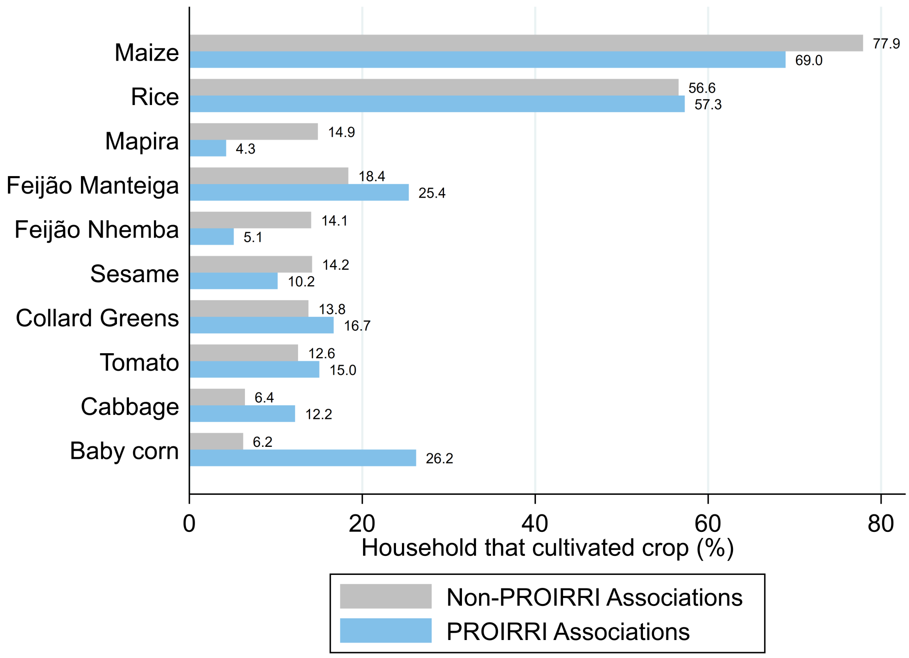
Figure 5 shows the most commonly cultivated crops by farmer association members for PROIRRI and non-PROIRRI farmer associations. Indeed, we observe that households with PROIRRI irrigation systems grow a higher rate of cash crops than otherwise, in particular baby corn and cabbage. Staples such as sorghum and maize are cultivated at higher rates in associations without PROIRRI systems. In general, maize and rice are widely grown in all associations, reflecting their importance as staple crops in Mozambique.

Figures 6 and 7 display the crop cultivation choices by farmers from PROIRRI farmer associations specifically on plots covered by PROIRRI irrigation infrastructure. Figure 6 displays these choices for outgrower and horticulture value chain farmer associations, while Figure 7 shows farmer associations linked to the rice value-chain.

Farmers in horticulture or outgrower association show a great heterogeneity in crops cultivated on their irrigated plots. In these schemes, around two-thirds of households cultivate baby corn (68%) and maize (64%). Despite maize being a common staple crop, surplus production is also widely marketed, particularly in Manica province. Moreover, the fact that one-third of households are *not* cultivating maize on PROIRRI plots implies that they are focusing on higher-value horticulture crops and shifting away from staple crop production. Butter beans (*feijão manteiga*) are cultivated by slightly over half of households on their PROIRRI plots, followed by collard greens (34%), cabbage (27%) and tomato (27%). These crops are all generally sold in their respective value-chains.

As anticipated, rice is cultivated on the majority of plots on PROIRRI irrigation schemes linked to the rice value chain (98%). Maize is also cultivated on 9% of plots. Most other cultivated crops are food security staples, with the exceptions of sesame (2%)

Figure 5: Ten most commonly cultivated crops

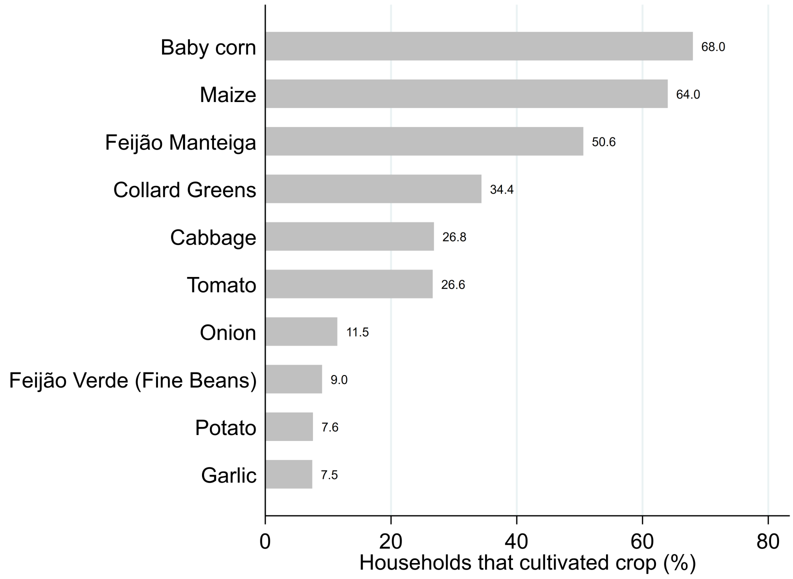


Notes: Sampling weights applied.

and tomato (1%). In this regard, these farmer associations are highly specialized towards rice production and are therefore capable of integration in the commercialized rice value-chain.

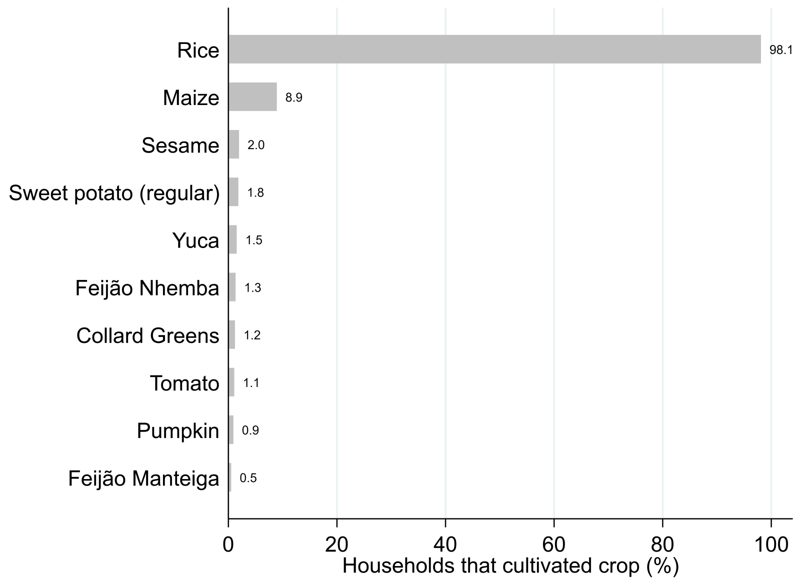
Such diversity in crop choice observed in farmer associations with PROIRRI infrastructure is motivated by market linkages established through outgrower arrangements with agribusiness entities for horticulture crops. Moreover, farmers with irrigation have the potential to cultivate throughout the year, further increasing their potential profitability compared to a scenario of no irrigation.

