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Impact evaluation of the Innovation for Agribusiness (InovAgro) program in Northern Mozambique

INTERNATIONAL FOOD POLICY RESEARCH INSTITUTE (IFPRI)

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ACRONYMS AND ABBREVIATIONS

ATT	Average Treatment effect on the Treated
APROSE	Association for Promotion of the Seed Sector
CAPI	Computer-Assisted Personal Interviewing
CGIAR	Consultative Group on International Agricultural Research
CSPRO	Census and Survey Processing System
DAI	Development Alternatives Incorporated
DID	Difference-in-difference
DNSA	National Directorate of Agrarian Services
FDA	Agricultural Development Fund
FGD	Focus Group Discussion
GIS	Geographic Information System
GPS	Geographic Positioning System
HH	Household
IFPRI	International Food Policy Research Institute
IIES	InovAgro Impact Evaluation Survey
InovAgro	Innovation for Agribusiness
KII	Key Informant Interview
MADER	(new) Ministry of Agriculture and Rural Development
MASA	(former) Ministry of Agriculture and Food Security
MSD	Market Systems Development
MZN	Mozambique Metical (currency)
NGO	Non-Governmental Organization
NSDP	National Seed Dialogue Platform
PCA	Principal Component Analysis
PIM	Policies, Institutions, and Markets
PSM	Propensity Score Matching
RCT	Randomized Control Trials
SDAE	District Services for Economic Activities
SDC	Swiss Agency for Development and Cooperation
SRTM	Shuttle Radar Topography Mission

VBA	Village-based Agent
VCA	Value chain actor

EXECUTIVE SUMMARY

This report presents the findings of the impact evaluation of the development intervention “Innovation for Agribusiness” (InovAgro) on households and markets in Northern Mozambique. Using a Market System Development (MSD) approach, InovAgro project – funded by the Swiss Agency for Development and Cooperation (SDS) and implemented by Development Alternatives Inc (DAI) – aims at increasing income and economic security for poor men and women smallholder farmers in Northern Mozambique through improved agricultural productivity and enhanced connectedness to market systems of selected high-potential value chains, namely maize, soya beans, pigeon peas, sesame, and groundnuts. Although InovAgro’s market systems interventions cut across these five value chains and many more, this impact evaluation focused on three value chains (maize, soya beans and pigeon peas).

The second section of the report provides the InovAgro project’s overview and theory of change as well as the project’s expected outcomes. InovAgro project consisted of three phases. The first phase (referred to as InovAgro I project) – a design and pilot phase spanning 2010 through 2013 – focused on engaging lead firms throughout-grower schemes for soy and maize, and supporting model small farmer entrepreneurs, such as input suppliers, large-scale agricultural output buyers and influential community lead farmers, through well-functioning market mechanisms to strengthen smallholder farmers’ access to input and output markets. The second phase (referred to as InovAgro II project) adapted to the bottlenecks encountered during phase one and abandoned the out-grower scheme approach, to pursue well directed and defined partnerships with private sector actors, to strengthen smallholder farmers’ access to input and output markets. It did so by means of private sector organized farmer field days, promotions of lead-farmer demonstration plots, and greater extension efforts by enabling local traders of improved and certified seed varieties to provide extension, and by more targeting communities with growing demand for improved and certified seeds. Like InovAgro II project, InovAgro III project builds on previous phases by strengthening the capacity of seed companies and input suppliers, improving access to finance and output marketing.

The InovAgro project’s theory of change in phase II illustrates that the project intended to achieve three expected outcomes. To achieve those three expected outcomes, InovAgro project designed four well-structured and complementary project implementation strategies; namely seed market strategy, mechanization strategy, extension intervention strategy, and output trading market strategy for soya beans and pigeon peas, and access to finance through farmer generated savings. The first expected outcome of the project was to increase smallholder participation in commercial value chains and

smallholder competitiveness. The three expected indicators of progress toward this first outcome include (i) smallholder farmers' increased productivity for the project's value chain crops, (ii) increased numbers of smallholder farmers participating in commercial value chains through increased access to quality agricultural inputs and improved commercial value chain knowledge, and (iii) increased total volume of the InovAgro project crop production for project beneficiaries.

The second expected outcome of the InovAgro project is to increase direct transactions between private sector companies and smallholder farmers. The two expected indicators of progress toward this outcome include (i) the increased number of private sector companies establishing commercial contracts with smallholder farmers to purchase their agricultural production, and (ii) an increased number of private sector companies selling agricultural inputs to smallholder farmers. The third expected outcome of the InovAgro project is to increase commercial transactions, market-oriented relationships, and effective supply coordination in the seed industry. The two expected indicators of progress toward this outcome are (i) a reduced volume of pigeon pea and soya beans certified seed supplied to smallholder farmers by the government and donor funded projects, and (ii) an increase in the number of formal agreements between agricultural research institutions and private sector seed companies to directly supply basic and pre-basic seed to private sector seed companies. However, these two were dropped in InovAgro phase III as they proved unrealistic to measure. Adaptive

Section three of the report outlines the main challenges for impact evaluation of MSD programs, in general, and that of InovAgro, in particular, and presents the mitigative measures taken to overcome the methodological challenges. To investigate the causal effect of the InovAgro program, the study originally adopted a cluster (community) level randomized controlled trial (RCT) randomly selecting 8 communities (4 each from the two study districts) to be the focus areas for project implementation while the other 8 communities (4 each from the two study districts) identified as project non-beneficiaries (control communities). However, randomly assigning some households to various treatment arms (treatment communities) was not possible in the context of the InovAgro project due to three main challenges: (1) Ethical issues involved with exclusion of households for a control group; (2) The MSD (systemic) approach adopted by InovAgro project made strict exclusion criteria impossible to avoid contamination (it was extremely hard to contain treatment activities from the control groups); and (3) Adaptive nature of the MSD approach (highly responsive to supply and demand forces) made it difficult to randomize treatment (exposure to the program). This was evident during the project monitoring phase that, two years after the project launch in 2015, the units selected for treatment failed to receive the treatment or receive it in

the fashion that was intended by the intervention. To account for such discrepancies and address potential bias in our estimates, the InovAgro impact evaluation supplements the three-wave household panel dataset of intended beneficiary and non-beneficiary households with “intention-to-treat” data as an instrument for treatment (Abadie et al. 2002). Hence, we conducted a **unique geo-reference census data** of every value chain intervention operational in all the 16 communities of our study area and use the median distance to these value chain interventions (60 minutes in our case) as a cut-off for defining the catchment area of the intervention/treatment. Using this spatial identification strategy for generating beneficiary and non-beneficiary households, the study team, then, employed a combination of quantitative and qualitative methodological approaches to assess the macro (market) and micro (household) level impacts of the InovAgro project: namely, difference-in-difference (DID), Propensity Score Matching (PSM) and geo-spatial analysis. In addition to documenting the causal effect of InovAgro interventions on intended beneficiary households (micro level effects), an attempt has been made to shed some light on four potential channels through which the InovAgro project could have impacted system (macro/market level effects); namely systemic (long-term) effects, sustainability effects, large-scale (spillover or multiplier) effects and unintended (positive or negative) effects.

The fourth section of the report describes the data and presents descriptive findings of the impact evaluation. We employed three rounds of household-level panel data (2015, 2017 and 2019), complemented with two rounds of geo-spatial data (2017 and 2019) and three rounds of data (2015, 2017 and 2019) gathered through Key Informant Interviews (KIIs) and Focus Group Discussion (FGD) with local stakeholders including market actors and local authorities. The first round of the panel data (baseline survey) was collected in 2015 covering the 2014/2015 agricultural season, prior to the phase-two InovAgro intervention, in Alto Molocue and Molumbo districts in Zambezia province. While the second (midline survey) and third (endline survey) rounds of the panel data were collected in 2017 and 2019 covering, respectively, the 2016/17 and 2018/19 agricultural seasons, during the InovAgro intervention (they cut across two phases - phase two and three) which had different logframes and incorporated shifts in approach. The questionnaire focused on agricultural production and market access for all crops grown by farm households, and particularly for three of the InovAgro value chain crops (maize, soya beans and pigeon peas). Geo-spatial data enabled the study team to categorize all sampled households into four groups: (1) MSD beneficiary – InovAgro facilitated; (2) MSD beneficiary – Non-InovAgro facilitated; and (3) Non-MSD beneficiary; and (4) non-beneficiary (control households). This categorization was employed to assess the macro (market) and micro (household) level impacts of InovAgro project.

Descriptive findings presented in the fourth section reveal stark (statistically significant) differences in key household characteristics (such as age, marital status, gender and education of the head of households, etc.) and selected outcome variables (such as access to agricultural input and output market information, volume of production, income and crop diversification, etc.). Overall, results show treatment households are younger, more female headed, with a relatively larger farm holding and better adoption of improved seed varieties. On the other hand, with a particular relevance to our concern of selection (endogeneity) bias, control (non-beneficiary) households start from a favorable baseline condition in all of the core outcome variables except the three adoption variables – adoption of fertilizer and agrochemicals (but with no significant difference) as well as adoption of improved seed varieties (significant difference favoring the treatment group before any intervention started on the ground). Such stark differences on key variables of interest at baseline reinforces the validity of the endogeneity with which the study team are concerned, leading to a potential downward bias into our estimates given that control (non-beneficiary) households are starting with a favorable condition compared to treatment (beneficiary) households. Hence, we accounted for such potential selection bias issues (either due to self-selection or program targeting) by using a PSM method.