Figure 6: Ten most commonly cultivated crops - PROIRRI plots in outgrower and horticulture schemes



Notes: Sampling weights applied.

Figure 7: Ten most commonly cultivated crops - PROIRRI plots in rice schemes



Notes: Sampling weights applied.

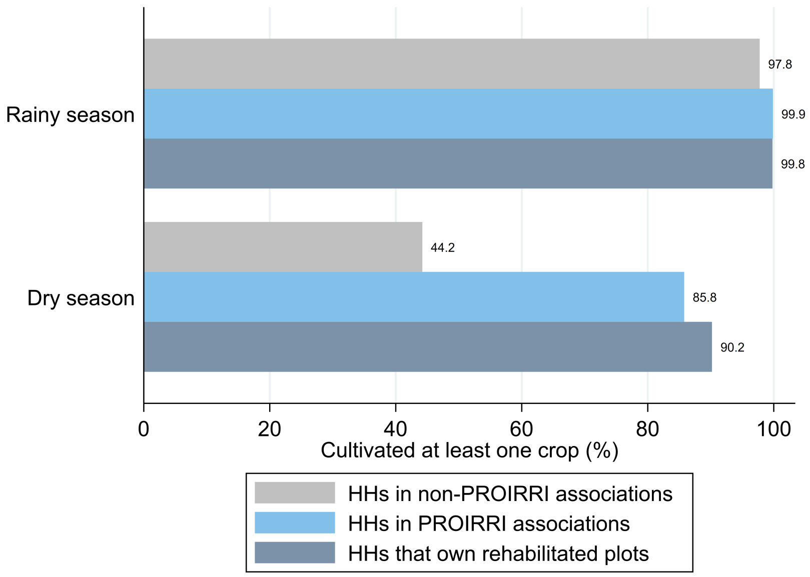
4.3 Cultivated area

As previously outlined, one of the principal benefits of irrigation is that it permits farmers to produce in the dry season. Gains from irrigated agriculture in this regard would be reflected in higher rates of cultivation in months outside of the prime cultivation season. The endline survey defined the primary (rainy) season as crops harvested between 1 October 2017 and the date of the survey (May-July 2018), while the second season covers crops harvested between 1 June 2017 and 30 September 2017. This follows the same structure as the Integrated Agricultural Survey operated by the Ministry of Agriculture (MASA).

Cultivation decision The endline data shows that variation in access to irrigation seems to be associated with considerable differences in second season cultivation when comparing households in PROIRRI and non-PROIRRI farmer associations, particularly in horticulture and outgrower associations. Figures 8 and 9 display the cultivation decision rates for households over both seasons by scheme type. These figures consider whether households decided to cultivate at least one crop on at least one of their plots in the relevant season. In the primary season the majority of member households in all types of association are cultivating on at least one plot (between 98-100% in all cases). Differences arise in their utilization in the secondary (dry) season. Members of PROIRRI associations in horticulture and outgrower associations have substantially higher rates of dry season cultivation than their equivalent in non-PROIRRI associations. 86% of households cultivate in the secondary season in PROIRRI associations compared to 44% in non-PROIRRI associations (Figure 8). Moreover, when restricting the households in PROIRRI supported associations to households that have access to the area rehabilitated by PROIRRI, the rate is even higher at 90% of households. This suggests that access to water resources is an important constraint for dry season cultivation decisions in horticulture based associations.

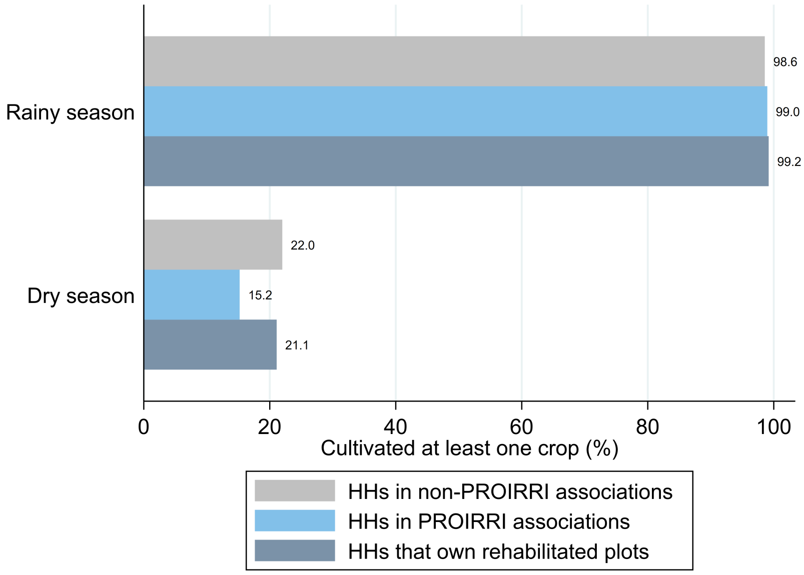
We do not observe this result in rice schemes, where the data shows that secondary season cultivation is limited in both PROIRRI (15% of households) and non-PROIRRI (22%) associations (Figure 9). As referred to previously, only three PROIRRI rice schemes had access to irrigation at the start of the secondary season under consideration (in June 2017), which likely explains the lack of dry season cultivation in PROIRRI associations.

Figure 8: Planting decision - outgrower and horticulture schemes



Notes: Sampling weights applied.

Figure 9: Planting decision - rice schemes



Notes: Sampling weights applied.

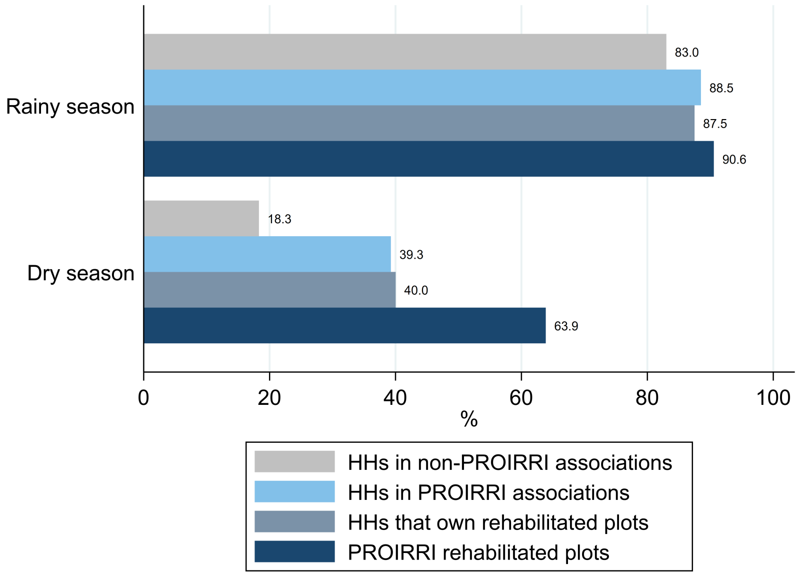
Share of land cultivated The next set of figures show the percentage of the available area that was utilized. Figures 10 and 11 display the average percentage of land cultivated per household by season, by scheme type. These are shown for 4 sub-groups: 1) all household plots in non-PROIRRI associations, 2) all household plots for farmers who are member of a FA that received PROIRRI investments, 3) same as *2)* but restricted to only those households that had access to a PROIRRI plot, and 4) same as *3)* but only their PROIRRI plots.