These descriptive findings also revealed that usage of yield-enhancing agricultural inputs among households in the treatment group increased substantially from 2014/15 to 2018/19 agricultural seasons, compared with those in the control group. The share of households who used agrochemicals (insecticide or herbicide) increased from 0.0% in 2014/15 to 13.8% in 2018/19 in the treatment group, compared to an increase from 0.0% to 3.9% in the control group. Similar patterns were registered for fertilizer adoption (with an increase from 0.0% to 20.8% for treatment households while the control households, on average, registered an increase from 0.0% to 8.2%); and use of improved seed varieties (with an increase in adoption from 4.9% to 27.0% for treatment households while the change for control households is only from 0.0% to 13.6%). However, during the same period, household's perception of demand for improved seed varieties (willingness to adopt improved seed variety) has declined for both treatment and control groups¹; but the reduction (downward trend) was considerably higher among control households (37.6 percentage points from 52.6% to 15.0%) than among those in the treatment group (7.9 percentage points from 36.2% to 28.3%).

¹ Such result could be perhaps due to an overall behavioral effect of external factors that affected both treatment and control households (e.g., weather shock, flood, price inflation, etc).

The fifth section of the result presents findings of the impacts of InovAgro project on households and markets. Overall, the findings revealed that, comparing the time before and after the launch of the InovAgro project (before and after 2015, respectively), there is a significant percentage increase in the number of non-InovAgro facilitated or sponsored value chain interventions. This trend remains consistent in both of the study districts, namely Molumbo and Alto Molocue. Similarly, results also show that, on average, non-InovAgro facilitated or sponsored MSD value chain interventions had significantly shorter time lapsed since the InovAgro's launch compared to InovAgro facilitated or sponsored value chain interventions. Both results are indicative of the facilitative role InovAgro has played in bringing more MSD value chain interventions into the system (i.e., crowding-in effects). As a result, due to such overall market (systemic) effect of InovAgro, MSD effect/impact and InovAgro effect/impact are, hereafter, used interchangeably.

With regard to the sustainability effect of InovAgro interventions, results presented in section five support our hypothesis that the InovAgro MSD program is more sustainable than non-MSD programs. We used 10 alternative definitions of usage of modern farming practices disaggregated by three types of value chain interventions, totaling 30 hypotheses to be tested. Of the 30 hypotheses tested, 21 cases show that the proportion of households that continue to use modern farm practices was significantly (at least at 10% level of statistical significance) larger for households treated or exposed to the InovAgro MSD program compared to those that are treated or exposed to non-MSD programs. More interestingly, the result is more robust and consistent for two InovAgro value chain crops (soya beans and pigeon peas), as the proportions of smallholder farmers who continued use of the modern seed varieties of soya beans and pigeon peas are significantly larger among InovAgro MSD project beneficiaries, compared to those who benefited from direct service delivery or subsidy programs (non-MSD programs). The finding remains robust regardless of the type of value chain interventions (agro dealer, lead farmer and demonstration plot). This result reinforces the skepticism around non-MSD programs which focus on free or subsidized direct delivery of services that are prone to dropouts as soon as such supports are withdrawn.

As in the case of the sustainability effects tests, we tested 30 hypotheses for the InovAgro spillover effects. Overall, the findings support the hypothesis that InovAgro project benefited a large numbers of smallholder farmers beyond the project's direct sphere of influence and intended beneficiaries. Of the 30 hypotheses tested, 23 cases show that the proportion of households who were new adopters of modern farm practices (those who did not adopt during the midline survey in the 2016/17 agricultural season but adopted during the endline in the 2018/19 agricultural season) was significantly larger (at least at a 10%

level of statistical significance) for non-beneficiary households who resided in close proximity to households treated or exposed to the InovAgro MSD program, compared to those who resided further away (more pure controls). Regardless of the proxy variables used to capture adoption of modern farm practices, the result is more robust and consistent for those beneficiaries with access to a lead farmer as a value chain intervention, compared to those who are benefited by access to agro-dealers and demonstration plots. This is perhaps not surprising given the role social capital can play in magnifying the potential spillover benefits where lead farmers have better comparative advantages compared to those of agro-dealers or access only to a demonstration plot.

With regard to the unintended effects of InovAgro interventions, our findings revealed that a negative unintended effect of both MSD and non-MSD programs on households' crop diversification. This is expected since these programs encouraged smallholder farmers to specialize rather than diversify. We consider this as a potential unintended effect of the program given that smallholder farmers often use crop diversification as a risk-coping or mitigation strategy to deal with potential crop failure. Findings also revealed a potential negative effect of MSD programs on youth access to or control over land – perhaps, expected due to competition for land increases the more profitable the agricultural sector becomes. Other results show a contrasting evidence on household income diversification and migration where such unintended effect is positive for InovAgro MSD beneficiary households while the opposite (a negative effect) is the case for non-MSD beneficiary households.

However, it is worth noting that these results are with caveats since they do not take into account other factors that might have affected such outcomes. To complement the above-mentioned univariate analyses, we employed regression analyses (difference-in-difference and propensity score matching approaches) – to control for potential selection bias (due to self-selection or program targeting) and other factors that might influence the outcome variables of interest – to obtain econometric estimates in a further investigation on the direct benefits of the InovAgro program on beneficiary households and its potential unintended effects (positive or negative). The second part of the fifth section summarizes our econometric findings.

These findings showed that, regardless of the value chain interventions households are exposed to, InovAgro had a positive and significant impact on households' likelihood of using agrochemicals (like pesticide, herbicide, etc.). Such positive impact on usage of agrochemicals remained robust whether households were exposed to a single value chain intervention or the complete package (of agro dealer, lead farmer and demonstration plot). Such impact also appeared to be consistent when comparison is

made between short and long term. In contrast with the findings on the usage of agrochemicals, our econometric findings revealed no evidence of short-term impact of the InovAgro project on households' likelihood of fertilizer use. However, the likelihood of fertilizer usage depends on program beneficiaries getting exposure to the complete package (exposure to all value chain interventions). Similar to the positive effect on usage of agrochemicals, such dependence on intensity of treatment (whether or not households benefit from the complete package) seems to matter little when it comes to the likelihood of fertilizer usage in the long-term. With regard to usage of modern seed varieties, results showed a positive short-term impact of InovAgro MSD exposure, regardless of the type of pf value chain intervention, on the usage of modern seed varieties. However, interestingly, such positive effect of the program is wiped out in the long-term. This finding is indicative of the potential long-term spillover benefits of the program as non-beneficiary households may be catch-up on the usage of the modern seed varieties by learning from program beneficiary households.

Program impact on productivity, income and overall welfare of smallholder farmers depend on the quality and timely information farmers get regarding agricultural input and output market information. Hence, we investigated household access to agricultural input and output market information as potential intermediary outcome of the program. Our results showed a positive and significant effect of InovAgro program on access to agricultural input and output market for beneficiary households who are exposed to all three value chain interventions. However, signifying the importance of our methodological approach in differentiating the treatment by the type and intensity of exposure, our findings revealed that program impact on access to agricultural input market information depends on the type and intensity of exposure (we found no evidence of program effects on input market access for beneficiary households exposed to a lead farmer or a demonstration plot, while long-term positive effects are registered for those who are exposed to an agro-dealer). On the other hand, results showed a positive and significant impact of InovAgro on access to output market information among beneficiaries compared to non-beneficiaries. The positive impact remains robust and consistent whether households are exposed to a single value chain intervention or the complete package and whether comparison is made between short and long term.

Production (input and output) data were not collected during the baseline survey (2014/2015 agricultural season). This limited us from investigating the long-term InovAgro effects on agricultural productivity. With this caveat, our findings showed no evidence of short-term InovAgro effect on enhancing agricultural productivity of program beneficiaries compared to non-beneficiaries. This remained to be so regardless

of the type and intensity of exposure to value chain interventions. However, when we assessed the InovAgro impact on maize productivity, we found that a positive and significant effect of InovAgro on boosting not only maize productivity of beneficiary households but also their likelihood of maize market participation (likelihood of selling maize produce) as well as the ratio of marketable surplus. Such positive impact on productivity and agricultural market participation remains robust whether or not households are exposed to a single value chain intervention or the complete package.

Our econometric findings also showed no evidence of short- and long-term welfare impact of InovAgro when beneficiary households are only exposed to a single value chain intervention. However, a positive and statistically significant effect of InovAgro on household welfare were found when beneficiary households were exposed to the most intense (complete package) treatment – i.e., households exposed to all three value chain interventions at a time. This result is indicative that the designing and implementation of future similar MSD programs like InovAgro needs an integrated approach in complementing (packaging) such interventions insuring the forward and backward linkages. Furthermore, we found a positive and significant short-term effect of InovAgro program on beneficiary households having at least one member who has migrated temporarily (at least one month of the previous 12 months), while no evidence of long-term effect was found. By contrast, findings revealed a positive and significant long-term InovAgro effect on the likelihood of having at least one member of the household generating income from non-agricultural source, but no evidence of short-term effect. These findings are consistent with the notion that entry to the non-agricultural sector is costly (both financially and socially) and requires payment of up-front cash to finance it as documented by Carrington et al. (1996). This is in contrast with a temporary migration which involves less cost (both socially and financially), and, hence, with more short-term impact compared to non-agricultural income generation (employment).