In the rainy season, we observe that a similar percentage of plot area was cultivated over all four groups – both for outgrower and horticulture associations (83-91%) and in rice associations (74-77%). This implies that the infrastructure did not influence the utilization of land (both on and off the irrigation scheme) during the rainy season. The percentage of land farmed on each cultivated plot was similar for plots on PROIRRI association land, plots outside of the PROIRRI association land, and for plots of households from non-PROIRRI associations.

Significant variation can be observed in the dry season. In general farmers in PROIRRI associations cultivate a larger share of their land. The fact this is happening at the same rate among farmers with and without PROIRRI rehabilitated plots, may suggest some of these differences are not only due to the project alone. When focusing on farmers with access to PROIRRI rehabilitated plots, we can see that overall they cultivate 40% of their available land. This is largely driven by substantially higher rates of cultivation on PROIRRI rehabilitated plots. On average 64% of the total land area on PROIRRI plots was cultivated inside horticulture and outgrower PROIRRI associations (Figure 10). As this value is larger than the rate observed over *all* household plots (which include the PROIRRI plots) for households with PROIRRI plots (39-40%), there is evidence of cultivation shifting from other plots to cultivating a larger proportion of their PROIRRI plots in the dry season. This is an unsurprising result, as one of the primary benefits of irrigation is to permit a second (and third in the case or horticulture production) harvest over an agricultural year. The rate of cultivation is encouraging, and it shows widespread adaptation of farmers to the new production possibilities endowed with the PROIRRI irrigation systems.

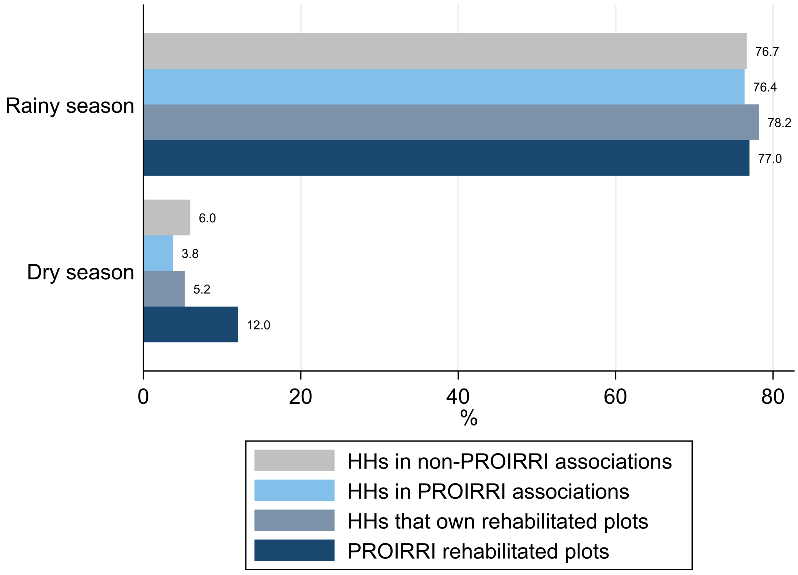
This is also apparent, though to a lesser degree, when looking at rice associations. We find that secondary season cultivation on plots of farmers of rice associations is minimal in the dry season (between 4-12% of the plot area covered) (Figure 11). There is a slight increase in the average area of PROIRRI plots being cultivated compared to all other types of plot, yet there is little evidence of irrigated production in the dry season in rice associations. Implementation issues are likely the cause of the limited secondary season uptake in plot usage in PROIRRI rice schemes. It will be important to closely monitor these farmer associations and provide the necessary extension support to encourage multiple annual harvests utilizing the productive irrigation infrastructure over the forthcoming agricultural campaigns.

Figure 10: Average percentage of total landholding cultivated - outgrower and horticulture schemes



Notes: Cultivated area and plot sizes are winsorized at 95th percentile. Sampling weights applied.

Figure 11: Average percentage of total landholding cultivated - rice schemes



Notes: Cultivated area and plot sizes are winsorized at 95th percentile. Sampling weights applied.

4.4 Crop yields

A core aspect of the Project Development Objectives (PDOs) is the crop yields obtained by PROIRRI farmers – substantial increases in these indicators were projected during program design. Average tomato yields were expected to double (from 10 to 20 tons per hectare), onion and cabbage yields to increase by 50%, and rice yields were anticipated to quadruple from 1 to 4 tons per hectare (tn/ha) over the project cycle.[7] The baseline yield values defined in the PDOs were in fact considerably higher than those reported in the baseline survey report. Overall, the data collected in the endline survey does not show increases in yields to the target levels in the PDOs related to yields, although we do see superior crop yields for farmers cultivating on PROIRRI schemes compared to i) farmer associations without PROIRRI infrastructure, and ii) average yields in Mozambique.

Tables 1 to 4 show the estimated crop yields under a variety of contexts in order to better understand their magnitudes and distributions throughout the range of contexts covered by the endline survey. First we present interpretations of crop yields found on PROIRRI irrigation schemes, second the construction finalization date is considered, and finally, yields are compared between PROIRRI and non-PROIRRI schemes. In general, the number of surveyed farmers that cultivated potato, tomato, onion, and cabbage was low. Therefore yield comparisons are not advised due to the uncertainty associated with computing indicators for some activities practiced by a small number of farmers. Any inference in yields can only confidently be made by looking at maize and rice.

The yields calculated in the endline survey are a function of the reported crop harvest and the size of the area planted. Crop harvest was estimated by farmer recall of production on each plot in each season under consideration. Farmers estimated the size of each plot in hectares and crop area was estimated as the percentage of the total plot size that

[7] By way of comparison in the degree of yield growth predicted for rice, FAO (2019) estimates that average rice yields in 2017 were 0.8 tn/ha in Mozambique, 3.1 tn/ha in Thailand, and 3.8 tn/ha in India.

was allocated to the cultivation of the crop. Plot mapping was not performed due to cost considerations. This procedure adheres to standard agricultural survey methodology, such as that used in the Integrated Agricultural Survey undertaken by MASA.

Crop yield on PROIRRI plots Table 1 displays the estimated average of PROIRRI scheme yields at different levels. Crop yield can be calculated at various aggregation levels. For example, a yield aggregated at the "plot level" is calculated by computing the yields (production divided by area) at each cultivated plot and taking the average across plots. This places equal weight of yields on plots of different sizes. While those calculated at the "scheme level" sum the total production and divide by the total area cultivated with that crop on an irrigation scheme (an association's irrigated land) to calculate the yield for that individual scheme. In this calculation each plot is weighted proportional to its size in the scheme. This logic is also applied at the "total yield level" (all individual crop production on all plots is first summed, then this total production is divided by the total cultivated area on all plots) and the "household level" (which sums production across all plots of a household before dividing by the area dedicated to the crop, then takes an average of these individual household yields). Comparing these estimates can provide further insights into the structure of production patterns.

In general, yield estimates increase as the level of aggregation decreases, with the average of plot yields resulting in higher yield estimates. This implies that farmers cultivating smaller areas have higher yields than those cultivating larger areas.[8] Indeed, due to constraints in the availability of labor it is difficult for farmers to maintain yields as the area cultivated increases. In the context of low levels of mechanization, such an observation adheres to this principal.

Average maize yields are found to lie between 1.2-1.6 tn/ha in the rainy season and between 1.0-1.6 tn/ha in the dry season on irrigated plots developed by the project, depending on which yield aggregation level is chosen. The data estimates that average rice yields lie between 0.8-1.1 tn/ha in the wet season and 0.7-1.4 tn/ha in the dry season. The upper bounds of these values are higher than the average yield for each crop found nationally, despite rice being below the target PDO values.[9]

Yield distribution Although the data shows that the average farmer has not attained the target yields put forward in the PDOs, viewing the distribution of household crop yields allows us to better understand the productivity of project farmers. Table 2 shows the distribution of household crop yields over various percentiles for households with PROIRRI plots, separated over seasons. These values indicate the yield at that point of the crop yield distribution, after sorting from smallest to largest. The 25^{th}, 50^{th} (median), 75^{th} and 90^{th} percentiles are reported.

In general, the distribution of crop yields shows large variability, demonstrating that elevated yields were achieved by some of the project farmers. In most cases there is a significant jump between the median values and the 75^{th} percentile values, from which point crop yield estimates are strong. At the 75^{th} percentile in the rainy season both maize (1,800 kg/ha) and rice (1,450 kg/ha) yields are at least 50% higher than the national average. This suggests that there is a group of at least 25% of farmers cultivating on PROIRRI plots that are producing at high levels of productivity. The modest yields found at the lower end of the distribution could be caused by numerous factors, for example

[8]At higher aggregation levels, such as "total yield" and "scheme level", smaller areas carry less weight.
[9]There is no PDO target yield for maize.

Table 1: Average crop yield per season in PROIRRI plots at different aggregation levels

	Total yield	Scheme level	Household level	Plot level
Rainy Season				
Maize	1162	1171	1607	1564
Rice	980	796	1091	1061
Butter Bean	556	594	714	761
Potato	981	1622	1213	1213
Onion	1578	1703	2183	2140
Tomato	1979	3077	3045	2863
Cabbage	5270	5814	8624	9510
Baby Corn	2095	1943	3709	3909
Dry Season				
Maize	1037	1362	1606	1624
Rice	659	1369	705	670
Butter Bean	530	1625	996	969
Potato	1874	2735	3207	3207
Onion	985	1108	1355	1355
Tomato	1873	2722	2900	2900
Cabbage	4249	4821	10503	10407
Baby Corn	2057	1866	3366	3525

Notes: Yield is reported in KG per hectare. Sample is restricted to PROIRRI rehabilitated plots. Winsorized at the 95th percentile. Sampling weights applied.

heavy pre-harvest losses from water shortages or flooding, pre-harvest losses from disease and pests, non-adoption of improved agricultural inputs, large spacing between plants, or plot size overestimation.

Impact over time The full impact of utilizing irrigation on crop yields would not likely be realized immediately. When taking advantage of new production methods, farmers require a period of experimentation and observing others to reinforce learning over several seasons in order to better understand its productive potential. When producing with irrigation for the first time, farmers need to adapt to new crops, to discover and optimize their water requirements, to understand input combinations and when to apply them, among numerous other decisions. This is a process that takes time, thus it is unlikely that high yields will be generated by all farmers at the first harvest using new irrigation infrastructure.

Yet as previously mentioned, the majority of PROIRRI irrigation schemes were completed in 2017 or 2018. Given that the endline survey was undertaken in mid-2018, these associations did not have finalized irrigation infrastructure in place over the entire period covered by the survey. Only 5 associations reported to have PROIRRI infrastructure finalized before the start of the dry season in 2016 – one year before the start of the survey period. As a result, yield comparisons of all PROIRRI associations are likely to underestimate the true long-run impact of irrigation infrastructure, due to the necessary learning period not being realized, nor all schemes having irrigation for the period under consideration.

To shed light on this issue, Table 3 provides yield estimates at the association level,

Table 2: Household distribution of crop yields on PROIRRI plots

			Percentile			
	N HHs	Mean	25th	50th	75th	90th
Rainy Season						
Maize	324	1607	600	1100	1800	3000
Rice	538	1091	500	833	1450	2000
Butter Bean	114	714	300	500	1000	1667
Potato	15	1213	500	667	1450	3000
Onion	16	2183	833	2222	2500	5000
Tomato	44	3045	937	2000	4000	6000
Cabbage	75	8624	2900	5000	11600	20833
Baby Corn	344	3709	1389	2600	4000	6667
Dry Season						
Maize	75	1606	556	1200	2000	3333
Rice	60	705	200	357	980	1905
Butter Bean	70	996	250	571	1060	2000
Potato	16	3207	1000	1500	4833	7250
Onion	31	1355	417	750	1267	3360
Tomato	50	2900	833	1200	4160	7200
Cabbage	74	10503	1333	4833	11100	19333
Baby Corn	209	3366	1333	2600	4000	6667

Notes: Yield is reported in KG per hectare and calculated at household level. N HHs is the sum of the sampling weights, meaning that it is the size of the total population represented by this sample. Sample is restricted to PROIRRI rehabilitated plots. Sampling weights applied.

filtered by the year that the irrigation system was finalized and first cultivation took place. The schemes that were completed pre-2016 had at least 18 months of experience with the irrigation system before the period covered by the endline survey took place, while pre-2017 associations had at least 6 months experience beforehand.[10] The data suggests strong evidence of a learning-by-doing effect being present in PROIRRI associations – maize yields in pre-2016 associations are 64% larger in the wet season and 89% larger in the dry season compared to the average PROIRRI association, while all other crop yields in both seasons are higher than the PROIRRI association average, save for tomato. As no rice schemes were finished and utilized before 2016, there are no rice yields to compare. The 3 rice schemes that were finished in 2016 had lower yields than than the average PROIRRI rice association.

Comparisons of PROIRRI and non-PROIRRI associations As a final approach to understanding the distribution observed crop yields, Table 4 presents comparisons in the average yields for key crops between farmers in PROIRRI associations and non-

[10]Pre-2017 also includes those associations listed in pre-2016 by definition. PROIRRI associations also includes both pre-2016 and pre-2017 associations.