With regard to unintended effect on women and youth empowerment, our findings showed a negative short-term effect of InovAgro program on access to and control over land by vulnerable groups such as women and youth, while such adverse effect of the program on women land rights is reversed (with a positive and significant effect) in the long term. Such short-term adverse effect on land rights of women and youth could be associated with fact that a more commercialized agricultural practice may not always guarantee a favorable outcome for vulnerable groups since more profitability in agriculture could mean exclusive control of resources (such as land) by the head of the household (usually male above the age of 35). Hence, unless deliberate measures are taken to mainstream gender and youth issues into the designing and implementation of similar programs like InovAgro, such negative effects of the program on

land rights of these groups may undermine the full potential of MSD programs in generating desirable outcomes for all household members.

1 INTRODUCTION

Poverty incidence declined by 5.6 percentage points from 51.7% in 2008 to 46.1% in 2015, but it remains widespread in Mozambique, with considerably higher incidence in rural areas (50.1%) compared to urban areas (37.4%). Over the same period, poverty reduction was considerably higher in urban areas (reduction of 9.4% from 46.8% to 37.4%) than in rural areas (reduction of 3.7% from 53.8% to 50.1%). This – complemented with the fact that 70% of population lives in rural areas – makes poverty predominantly a rural phenomenon. Furthermore, poverty is more pronounced in Northern and Central Mozambique than in Southern Mozambique (55.1% in Northern Mozambique versus 46.2% in Central Mozambique versus 32.8% in Southern Mozambique). Agriculture employing about 80% of the country's labor force is undoubtedly the main livelihood strategy, especially in rural areas. However, agriculture is characterized by production systems predominantly based on rain-fed conditions coupled with low use of improved agricultural inputs, leading to low agricultural productivity. On the hand other, empirical evidence revealed that agriculture has the largest poverty elasticity estimated at -2.7%; more than threefold higher than that of other economic sectors. This suggests that agriculture has the largest potential for reducing poverty incidence. Under these auspices, the Innovation for Agribusiness (InovAgro) project was designed aiming at increasing incomes for poor smallholder farmers in Northern Mozambique through improved agricultural productivity and participation in selected high-potential value chains, including maize, pigeon peas, soya beans, sesame, and groundnuts.

The InovAgro project — funded by the Swiss Agency for Development and Cooperation (SDC) and implemented by Development Alternatives Inc (DAI) in partnership with COWI — operates in 11 districts, namely Mocuba, Ile, Namarroi, Molumbo, Gurúe and Alto Molócue in Zambézia province; Malema, Ribáuè and Erati in Nampula province; and Namuno and Chiúre in Cabo Delgado province. The overall objective of the InovAgro project is to increase incomes — and ultimately reduce poverty — of men and women small-scale farmers in northern Mozambique, through improved agricultural productivity and participation in selected high-potential value chains. These include maize, soybean, pigeon pea, sesame and groundnut. The InovAgro project's primary approach for achieving impact is to promote the development of inclusive and sustainable market systems such that the impact of the InovAgro project interventions is felt long beyond the termination of the project. This approach is also known as the Market Systems Development (MSD) approach (Osorio-Cortes and Lundy, 2018).

The InovAgro project is now in Phase III, which spans the years from 2018 to 2020. The InovAgro II project covered the three years prior, from 2014 through 2017, and the InovAgro I project took place from 2010

to 2013. The InovAgro I project focused on engaging lead firms and supporting model small businesses or small farmer entrepreneurs, such as input suppliers, large-scale agricultural output buyers and influential community lead farmers. These are put in place along with well-functioning market mechanisms to strengthen smallholder farmers' access to input and output markets. The InovAgro II project emphasized and pursued the strengthening and scaling up of the interventions begun in Phase I. It did so by means of farmer field days, promotions of lead-farmer demonstration plots, and greater extension efforts by enabling local traders of improved and certified seed varieties to provide extension, and by more targeting communities with growing demand for improved and certified seeds. Like the InovAgro II project, the current InovAgro III project builds on previous phases by strengthening the capacity of seed companies, input suppliers, output marketers, and access to finance.

The Swiss Agency for Development and Cooperation (SDC) engaged the International Food Policy Research Institute (IFPRI) to conduct an impact evaluation of selected aspects of the InovAgro project, in order to identify and test which interventions of the MSD approach were most successful, and in what respects and how the interventions could be improved. This is what the current paper sets out to do. As part of the impact evaluation, three rounds of the InovAgro Impact Evaluation Survey (IIES) were conducted: a baseline survey with a sample of 1,886 households was conducted between August and September 2015 (hereafter referred to as IIES 2015), followed by a midline survey conducted between October and December 2017 (hereafter referred to as IIES 2017) and an endline survey conducted between July and August of 2019 (hereafter referred to as IIES 2019) during which the households interviewed in 2015 were re-interviewed. Although the InovAgro project aimed to cover eleven districts in northern Mozambique (Namuno and Chiúre in Cabo Delgado province; Erati, Mecaburi and Malema in Nampula province; and Alto Molócue and Molumbo in Zambézia province), only two districts (Alto Molócue and Molumbo) were selected for impact evaluation.

To investigate the causal effect of the InovAgro program, the study originally adopted a cluster (community) level randomized controlled trial (RCT) randomly selecting 8 communities (4 each from the two study districts) to be the focus areas for project implementation while the other 8 communities (4 each from the two study districts) identified as project non-beneficiaries (control communities). However, randomly assigning some households to various treatment arms (treatment communities) was not possible in the context of the InovAgro project due to three main challenges: (1) Ethical issues involved with exclusion of households for a control group; (2) The MSD (systemic) approach adopted by InovAgro project, which supported private companies to adopt new approaches to reach more clients, made strict

exclusion criteria impossible to avoid contamination (it was extremely hard to contain treatment activities from the control groups); and (3) Adaptive nature of the MSD approach (highly responsive to supply and demand forces) made it difficult to randomize treatment (exposure to the program). This was evident during the project monitoring phase that, two years after the InovAgro II launch in 2015, the units selected for treatment failed to receive the treatment or receive it in the fashion that was originally intended by the intervention. To account for such discrepancies and address potential bias in our estimates, the InovAgro impact evaluation supplements the three-wave household panel dataset of intended beneficiary and non-beneficiary households with “intention-to-treat” data as an instrument for treatment (Abadie et al. 2002). Hence, we conducted a **unique geo-reference census data** of every value chain intervention operational in all the 16 communities of our study area and use the median distance to these value chain interventions (60 minutes in our case) as a cut-off for defining the catchment area of the intervention/treatment. Using this spatial identification strategy for generating beneficiary and non-beneficiary households, the study team, then, employed a combination of quantitative and qualitative methodological approaches to assess the macro (market) and micro (household) level impacts of the InovAgro project: namely, difference-in-difference (DID), Propensity Score Matching (PSM) and geo-spatial analysis. In addition to documenting the causal effect of InovAgro interventions on intended beneficiary households (micro level effects), an attempt has been made to shed some light on four potential channels through which the InovAgro project could have impacted system (macro/market level effects); namely systemic (long-term) effects, sustainability effects, large-scale (spillover or multiplier) effects and unintended (positive or negative) effects.

Overall, the study provides evidence in support of the project’s having a systemic market-level effect, benefitting large numbers of smallholder farmers beyond the program’s direct sphere of influence, as well as sustainable long-term effects on household’s adoption of good agricultural practices and access to input and output market information, as compared to non-MSD programs. Further, one key takeaway from our findings is that a more intense, combination approach of using agro-dealers, lead farmers and demonstration plots appears to be necessary to achieve long-term positive effects on the overall welfare of households. Finally, to avoid undermining the full potential of MSD programs in generating desirable outcomes, we recommend that future MSD programs like InovAgro mitigate the negative effects on land rights of vulnerable groups such as women and youth, by taking deliberate measures to mainstream gender and youth issues into their design and implementation.

This paper is structured in six sections, including this introductory section. The first section of the paper provides brief background information about the InovAgro interventions and the impact evaluation research design, while the section 2 describes InovAgro's theory of change, including relevant indicators to monitor project progress. Section two also describes the InovAgro market systems development (MSD) approach within the following intervention arms: seed market strategy, mechanization strategy, extension strategy and agricultural output trading market strategy for soybean and pigeon pea. Section 3 is dedicated for the impact evaluation research design outlining the challenges in impact evaluation of MSD programs, presents the empirical strategy employed in the evaluation design and the mitigative measures taken to assess both the household level micro impacts as well as the market level macro impacts of the project. The fourth section presents the data used and a descriptive look at the basic household, market and several other outcome variables across treatment vs. control groups. The fifth section presents the key macro (market level) and micro (household) level results, and the final section presents summary and conclusions.