Table 3: Average crop yield per season for PROIRRI scheme subgroups

	PROIRRI Associations			Pre-2017			Pre-2016		
	Mean	N Schemes	N HHs	Mean	N Schemes	N HHs	Mean	N Schemes	N HHs
Rainy Season									
Maize	983	29	1120	1209	10	124	1619	4	54
Rice	821	17	1133	598	3	226	.	.	.
Butter Bean	557	22	217	605	8	39	612	4	16
Potato	1854	13	27	4400	2	.	4400	2	.
Onion	1861	19	47	1749	4	4	1970	2	2
Tomato	2423	20	89	2012	2	10	1148	1	4
Cabbage	4247	22	120	6013	7	40	7391	4	28
Baby Corn	1903	17	439	2583	7	177	3225	3	104
Dry Season									
Maize	1004	26	174	1315	8	43	1901	4	23
Rice	1199	7	65	798	3	58	.	.	.
Butter Bean	567	20	120	821	8	33	594	3	12
Potato	1994	12	30	2356	4	6	3000	3	3
Onion	1063	16	56	1704	4	14	2554	2	5
Tomato	2022	21	89	4512	4	16	963	1	9
Cabbage	3854	19	94	4624	8	47	7032	4	31
Baby Corn	1855	17	272	2647	7	118	3545	3	71

Notes: Yield is reported in KG per hectare and aggregated at scheme level. N HHs is the sum of the sampling weights, meaning that it is the size of the total population represented by this sample. Winsorized at the 95th percentile. Sampling weights applied.

PROIRRI associations.[11]

Crop yields are higher in the PROIRRI associations than the non-PROIRRI association in all cases except for baby corn.[12] Productivity of the primary staples (maize and rice) is around 25% higher. Horticulture crops also show sizable yield disparities – onion yields are almost double, tomato yields are 62% higher, and cabbage yields are 34% larger. Crop productivity for PROIRRI associations is substantially higher than for sampled schemes without PROIRRI infrastructure.

As previously discussed, attribution of higher yields directly to the impact of irrigation requires careful caveats. There are numerous factors that could account for these differences beyond the access and use of irrigation. For example, this report earlier noted that farmers in non-PROIRRI associations did not generally cultivate in the dry season. Differences in yield will, therefore, mix the comparison of yields across seasons with differences in yields within season that could be attributed to management of water within irrigation. In general, because the assignment of which schemes and plots would receive irrigation upgrading is not randomized, these comparisons will also be influenced by any differences in which schemes were selected to be upgraded. If more productive schemes are selected for upgrading, then comparing upgraded schemes to those not selected would overstate the degree to which irrigation improves yields. If the least productive schemes

[11]PROIRRI schemes that were cancelled or not finished / never used by the time of the survey are not classified as PROIRRI schemes.

[12]Because baby corn is cultivated by only 141 households in non-PROIRRI schemes and over 500 in PROIRRI schemes, yields of this crop must be interpreted especially with caution. For example, if only the most productive farmers cultivate baby corn without improved irrigation, the small number of farmers cultivating this crop may have higher yields than the larger number of farmers in PROIRRI schemes who take up cultivation of this crop. When a crop is much more likely to be cultivated in one type of scheme than the other, these comparisons become especially important.

were selected for improvements, then these comparisons would understate the causal effect of irrigation on yields.

Table 4: Average annual crop yield comparing PROIRRI and non-PROIRRI schemes

	Non-PROIRRI Associations			PROIRRI Assocations		
	Mean	N	Num HHs	Mean	N	Num HHs
Maize	762	35	1703	978	29	1148
Rice	713	18	1285	880	18	1139
Butter Bean	424	27	278	540	23	306
Potato	2000	3	10	2038	16	53
Onion	842	22	98	1608	23	95
Tomato	1326	28	168	2159	23	160
Cabbage	2905	22	116	3884	24	193
Baby Corn	1932	7	141	1887	17	509

Notes: Yield is reported in KG per hectare and aggregated at scheme level. N HHs is the sum of the sampling weights, meaning that it is the size of the total population represented by this sample. Winsorized at the 95th percentile. Sampling weights applied.

4.5 Crop revenue

To compare production across crops we present revenue indicators. To aggregate the different crops and their units we use the median sales price for that crop over the entire sample during the relevant season. As such, the revenue indicators aim to show the market value of aggregated production, not the value received from sales. This section presents i) revenues per harvest realized on cultivated land (in Tables 12 and 13), and ii) revenues per hectare of available land (Tables 14 and 15). The sample considers all cultivated crops in each plot, by all households, over both seasons.

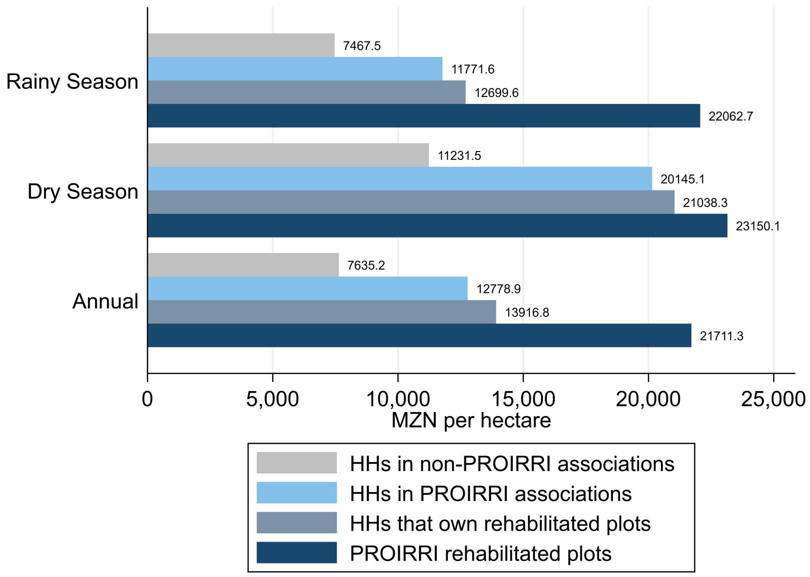
Average revenue per hectare cultivated We start by looking at a measure for the value generated per harvest on each plot. Revenue is calculated by aggregating the estimated revenue across all crops cultivated (production * median price) by a household during the relevant time period (season or year). This total revenue is then divided by the total area cultivated in each cropping cycle to estimate the average revenue per hectare for each household. In case of multiple cycles the areas are counted multiple times, as such providing the average revenue per hectare for a cycle of planting. Through this measure, higher revenue can either be obtained by cultivating higher value crops and/or harvesting more produce per hectare for a given crop. It does not consider the ability to expand the area cultivated or being able to plant multiple cycles. These values are then averaged over households in the relevant group. Figures 12 and 13 demonstrate estimates of average crop revenue per hectare for one harvest in outgrower and horticulture associations, and rice associations respectively. The average revenues are further divided by season and the type of association (PROIRRI or not).

We observe that there is substantial difference in average revenues of crop harvests between production in PROIRRI plots and all other plots considered in the survey. Annually on horticulture and outgrower schemes the average revenue *per harvest* per hectare cultivated on a PROIRRI plot was 21,711 MZN (362 USD), compared to just 7,635 MZN (123 USD) for the average hectare harvested by households in non-PROIRRI associations (Figure 12).

There is little variation between average revenues per harvest generated on PROIRRI schemes over seasons, suggesting that with irrigation, dry season cultivation is as productive per hectare in a given harvest as rainy season cultivation. At first sight, we observe surprising results when comparing between the dry and rainy season, where the average revenue appears to be higher in the dry season. However, this is likely driven by i) the fact that only the most productive farmers opt to farm in the dry season, and ii) a shift in cultivation from rainfed and irrigated plots in the rainy season to just irrigated plots in the dry season, where more profitable cash crops can be cultivated. Rainfed plots are generally used for staple crop cultivation, which have a lower potential revenue.

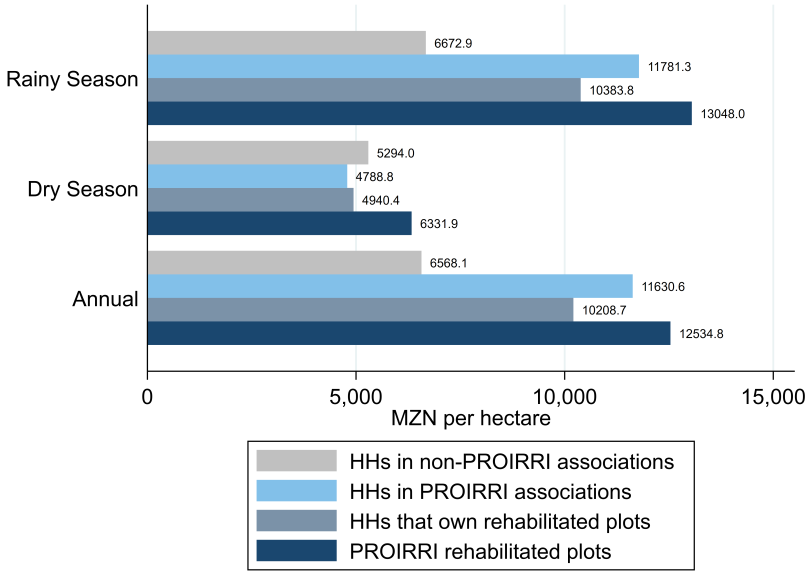
Different trends are observed on association plots on PROIRRI rice schemes, where the revenue per harvested hectare is significantly higher in the wet season than in the dry season – 13,048 MZN (210 USD) compared to 6,332 MZN (102 USD) (Figure 13). Average annual production revenues are similar to the values found in the rainy season, when (as previously noted) the vast majority of rice production was realized. The average revenue for each harvest per hectare observed shows that the outgrower and horticulture schemes are generating productive values per harvest at current levels of utilization.

Figure 12: Average revenue per crop harvest per hectare cultivated - outgrower and horticulture schemes



Notes: PROIRRI plot data only includes plots that were cultivated in a given season. Cultivated area and revenue are winsorized at 95th percentile. Sampling weights applied.

Figure 13: Average revenue per crop harvest per hectare cultivated - rice schemes



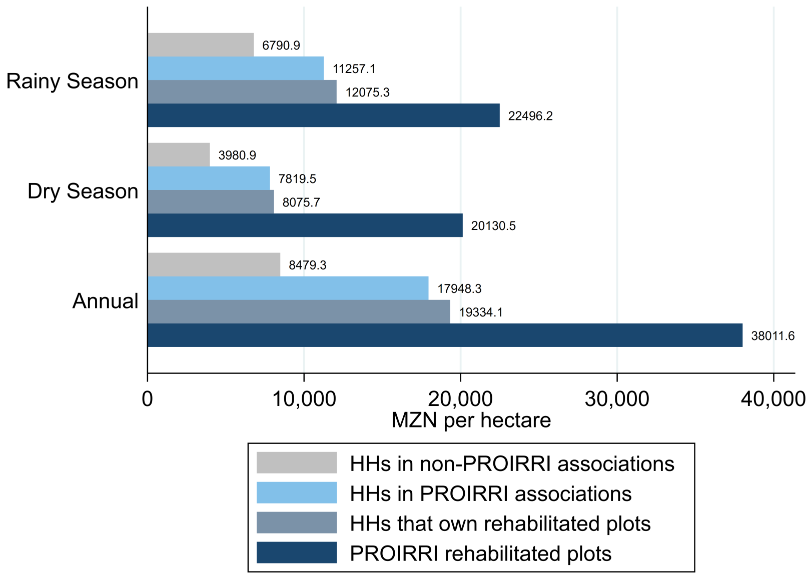
Notes: PROIRRI plot data only includes plots that were cultivated in a given season. Cultivated area and revenue are winsorized at 95th percentile. Sampling weights applied.

Average revenue per hectare available Now we focus on the revenues generated per hectare on all land *available* to farmers. While previously we considered the potential value from one harvest cycle, we now allow for multiple harvests per season, as well as taking into account the entire area available to farmers. This represents a measure of the current value generated on the association member's farmland. Uncultivated plots, or parts of plots, will reduce this value compared to the previous section, while more intensive cultivation (multiple harvests) has the potential to increase the values. As before, the estimates are constructed by aggregating the estimated revenues of all crop production over the relevant time period per household, but now we divide by the total farmland available to each household (instead of the area cultivated). The revenues per hectare available are then averaged over all households in the relevant group.

Figure 14 shows estimated revenues per hectare of available land in outgrower and horticulture associations. Here we observe that plots on the area covered by the PROIRRI infrastructure were utilized more productively than all other types of plots surveyed – those of households in non-PROIRRI schemes and also other plots that PROIRRI association members have outside the PROIRRI irrigation scheme. The productive difference on horticulture and outgrower associations is stark. We estimate that farmers on these associations generated revenues of 38,011 MZN (634 USD) per available hectare annually, compared to 8,479 MZN (141 USD) per hectare on non-PROIRRI associations (Figure 14). Moreover, we can observe large differences in revenues generated per hectare for irrigated and non-irrigated plots in PROIRRI associations, where the average revenue per hectare available for households with irrigated plots is far smaller than the average on a PROIRRI plot. This implies that the revenue generated per hectare on non-irrigated plots of PROIRRI farmers is substantially lower, which could be driven by fewer annual harvests on these plots, preferring staple crops over cash crops, larger plot areas outside of the irrigation schemes, and the lower yields we have already observed.

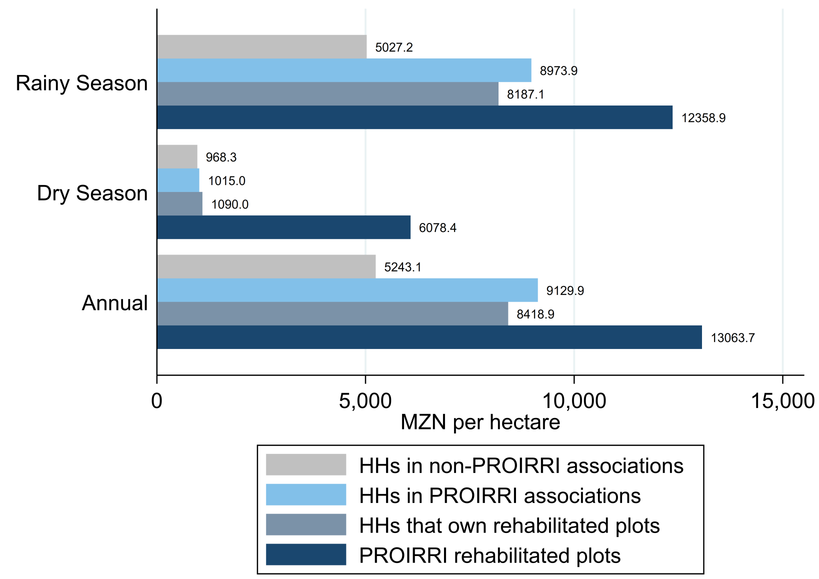
Average plot revenues on rice associations follow similar trends, with PROIRRI plots generating higher revenue levels than all other types. There are also noticeable productive differences between the plots on and off the irrigation schemes for households that are part of PROIRRI associations. The average annual revenue per hectare available on PROIRRI rice plots is 13,063 MZN (217 USD), compared to 5,243 MZN (87 USD) for households from non-PROIRRI associations (Figure 15). In the dry season, average revenue per available hectare is extremely low (around 1,000 MZN (17 USD) per hectare) for all household plots of non-PROIRRI association members and for plots outside of PROIRRI irrigation schemes for members of PROIRRI associations. This observation is largely powered by the extremely low cultivation rates of non-PROIRRI plots in the dry season.