2 MARKET SYSTEM DEVELOPMENT INTERVENTIONS AND THE INOVAGRO PROJECT THEORY OF CHANGE

2.1 Overview

The InovAgro project consists of three phases – a design and three-year pilot phase from the end of 2010 to 2013 (InovAgro I), a four-year expansion phase building off of the pilot (InovAgro) from 2014-2017, and a three-year wrap-up phase (2018-2020) (Ghebru, Grant and Smart 2020). The overall objective of the SDC InovAgro project is to increase income and improve economic security for poor men and women small-scale farmers in Northern Mozambique through improved agricultural productivity and the development of high potential value chains (Ghebru, Smart and Moguees 2019). Just as the evaluation was getting underway in 2015, however, InovAgro modified its strategy from more of its value chain focus on specific commodities, to an approach that focuses on creating three sustainable market systems which had not existed before: sales of inputs to farmers, new sales of outputs to buyers at buying points, and financial services to interface seed companies with farmers.

The project has a carefully articulated theory of change, but, as discussed by Ghebru, Grant and Smart (2020), it does not completely follow the normal logical framework, input-output-outcome sequence of a standard MSD program theory of change.² The generic sequence is greatly simplified in Figure 2.1, while Figure 2.2 demonstrates how the InvoAgro intervention activities at the input level on the left side of the graphical illustration, ultimately result in greater impacts on the right side of the figure, such as increased farmer incomes. The pathway from the activity inputs to impact, includes several levels of outputs and outcomes, including intermediate outcomes that cannot be reflected in a standard logical framework. For example, farmer organization and empowerment activities (at the inputs level) lead to more equitable relationships with private sector companies (at the output level) which in turn, lead to increased participation by farmers in value chains (at the outcome level) to increase their incomes (at the impact level).

² As stated in the report by Ghebru et al., “An MSD program has a standard theory of change: it focuses its attention on the system level issues, in order to get the system to perform more effectively to meet the needs of the target beneficiaries to have improved access and growth. The [InovAgro] project does not deliver the services directly to the target beneficiaries, since the project recognizes that it will not be around once the funding starts, so the market system much continues to drive the change. [In this way], most of the impact on the target beneficiaries, the rural poor, will be delivered from their engagement with the actors in the market system.”

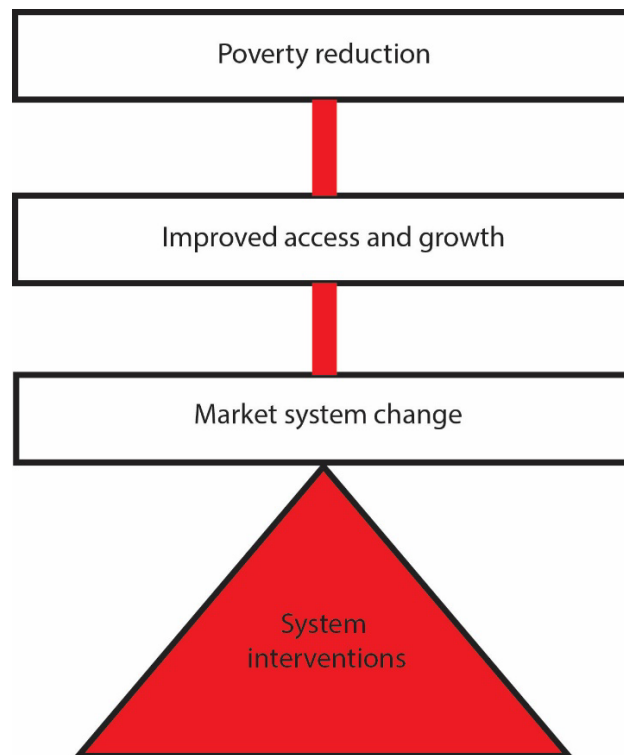
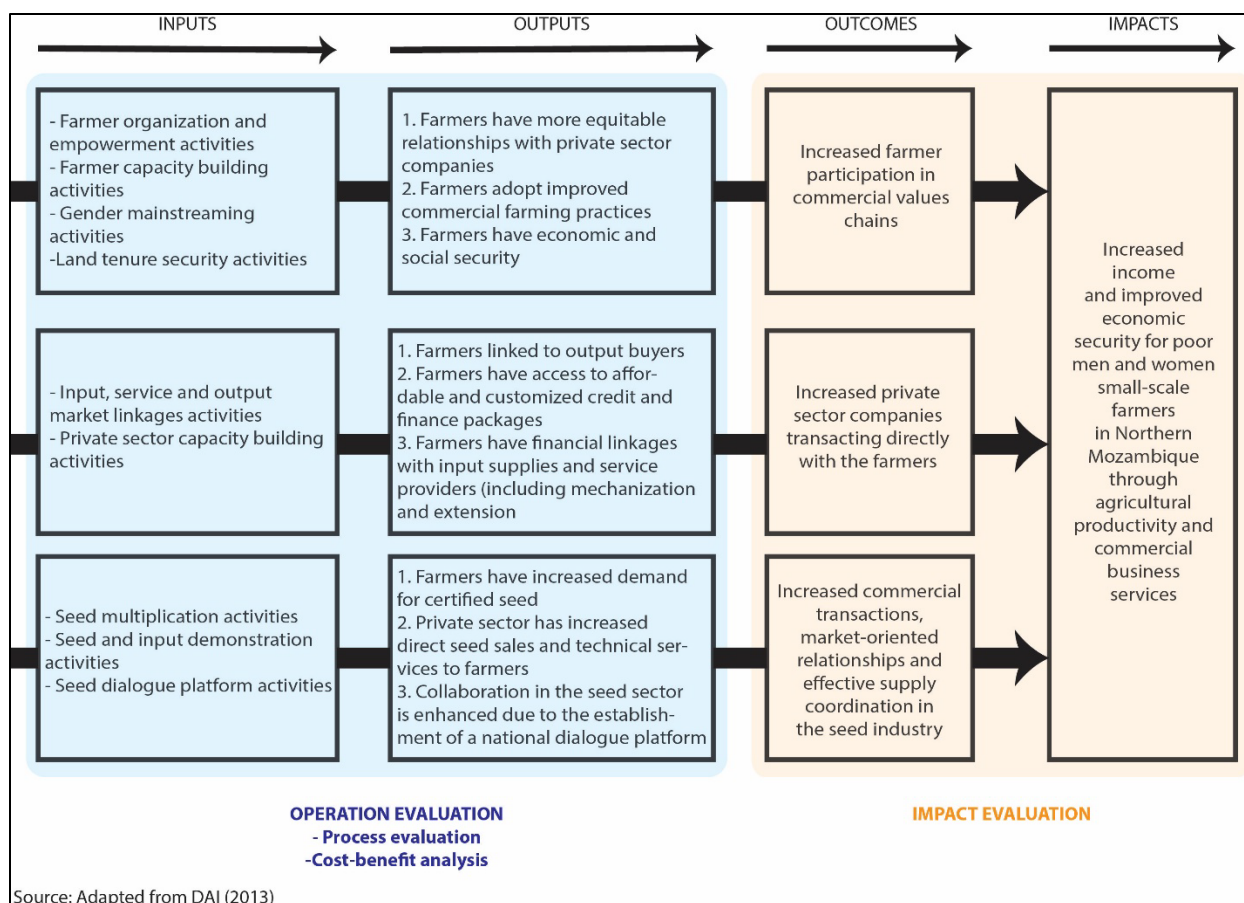


Figure 2.1 Generic market system development theory of change

Key indicators expected by the end of InovAgro II (2017) included increases in soybean, pigeon pea, groundnut and sesame annual net profit per hectare of production, by 43%, 234%, 139% and 147%, respectively, compared to 2012/2013 baseline levels. These projections assumed that prices would be stable, which they have not been, and that climatic conditions would remain favorable for crop production. As we discuss later, irregular rainfalls have caused serious adverse effects over the course of the project's implementation. Nevertheless, three major outcomes of the project were outlined in the original plan, by which the overarching goal of the project would be met.

Figure 2.2 illustrates that the first expected outcome of the project was to increase smallholder participation in commercial value chains and smallholder competitiveness. The three expected indicators of progress toward the first outcome include (i) smallholder farmers' increased productivity for their production of soybean, pigeon pea, sesame and groundnut, (ii) increased numbers of smallholder farmers participating in commercial value chains through increased access to quality agricultural inputs and improved commercial value chain knowledge, and (iii) increased total volume of production for smallholder farmers supported by the InovAgro project, for each value chain crop. The project's private sector led extension intervention strategy and organized field days have been the primary vehicles for

achieving the objective of improving farmers' production capacity. The InovAgro project has sought to facilitate the use of field days and increased numbers of visits to smallholder farmers by extension officers to help raise demand for quality seed and other yield-enhancing agricultural inputs, as well as to support the promotion of good agricultural practices in general, such as planting in a timely manner, weeding, etc. The project's interventions to facilitate the acquisition of land titles, national identification cards, and tax registrations of smallholder farmers were initially, the primary vehicles by which the objective of increasing smallholder farmers' economic and social security has been sought. And the InovAgro project has primarily attempted to increase smallholder farmers' access to interconnected services such as finance and mechanization by (i) facilitating the relationships of financial institutions to smallholder farmers and the financial institutions' willingness to offer loans, (ii) establishing savings groups among smallholders to enable group purchases of certified seed and other agricultural inputs, and (iii) promoting the relationship between smallholder farmers and mechanization service providers to improve agricultural production and productivity.



The third expected outcome of the InovAgro project is to increase commercial transactions, market-oriented relationships and effective supply coordination in the seed industry. The two expected indicators of progress toward this outcome are (i) a reduced volume of pigeon pea and soybean certified seed supplied to smallholder farmers by the government and donor funded projects, and (ii) an increase in the number of formal agreements between agricultural research institutions and private sector seed companies to directly supply basic and pre-basic seed (seed for multiplication into certified seed) to private sector seed companies. The project's seed market strategy has been the primary vehicle to achieve the objective of increasing the effective demand for certified seed by smallholder farmers, measured both in terms of the number of smallholder farmers purchasing improved and certified seeds and the volume of seed purchased directly by smallholder farmers. The InovAgro project's interventions to support the opening of new seed stores by private sector seed companies has been the primary way the project has sought to achieve the objective of increasing direct seed sales and increased technical services offered by the private sector to smallholder farmers. And the InovAgro project has primarily sought a better enabling

environment and services for certified seed production and sales. It did so firstly by means of approving the operational plan produced for the National Seed Dialogue Platform (NSDP) and thus contributing to the development of the seed sector in Mozambique, as the NSDP agrees upon decisions to recommend for government action to enable the seed sector to be more competitive. Secondly, it sought to do so by supporting the former Mozambique's National Directorate of Agrarian Services (DNSA) of the former Ministry of Agriculture and Food Security (MASA), now MADER, to create and manage a web-based tool for disseminating information to the private sector stakeholders, as well as by supporting an accreditation program through which DNSA trains and licenses private sector seed inspectors to monitor the quality of seed produced by the private sector seed companies.

2.1.1 Seed Market Strategy

InovAgro's seed market strategy is two pronged. The first goal is to establish a commercial distribution network, by facilitating market access for a growing number of private sector seed suppliers including PANNAR SEED, PHOENIX SEEDS, SEMENTES NZARA YAPER, ORUWERA, JNB, IKURU and KLEIN KAROO. In addition to the seed suppliers, InovAgro (in collaboration with APROSE) trains dozens of agro-dealers to work with the seed suppliers to retail the certified product to local smallholder farmers in the project implementation areas. The growth in the number of private sector seed suppliers entering the market in these areas is intended to contribute to a crowding-in effect, more competitive pricing, and the ability of the seed companies to thrive and expand their operations.

The second and parallel goal of the seed market strategy is to generate demand and promote the use of improved and certified seed. To this end, InovAgro partners (seed companies) install demonstration plots and organize field days targeted at smallholder farmers, where crop performance at the various stages of planting and harvest is demonstrated, extension messages on good agricultural practices are promoted and outlets are advertised where improved and certified seed can be purchased. During a given agricultural season, three field days are usually realized: one at planting season, another at weeding season and the last one at harvesting time. Technicians from seed companies work to create demand by smallholder farmers for improved and certified seeds by introducing, marketing and promoting an assortment of seed products and developing a commercial seed distribution network such that smallholder farmers have better access to improved and certified seeds.

Demonstration plots are established on lead farmers' own fields. Selected by seed companies promoting their certified seeds, lead farmers are usually farmers who have great credibility and social capital

established with other farmers in their communities, and have some experience using improved seed before becoming lead farmers. Many of the lead farmers who have demonstration plots on their fields are also village-based agents (VBAs) of agro-dealers. VBAs usually do not have their own shops but sell certified seed and other agricultural inputs generally acquired from local agro-dealers (input suppliers) within their communities. Due mainly to lack of own shops, VBAs are faced with financial constraints to afford large scale of seeds and limited storage capacities, resulting in higher risk of seed damage during storage. Other approaches to promoting demand include mobile agro-dealers and seed fairs, where efficiency gains can be made by bringing various entities (seed companies, agro-dealers and output buyers) together to sell agricultural inputs to and buy agricultural outputs from smallholder farmers. Seed fairs are generally organized around the beginning of the agricultural season.

2.1.2 Mechanization Strategy

The idea behind the mechanization intervention was to engage farmers who own their own tractors or other large machines such as threshers, etc., and see if they would consider offering paid services using their equipment to other smallholder farmers who cannot afford purchasing their own equipment. Like InovAgro's seed market strategy, the mechanization strategy also follows a two-pronged approach. One prong is the provision of mechanization services. This consists of identifying tractor owners as potential mechanization service providers and providing them with technical training on how to operate their tractors, planters, threshers and/or shellers effectively and efficiently. The approach also involved training on how to give effective sales pitches to other farmers in their communities, outlining the reasons these neighbors would benefit from the supplied mechanization services. The University of Zambeze, known as UniZambeze, has been engaged in offering full day trainings to over a dozen mechanization service providers located in the districts of Gurué, Mocuba and Malema (districts different from those selected for impact evaluation). The government's Agricultural Development Fund (commonly known by its Portuguese acronym FDA) was also funding mechanization parks to service smallholder farmers in some of the InovAgro project districts, (these too are not part of the study area). Recipients of the mechanization tractor parks receive the parks on credit and have to pay them off over a ten-year period. This is to bring tractor use to areas where there has been no tractor use in the past.

The other prong of the mechanization intervention strategy was directly on the demand creation front. During the same field days in which improved and certified seed purchases were promoted by extension workers, mechanization services are also demonstrated, and farmers' questions answered. Given that the

costs of using a tractor or other mechanization services are perceived as quite high, take-up of these services has been relatively slower than that of the improved and certified seeds.

2.1.3 Extension Intervention Strategy

InovAgro primarily partners with the District Services for Economic Activities (SDAE)—the local governmental district offices for agriculture and other economic sectors—to provide greater extension service delivery to smallholder farmers. However, InovAgro also partnered with seed companies (such as PANNAR SEED, PHOENIX SEEDS, SEMENTES NZARA YAPERA, SYGENTA and AKA) in Alto Molócue, Gurue, Ile and Mocuba to deliver extension services as either a substitute for or a complement to SDAE provision.

2.1.4 Output Trading Market Strategy: Soybean and Pigeon Pea

The InovAgro project supports improved access to output marketing for five crops, namely maize, pigeon pea, soybean, sesame and groundnut. This is done by negotiating deals with potential output buyers prior to when output purchases are generally made. The names of some of the output buyers that the project has engaged for negotiation include CARGILL, IKURU, and WINUA for soybean and maize, and MUBULA COMERCIAL and HAMID COMERCIAL for pigeon pea (InovAgro 2016) for the purposes of export, use in poultry feed, or resale to other local companies.

The output sellers identified by the InovAgro project have not generally been smallholder farmers, but rather community aggregators who need to be partially subsidized by the InovAgro project (up to 50% of their income) to increase the number of buying points and facilitate purchases of product from the surrounding local farmers (Nephas Munyeche, DAI, personal communication, June 6, 2017). Field visits realized in 2019 in Alto Molócue revealed that farmers associations also aggregate agricultural output from the surrounding smallholder farmers, who are members or nonmembers of the given association, to then sell to agricultural output buyers, taking advantage of economies of scale and the price premium given by agricultural buyers when buying from farmers associations rather than individual smallholder farmers. Community aggregators and other medium-to-large scale agricultural output buyers usually have several buying posts — generally staffed by an employee — where a log of selling records is kept, and these records have helped inform InovAgro’s strategic efforts to improve output purchase deals over time.

Political instability and violence between 2015 and 2016, which led many Mozambicans to flee across the border to Malawi, dampened and negatively affected the development of commercial agricultural activities in northern Mozambique. Molumbo, located closer to the Malawi border, appeared to have been more affected by the political instability than Alto Molócue. Higher insecurity when travelling by

road coupled with unreliable road access as a result of the political instability discouraged trade between villages, districts and provinces, including transport of agricultural inputs such as improved and certified seeds, fertilizers and pesticides. The InovAgro project is working to strengthen the trust between farmers associations and agricultural output buyers such that the risks and transaction costs faced by agricultural output buyers when purchasing agricultural outputs from smallholder farmers at various buying posts can be somewhat ameliorated (InovAgro, 2016).

In addition to the political instability experienced during the 2015/2016 agricultural season, Zambézia province experienced irregular rains during this same period, which negatively affected agricultural production and productivity in both districts covered by the InovAgro impact evaluation. However, According to InovAgro (2016), the delayed rains improved performance for pigeon pea while negatively interfering in the performance of soybean and maize production, especially reducing threshing efficiency and increasing post-harvest losses due to higher humidity during and after harvesting season.

Another challenge faced by the InovAgro project when promoting the purchase of agricultural output from smallholder farmers concerned the manual meters used by agricultural output buyers, which are not capable of measuring moisture levels when purchasing agricultural outputs. Providing digital scales, brand and price posters and record keeping training to agricultural output buyers is another area where the InovAgro project is intervening to promote agricultural output purchases from smallholder farmers. Furthermore, the InovAgro project seeks to help community aggregators to properly package their agricultural output as per the company brand and thus achieve traceability such that the end-buyer can trace the source of the crop and wholesale buyer. The project subsidizes better storage equipment and training on the principles of warehouse management as well as the purchase of mobile phones and airtime for agricultural output buyers staffing their buying posts. And the project also facilitates access to development projects that can help subsidize physical fixed infrastructure, like buildings (Nephas Munyeche, personal communication, June 6, 2017).