Figure 14: Average revenue per hectare available - outgrower and horticulture schemes



Notes: PROIRRI plot data only includes plots that were cultivated in a given season. Cultivated area, revenue and plot sizes are winsorized at 95th percentile. Sampling weights applied.

Figure 15: Average revenue per hectare available - rice schemes



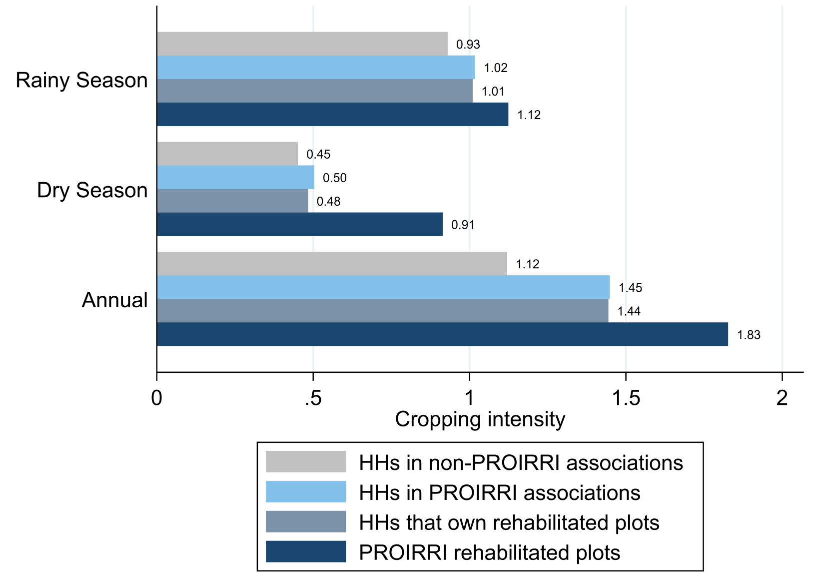
Notes: PROIRRI plot data only includes plots that were cultivated in a given season. Cultivated area, revenue and plot sizes are winsorized at 95th percentile. Sampling weights applied.

4.6 Cropping intensity

One of the drivers of the higher revenue per available land could be the potential to grow multiple cycles per season. To explore this channel we present estimates of cropping intensity. *Cropping intensity* describes the number of different harvests realized on a plot over a specified period of time in relation to the total size of the plot. It is calculated as the sum of the area used in each cropping cycle across all crops planted on a plot divided by the plot area. If an entire plot is cultivated once a season for both seasons, this will have a seasonal cropping intensity of 1 in each season, and an annual cropping intensity of 2. Increases in cropping intensity can be achieved by increasing the area of a plot under cultivation, or increasing the number of cycles on a given area. If only half the plot area is cultivated once the area would have a cropping intensity of 0.5. Meanwhile a cropping intensity of 1 would be achieved by either cultivating half the plot twice or the entire plot once. The seasonal values presented here only consider cultivated plots, while plots are counted for the annual value if they were cultivated at any point over the study period.

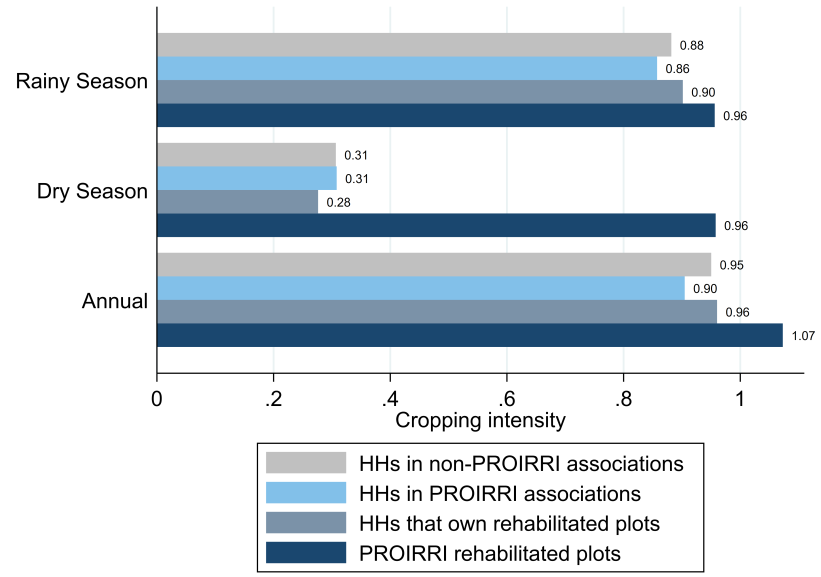
Figures 16 and 17 show cropping intensity estimates for outgrower and horticulture associations, and rice associations respectively. In the rainy season, PROIRRI plots are utilized at a slightly higher rate in all scheme types, though all types of plots have a cropping intensity between 0.88 and 1.12, implying that in most cases farmers cultivate the equivalent of the area available about once. In the dry season, we observe that farmers cultivate the equivalent of cultivating half the available area once. However, PROIRRI plots show a similar intensity as any plot in the rainy season. Sharply defined differences are present when comparing the annual cropping intensity rates of outgrower and horticulture schemes with rice schemes on PROIRRI plots – 1.83 compared to 1.07. Such differences are primarily due to higher dry season cultivation rates for PROIRRI plots in the dry season, where just 12% of the total available area of irrigated PROIRRI plots were cultivated (Figure 11). As we have previously seen in Figure 8, 64% of total available area was cultivated in the dry season on irrigated PROIRRI plots.

Figure 16: Cropping intensity - outgrower and horticulture schemes



Notes: PROIRRI plot data only includes plots that were cultivated in a given season. Cultivated area and plot sizes are winsorized at 95th percentile. Sampling weights applied.

Figure 17: Cropping intensity - rice schemes



Notes: PROIRRI plot data only includes plots that were cultivated in a given season. Cultivated area and plot sizes are winsorized at 95th percentile. Sampling weights applied.