Finally, in addition to the above strategies, the InovAgro project also added an access-to-finance “economic security strategy” to enable farmers to achieve access to the financial resources needed for inputs and services procurement. This strategy has involved commercial bank linkages and savings groups. The impact evaluation traces the project’s theory of change, by judicious identification of variables to measure and analyze. This contributes not only in identifying the impact of InovAgro, but also in shedding empirical light on the mechanisms through which such impact occurs, quantifying both impacts and outcomes. Impact evaluation of the outcomes to impact is a process that is complementary to the

operational evaluation of tracing inputs, or project activities, into project outputs. Monitoring and evaluation, cost-benefit analysis and process evaluations using administrative data and qualitative assessments are all valuable tools used to conduct such operational evaluations. Operational evaluation and impact evaluation analyses are not mutually exclusive and rather, combined, do the best job at offering the full story.

One method of operational evaluation that hints at the attempt to ascertain outcomes and systemic level impact, albeit not via a quantitative impact evaluation, is assessing the maturity level of the project activities in achieving a level of systemic change. The Initiative for Global Development has leveraged the theory of the “tipping point” to gauge the level of adoption at which an innovation is considered to then be on a path towards eventual self-sustenance. According to the theory, this point is reached when roughly 16% of a population have adopted an innovation, given that such a level of adoption indicates that activity plans have become clearly defined and “sticky”, thus leading to the buy-in, consistency and strategy of stakeholders, funding, and/or monitoring which helps programs have what it takes to take off and build to scale (Gifford et al 2016).

Finally, changes from the original TOC and project strategies that came about during the second phase of the project included:

1. In the first listed outcome, maize was added to the list of value chain crops (which also included soybean, pigeon pea, sesame and groundnut), primarily because it was the top product driving much of the business decisions being made by the seed companies.
2. The objective of increasing smallholder farmers’ economic and social security by way of the interventions to facilitate the acquisition of land titles, national identification cards, and tax registrations of smallholder farmers, was recognized as being too much for Inovagro to undertake, and so the role of this objective was reduced significantly.
3. At the time the evaluation was launched, the InovAgro did not yet have either the Fundo Agricola or the Output Marketing (CAT) interventions in place and the associated actors were therefore not included among those interviewed in the three panel rounds of the present study, however both may have contributed (alongside the agro-dealers, lead farmers and demo plots included in the original project strategy) in benefiting farmers’ access to markets over the length of the project.

3 CHALLENGES IN IMPACT EVALUATION OF MSD PROGRAMS AND MITIGATIVE MEASURES TAKEN

3.1 Challenges in impact evaluation of MSD programs

The on-going debate on the selection of appropriate impact evaluation methods for MSD projects continues within the development research and evaluation community, and indeed also within practitioner and policymaker circles (see, for example, Cohen and Easterly, 2009). This section discusses the multiple conceptual and methodological challenges in impact evaluation of MSD programs referring to randomized and non-randomized methods.

The objective of this impact evaluation is to assess the linkages between the MSD approach operationalized by InovAgro and its impacts on household welfare of participating farmers, using a technically rigorous impact evaluation methodology of evaluating a development intervention that uses the MSD approach in the agricultural sector.

We employ a quantitative approach of data collection and analysis. According to White (2013), multiple quantitative methods allow comparing and testing the sensitivity of results of one approach against the other. Our initial design was based on the intent to carry out a randomized controlled trial (RCT) alongside other panel and cross-sectional based approaches as explained below. RCTs are considered the ‘gold standard’ for addressing the type of question that is at the heart of this study: What difference did the intervention make to the development outcomes considered, and how large is the difference that it made? More generally, carefully designed and executed experimental and quasi-experimental studies — which are a subset of quantitative approaches — are crucial in order to credibly attribute changes in outcomes to an intervention or project. The essential approach of RCTs in the context of the InovAgro project consisted in working with the implementing agency to first identify communities within the study area that would be eligible to participate in the project, based on the project’s own criteria. Then, from this set of eligible communities, the study team randomly selected communities to be the focus areas for project implementation, with the other communities remaining non-participant areas. Within communities, a similar selection took place at the farmer level.

A baseline survey was undertaken in 2015 among both participating and non-participating farmers, and the midline and endline surveys were conducted in 2017 and 2019, respectively, on the same sample as the baseline survey. A total of 1,886 households were interviewed in 2015 covering the agricultural season

2014/2015, 1,749 households were re-interviewed in 2017 covering the agricultural season 2016/2017, and 1,733 of these same households were interviewed a third time in 2019 covering the agricultural season 2018/2019. Details of the sampling techniques and the data collection method are outlined in section 4.1 titled “Data”. Both mean differences and regression analysis are conducted with the survey data to determine the impact of the InovAgro project. Section 4.2 presents the descriptive results, followed by the impact evaluation regression results in section 5.

Randomization solves the problem of selection bias because InovAgro and non-InovAgro areas were drawn randomly from the same underlying population and therefore, the average characteristics of these groups will not systematically vary, and any differences observed in the outcomes of interest can therefore be attributed to the InovAgro intervention. The core experimental study design, mentioned above and elaborated in the data and sample selection section below, can be classified as a ‘gold-standard’ strategy to assess the impact of the InovAgro intervention. It therefore yields reliable results. Given that, after extensive discussions with the implementing agency shortly before the 2015 baseline survey, it was concluded that the RCT approach was not feasible from an operational perspective (see also Erman et al. 2015) mainly due to three major challenges associated with impact evaluation of MSD programs, namely:

- (a) Ethical issues
- (b) Challenges associated with implementation (operationalization) of programs
- (c) Challenges associated with level of impact (scope)

3.1.1 Ethical issues:

While using a RCT is considered the gold-standard quantitative method for impact evaluation, one of the greatest challenges facing project evaluators in choosing to use it, both in the context of this evaluation and others, is the thorny ethical consideration of how one justifies the randomization process in practice: that is, the designating of some groups as treatment groups and others as the control groups. This can present difficulties particularly when it comes to evaluators needing to respond to the reactions of both beneficiary and non-beneficiary affected stakeholders. The experimental nature of a study’s design must be handled delicately, as participants and others can have a hard time understanding the reasons for the perceived inequities in the roll-out of project interventions, can potentially grow resentful because of this, and many find that they simply cannot morally support the design framework given the disparities of how benefits are allocated across groups. Policy makers find the process of random allocation to be unacceptable in many cases as well (e.g., Bamberger and White, 2007; Ravallion, 2009). Interventions are

often intended to be targeted to specific groups and this poses direct concerns to policy makers: Randomization might very well limit outreach at the same time as often being viewed as unethical when taken into consideration in light of the target population's pressing needs.

3.1.2 Challenges associated with implementation/operational issues:

Another family of challenges which threaten the validity of a given impact evaluation method involve issues associated with the actual implementation of the MSD programs after the impact evaluation design is complete. Such issues include:

- (a) Selection bias issues
- (b) Contagion/contamination (treatment diffusion)/spillover effects
- (c) Historical phenomena/effects

3.1.2.1 Selection bias issues

Self-selection arises when farmers themselves decide whether or not to participate in MSD programs, often due to differences in resource endowments or in their attitudes towards learning. Thus, the selection bias emanates from the fact that treated individuals may be systematically different from the non-treated for reasons other than the treatment status. In MSD projects, driving systemic change means driving behavioral change at the farmer level. This means that the project must have the most interested partners (farmers and service providers) participating in the project interventions who are the innovators and early adopters to drive the adoption and uptake of new innovations, to get the market system going and stimulate copying. The endogeneity problem may arise because the program may target farmers with specific characteristics (innovative farmers, community leaders, smallholder farmers, market-oriented farmers, poor farmers or relatively wealthy farmers). These may result in overestimating or underestimating the impacts of the MSD program.

3.1.2.2 Contagion/contamination issues

Once the design for impact evaluations of MSD programs is finalized and beneficiary and control groups are established, issues may arise in which the groups which are not supposed to be exposed to (or receiving) certain benefits (the control groups) are in fact benefiting from an intervention. This may arise by directly receiving the benefits from the intervention (eg. in the case of InovAgro partners chasing the market and spreading the intervention to areas that were designated as controls), or by receiving similar benefits from other organizations who are not direct partners of InovAgro but may be delivering similar

services. The latter could also be the case due to local government budget shifts (e.g., similar interventions being financed via the SDAE(s)).

3.1.2.3 Historical phenomena/effects

Historical phenomena effects are caused when behavioral change or adjustments by farmers and/or market actors are caused due to external events other than the intervention, occurring during the same time period as the intervention. In the case of Mozambique (InovAgro project), the rapid devaluation of currency starting in January 2015 and the flooding in early 2015 are two noteworthy cases in this regard, with implications on the validity of impact evaluation designs for similar MSD programs, and more so in the latter case, as devaluation may have similar effects both the control and treatment groups might have direct effect on cost of imported agricultural inputs. Such effects could be due to a possible lower adoption of modern farm practices caused by inflated prices for imported inputs (devaluation effect) and/or slowing down of farmers' participation in high-value crops and shift towards lower-risk crops (natural disaster effect). As a result, the program effect could be understated if such external effects are not filtered out.

3.1.3 Challenges associated with level of impact (scope):

3.1.3.1 Beneficiary versus institutional/systemic level effects

Broadly, intended outcomes of MSD projects can be categorized into two: beneficiary (primary) level and institutional (systemic) level effects. Beneficiary (primary) level effects are the direct impacts that an intervention seeks to achieve on targeted beneficiaries, such as increasing farm productivity and incomes for a target group or facilitating access to services by intended beneficiaries. However, most MSD programs (if not all) are primarily set out to produce outcomes that are to the benefit of the entire sector, not just for a few firms (more of an institutional or systemic level changes). It is, hence, always a challenge in designing and implementing impact evaluation methods that are sufficiently equipped to document impacts at both levels – i.e., micro as well as macro level impacts.

3.1.3.2 Short-term versus long-term effects

Depending on what level of effect one tries to evaluate, for MSD interventions, primary-level effects (such as access to inputs, behavioral changes, etc.) may emerge quickly. In other cases, some effects may take much longer to become manifest, and change over time (such as income, poverty or overall welfare). MSD interventions are usually assumed to contribute to long-term development (income, poverty and overall systemic level effects). However, impact evaluations with a short evaluation time period, focusing

on short-term or intermediate outcomes, often provide more useful and immediate information for policy- and decision-making but fail to document effects achieved in the longer term. Many of the beneficiary level impacts of interest from MSD interventions will only be evident in the longer-term, such as overall income and/or welfare impacts. Hence, searching for evidence of such effects too early (via scientific impact evaluation programs with short evaluation period) might mistakenly conclude that interventions have failed. Hence, it should be noted that ideal length of the impact evaluation period depends on the level of impact one seeks to document since the longer the project the more susceptible the impact evaluation design will be to challenges of spillover and contamination.

3.1.3.3 Intended versus unintended effects

Another issue related to the selection and/or validity of impact evaluation methods of MSD projects is how well the Impact Evaluation (IE) method is equipped to deal with unintended effects. MSD programs usually are designed to have systemic level effects that are prone to unintended effects (positive or negative) on both intended beneficiaries and non-beneficiaries. For example, programs that aim to provide market-driven agricultural training, extension or credit services in a given area may lead to: (i) the government deciding to shift its budget allocations (cut its spending) for similar activities from beneficiary communities to control (non-beneficiary) communities (producing a negative unintended effect on beneficiary communities and an unintended positive effect on control communities); and, (ii) potential spillovers – i.e., households/farmers in control areas benefiting from market responses (input as well as output) due to their proximity to beneficiary communities. Both cases, unless addressed through appropriate impact evaluation methods, may lead to underestimation of the impact of MSD programs.

3.2 Study design and mitigative measures taken

As outlined in section 3.1, randomly assigning subjects to various treatment arms was not possible due to: (1) Ethical issues involved with exclusion of subjects for a control group; (2) The MSD (systemic) approach adopted by InovAgro project meant strict exclusion criteria impossible (hard to contain treatment activities from control groups); and (3) Adaptive nature of the MSD approach (highly responsive to supply and demand forces) made it difficult to randomize treatment (exposure to the program).

We employed selected methods from the body of quasi-experimental approaches – mainly, to account for any potential discrepancies in observable and unobservable characteristics between treatment and control groups, each of which addresses selection bias in different ways and has different strengths and limitations, with none being unambiguously superior in all circumstances (Ravallion, 2007). The section

below discusses the methodological approach adopted by this study, with a closer look at the two levels of impact the InovAgro program (MSD programs) set out to achieve.

The InovAgro impact evaluation aims to evaluate the impact of the InovAgro program at two levels (summarized in Table 3.1):

- i. Micro (household) level effects: Focusing on program effect on the direct sphere of interaction (intended beneficiary households).
- ii. Macro (market) level effects: In addition to the impact evaluation on targeted (intended) beneficiaries, this impact evaluation also attempts to document the macro (market) level effects, namely:
 - a. Systemic (long-term) effects: could be either due to crowding-in or copying of the InovAgro (MSD) approach
 - b. Sustainability effects
 - c. Large-scale (spillover or multiplier) effects, and
 - d. Unintended (positive/negative) program effects

3.2.1 Micro (household) level impacts

One of the possible limitations, even in ‘gold-standard’ randomized designs, is that the units selected for treatment may in fact not receive the treatment or may not receive it in the fashion that was intended by the intervention. Conducting standard analysis that does not account for this potential discrepancy between treatment and intention to treat could understate the impact of the intervention. In the case of the InovAgro project, we conducted careful discussions with the implementing agency about the importance in adhering to a pre-determined design. Even with these measures in place, however, it appears to be impossible to completely rule out any potential discrepancies between design and actual treatment, because in some cases it is hard to obtain full field information about the actual features of treatment. To account for such discrepancies and potential bias in our estimates, the InovAgro impact evaluation supplements the three-wave household panel dataset of intended beneficiary and non-beneficiary households with “intention-to-treat” data as an instrument for treatment (Abadie et al. 2002). Hence, we conducted a **unique geo-reference census data** of every value chain intervention operational in all the 16 communities of our study area and define a median distance to these value chain interventions (60 minutes in our case) as a cut-off for defining the catchment area of the intervention/treatment. Based on this approach, using the intention-to-treat definition for treatment

(exposure to intervention), smallholder farmers included in our study that are located within a 60-minute walking distance buffer of a value chain intervention are defined as beneficiary (treated/exposed) while those that are located outside the 60-minute walking distance buffer are defined as control (non-beneficiary households)³.

Table 3.1 Study design

Approach	Method	Data	Level of effect	Example
Quantitative (quasi-experimental) approach	Difference-in-difference (DID) approach	Three round panel data of about 1,800 farm households from 2015, 2017 and 2019	Micro (household) level effect	-adoption of modern farm practices -Access to information - Market integration (Access to input and output markets) -Agricultural production and productivity -Income diversification -Household welfare and Income -etc.
	Propensity Score Matching (PSM) approach	2019 endline survey on beneficiary and non-beneficiary households that are matched on observable baseline characteristics		
	Geo-spatial analysis	Geo-reference data on agricultural and residential parcels of households		
Qualitative approach	Geo-spatial analysis	Census of geo-reference data on locations of all value chain actors	Macro (market) level effect	-Systemic/long term (due to crowding in and/or copying) effects -Sustainability -Large-scale (spillover) impact -Unintended effect
		Key informant interviews		
	Descriptive analysis	Focus group discussions		

However, even after such careful approach for definition of treatment, major challenges such as natural learning, self-selection, program targeting and the adaptive nature of MSD programs like InovAgro remain as causes for concern in making causal inferences (or differentiating contribution (correlation) versus attribution (causality)). Hence, to isolate InovAgro effects and account for possible influence (positive or negative) of external factors (eg. improved government policy, improved infrastructure, natural disaster, natural learning or adaptation), we utilized a before-and-after intervention data (from intended beneficiary and non-beneficiary households) and employ a **difference-in-difference (DID) approach**. The

³ A sensitivity analysis was conducted to test the robustness of our estimates to the 60-minute buffer zone used to define treatment. For this purpose, all models were re-estimated with a 90-minute buffer zone and, overall, results remain fairly robust.

double-difference analysis compares the change in outcomes before and after the InovAgro interventions for intended beneficiary and non-beneficiary smallholder farmers included in our study. The double-difference method also helps account for any pre-treatment differences among beneficiary and non-beneficiary households (Angrist and Pischke, 2008). The advantage of using the double difference method is that it nets out the effects of additive factors that have fixed (time-invariant) impacts on outcome indicators, or that reflect common trends affecting participants and non-participants equally such as changes in prices, devaluation, flood/drought, etc. (Ravallion, 2007). The three-wave panel survey data collected in 2014/15, 2016/17 and 2018/19 are used to implement this approach.

Finally, to disentangle the potential effects of InovAgro from other similar programs that adopt MSD approaches, using our unique GIS census data, we analyze the number of years since operation, comparing InovAgro sponsored (facilitated) MSD value chain interventions with those MSD programs (value chain interventions) that are not directly affiliated with InovAgro. Hence, the validity of our identification strategy (our ability to claim causal inferences) depends on whether InovAgro has had an overall systemic (crowding-in) effect. Results from Table 5.1 show that the average number of months since operation for InovAgro-sponsored (facilitated) MSD actors⁴ is significantly (statistically significant) longer (34.7 months) than that of non-InovAgro sponsored (facilitated) MSD value chain interventions (i.e., 25.4 months). The result shows market/systemic level effects of InovAgro program (evidence of crowding in and/or copying InovAgro models by other partners) as more of these MSD actors not directly affiliated with InovAgro become operational in later years (on average) than those of InovAgro partners. Hence, we claim that any potential impact due to exposure to any MSD value chain interventions (even not directly affiliated/sponsored by InovAgro) can safely be considered as impacts of the InovAgro program due to such overall market/systemic effect. As a result, MSD effect/impact and InovAgro effect/impact are, hereafter, used interchangeably.