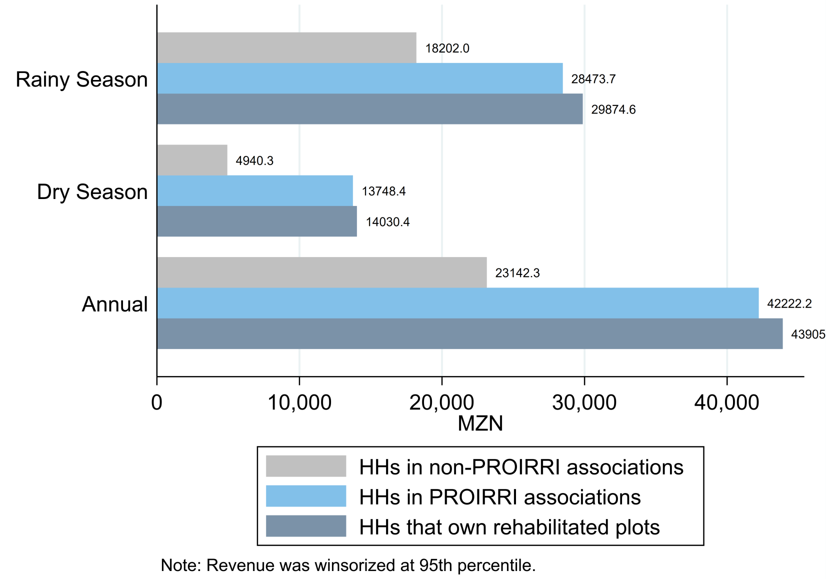
4.7 Total household revenue

The ultimate objective of the irrigation infrastructure is to increase overall production and revenue with the goal of improving household livelihoods. Household agricultural revenue is a function of the other parameters looked at in this section – the area cultivated, the type of crops planted, crop yields and cropping intensity – along with numerous other factors. This section estimates total household agricultural revenue across different groups, presented in Figure 18 and 19, which is simply calculated by aggregating all the production across crops and cycles and multiplying by the median price for each crop. Since the value is not divided by any area, we do not consider PROIRRI plots separately. These plots are included for "HHs that own rehabilitated plot" category.

We observe wide differences in average annual agricultural revenues between farmers of PROIRRI and non-PROIRRI associations. On horticulture and outgrower schemes, the average total revenue from agricultural production for a farmer with a PROIRRI plot was 43,905 MZN (732 USD), compared to 23,142 MZN (386 USD) for farmers without PROIRRI infrastructure, which is around 90% higher (Figure 18). On rice associations, the average annual household income for farmers with PROIRRI plots was 21,874 MZN (364 USD), while 15,845 MZN (258 USD) for those without, which corresponds to a 41% increase (Figure 19). It is important to note that we also observe substantially higher revenue in households in PROIRRI associations that did not receive the infrastructure. This can point towards either large spillover effects, impacts of complementary interventions, or selection bias. The latter would mean that the groups were already different at baseline, which we cannot test. This highlights the fact that we cannot interpret any of the results presented as only being caused by the irrigation infrastructure.

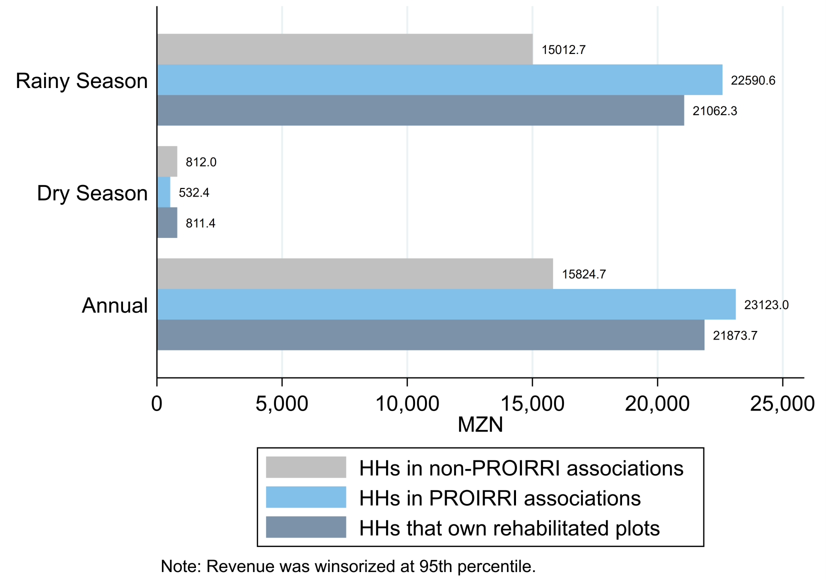
The majority of this differential in horticulture and outgrower associations can be attributed to higher earnings in the dry season for associations with PROIRRI systems, where income estimates are around 185% larger. Rainy season income is around 64% higher (Table 18). This is not the case in rice associations, where average dry season income estimates are minimal for both types of association. All increases in income for PROIRRI schemes are therefore associated with household activities during the rainy season. This provides further evidence that the PROIRRI horticulture and outgrower schemes were better able to take advantage of the productive potential of the irrigation infrastructure in the dry season, compared to those farmers on rice schemes. It is unclear how much this is due to the delayed irrigation delivery to rice farmers.

Figure 18: Average household agricultural revenue - outgrower and horticulture schemes



Notes: Household revenues are winsorized at 95th percentile. Sampling weights applied.

Figure 19: Average household agricultural revenue - rice schemes



Notes: Household revenues are winsorized at 95th percentile. Sampling weights applied.

5 Conclusions and Next Steps

The analysis conducted in this report finds positive trends associated with the construction and rehabilitation the irrigation infrastructure on PROIRRI associations when compared to similar associations that did not directly benefit from improved irrigation systems.

At the end of the project, PROIRRI farmer associations had more land under irrigation, produced more cash-crops, cultivated more frequently in the dry season, had higher crop yields, higher revenues from harvested crops and plots, and higher total agricultural revenues. These observations are all linked to the productive utilization of irrigation infrastructure – reducing crop production risk, permitting a second (and third) annual harvest, and increasing yields. Effects were most pronounced in the horticulture and outgrower associations in Manica than on the rice associations in Sofala and Zambézia. Analysis was hindered by the delay in construction of the irrigation schemes (particularly rice schemes), consequently most PROIRRI associations had not experienced an entire year of production under the new irrigation system by the time the endline survey took place.

This report is unable to establish the causal impact of irrigation on project outcomes, due to farmer association selection not taking place under experimental conditions. Causal impacts can be obtained in future projects by ensuring that a credible counterfactual is established during the process of selecting which associations will receive irrigation.

Further research is necessary to ascertain the true impact of irrigation in central Mozambique. One of the primary concerns with irrigation projects such as PROIRRI is the sustainability of investment, which can only generate positive economic returns if the infrastructure is still operational and utilized in the long-term. This requires strong management by water-user associations to maintain and repair the infrastructure following the end of the project. This report is unable to look into these aspects, as the majority of irrigation scheme construction was finalized so close to the endline survey. Further long-term monitoring of the associations and their members is required to understand these issues of sustainability. The desire of the new World Bank-financed Smallholder Irrigated Agriculture and Market Access Project (IRRIGA) to continue working with PROIRRI farmer associations provides opportunities in this regard.

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