Moreover, households may also self-select themselves into participation in InovAgro-sponsored (facilitated) programs depending on their characteristics. For example, households who are less able (with poorer labor endowments) or with liquidity constraints may decide not to take part in InovAgro-sponsored activities (MSD approaches) due to the poor labor endowment (they are not able to engage in intensive

⁴ Hereafter, MSD value chain interventions are defined as either agro-dealers, lead farmers, or a demo plot that are sponsored (supported or facilitated) by companies/partners that adopt market systems development (not direct service delivery either cost-free, subsidy or voucher systems). Similarly, those that are sponsored (supported or facilitated) by companies/partners that adopt direct service delivery (either cost-free, subsidy or voucher systems) are hereafter called as non-MSD value chain interventions.

market-oriented agriculture) and/or are not able to afford modern farm practices. Hence, in addition to the double-difference approach, our study adopted a **propensity score matching (PSM)** which enabled us to produce a sub-sample of beneficiary and non-beneficiary households which prove to have comparable household and parcel level characteristics at baseline (before any InovAgro program was launched).

3.2.1.1 Empirical Method

We employ a difference-in-difference (DID) estimation technique to assess the impact of the exposure to InovAgro program on selected outcomes using following regression model:

$$Y_{ijt} = \beta_0 + \beta_1 C_j + \beta_2 T_t + \gamma I_j \times T_t + \varepsilon_{ijt} \quad (1)$$

Where Y_{ijt} denotes the outcome variable of interest for household i in community j at time t ; C_j is an indicator variable equal to one if community j was exposed to the InovAgro project (treatment community) and zero otherwise (control community); T_t is a dummy variable equal to one if year equal to 2017 (midline survey year) and zero if year equal to 2015 (baseline survey year); I is the set of independent variables; ε_{ijt} is a random error with mean zero and constant variance; and $\beta_0, \beta_1, \beta_2$ and γ are unknown parameters to be estimated. The key parameter of interest is γ which gives the average impact of the exposure to the InovAgro project on a given outcome variable: the average difference between treatment and control groups after accounting for differences in trends between the two groups. One of the key assumptions behind the DID approach is that other covariates—rather than the InovAgro project—do not change between the baseline and midline surveys. However, this assumption is violated in our case. We controlled for household-level characteristics that could affect the difference in trends between treatment and control groups by modifying the above regress as follows:

$$Y_{ijt} = \beta_0 + \beta_1 C_j + \beta_2 T_t + \beta \mathbf{X}_{ijt} + \gamma I_j \times T_t + \varepsilon_{ijt} \quad (2)$$

Where $\mathbf{X}_{ijt}$ represents a set of household-level characteristics that could influence outcome variables of interest.

We are also interested in estimating the average effect of the InovAgro project exposure on households who were exposed to the InovAgro project (also known as average treatment effect on the treated and referred to as ATT). Put differently, we are interested in assessing whether the InovAgro project is generating the intended effects among beneficiaries (assessing the mechanisms by which beneficiaries are responding to the InovAgro intervention). ATT is given by the difference between the average

outcome variable in the presence of the InovAgro project and the average outcome variable had the InovAgro project not been implemented, among households who benefited from the InovAgro project. This raises a challenge because we cannot observe the average outcome variable for households who benefited from the InovAgro project, had those households not been the InovAgro beneficiaries (absence of data on counterfactual outcome variable). If we attempt to estimate the average outcome variable among beneficiary households had they not benefited from the InovAgro project, by using households who were not exposed to the InovAgro project, we would be faced with a selection bias problem. This is because either some household covariates could influence households' decision to self-select into participation in the InovAgro project or the InovAgro project beneficiaries were purposively selected by the project implementing agency. We estimate the following regression model:

$$Y_{ijt} = \alpha + \gamma C_j + \beta X_{ijt} + u_{ijt} \quad (3)$$

This regression model suffers from the selection bias problem described above and we control for this selection bias by using the propensity score matching (PSM) approach. PSM, which is the probability of assignment to the InovAgro project conditional on before-intervention characteristics, is specified as follows:

$$p_i = p(X_{ijt}) = \Pr(C_j = 1 | X_{ijt}) = E[C_j = 1 | X_{ijt}] = F\{h(X_{ijt})\} \quad (4)$$

Where $F\{\cdot\}$ can be a normal or logistic cumulative distribution. PSM controls for selection bias by constructing a counterfactual for households who benefited from the InovAgro project by matching every household from the treatment communities with those from the control communities with similar characteristics. Once the PSM is estimated, the ATT can be computed as follows:

$$\begin{aligned} ATT &= E\{Y_i^T - Y_i^C | C_j = 1\} = E\left[E\{Y_i^T - Y_i^C | C_j = 1, p_i\}\right] \\ &= E\left[E\{Y_i^T | C_j = 1, p_i\} - E\{Y_i^C | C_j = 0, p_i\} | C_j = 1\right] \end{aligned} \quad (5)$$

where Y_i^T and Y_i^C denote, respectively, the outcome variable if household i benefited (treatment communities), and the outcome variable if the household i did not benefit (control communities) from the InovAgro project.

3.2.1.2 Outcome variable definition

Following the program theory of change, our analysis focuses on investigating the effect of exposure to the InovAgro project on selected outcome variables including potential program impact on adoption of modern farm practices, access to agricultural input and output market information, agricultural productivity, overall household welfare and some unintended (positive or negative) effects such as empowerment of vulnerable groups, including women and youth. Table 3.2 below outlines the definition of each of the outcome variables together with the expected direction (sign) of program effect.

Table 3.2 Outcome variables definition and expected signs

Variable	Definition	Expected sign
Adoption of modern farm practice		(+)
Adoption of agro-chemicals	Dummy variable equal to 1 if the household has utilized herbicide, pesticide, inoculant, etc. on at least one of their agricultural parcels	(+)
Adoption of fertilizer	Dummy variable equal to 1 if the household has used/applied fertilizer on at least one of their agricultural parcels	(+)
Adoption of improved seed variety	Dummy variable equal to 1 if the household has used/applied modern seed variety for one of the intervention crops (Soya bean, Pigeon pea and/or maize on at least one of their agricultural parcels	(+)
Access to agricultural market information		(+)
Access to input market information	Dummy variable equal to 1 if the household has reported to receive information about input markets from sources such as SDAE, extension agent, radio, fliers etc.	(+)
Access to output market information	Dummy variable 1 if the household has reported to receive information about output markets from sources such as SDAE, extension agent, radio, fliers etc.	(+)
Agricultural productivity and market participation		(+)
Agricultural productivity (output value per hectare)	Obtained by dividing total value of quantity produced using median community-level price of each crop (total output value) by total area cultivated	
Sell of agricultural output	Dummy variable equal to 1 if household has reported a sell of cultivated crop (maize in our case) in the most recent agricultural season	(+)
Extent of market participation (ratio of marketable surplus)	Obtained by dividing total value of output sold by the total value of output produced	
Household welfare and income diversification		(+)
Asset index	Computed using principal component analysis (PCA), taking into account both animal and asset ownership. We considered four categories of asset index: i) functioning assets comprising of productive assets, ii) functioning and non-functioning assets consisting of productive and non-productive assets, iii) functioning durable assets consisting of productive durable assets, and iv) functioning durable and nondurable assets comprising of productive durable and nondurable assets.	(+)
Non-agricultural employment	Dummy variable equal to 1 if the household has reported to have a at least one household member age 15 or older to have generated income from a non-farm activity	(+)

Temporary migration	Dummy variable equal to 1 if the household has reported to have at least one household members aged 15 or older who was absent in the household in the last 12 months prior to the date the household were interviewed	(+)
Empowerment of vulnerable groups – women and youth		(+/-)
Land right:		
Women's land rights	Dummy variable equal to 1 if the household has at least one adult female member with the right to own, sell, give, or rent land, or has the right to contribute to the purchase of land	(+/-)
Youth land rights	Dummy variable equal to 1 if the household has at least one youth member (25 to 34 years of age) with the right to own, sell, bequeath, or rent land, or has the right to contribute to the purchase of land	(+/-)
Non-agricultural employment		
Women's non-agricultural employment	Dummy variable equal to 1 if the household has at least one adult female member age 15 or older to have generated income from a non-farm activity	(+/-)
Youth's non-agricultural employment	Dummy variable equal to 1 if the household has at least one youth member (25 to 34 years of age) to have generated income from a non-farm activity	(+/-)
Temporary migration		
Women's migration	Dummy variable equal to 1 if the household has at least one adult female member age 15 or older who was absent in the household in the last 12 months prior to the date the household were interviewed	(+/-)
Youth migration	Dummy variable equal to 1 if the household has at least one youth member (25 to 34 years of age) who was absent in the household in the last 12 months prior to the date the household were interviewed	(+/-)

Source: Authors' compilation

3.2.2 Macro (market) level impact

To assess the potential effect InovAgro program has on overall macro (market) level effects, we combined primary as well as secondary textual and geo-referenced data. Firstly, we utilized a unique geo-spatial data analysis technique using geo-referenced census data of locations of all value chain interventions that are operational in all the 16 communities included in our study. In addition to GPS coordinates of the locations of these value chain interventions, textual data on the type of value chain intervention⁵, years of establishment (launch of operation), affiliation with upstream actors (e.g. Seed companies, NGOs, government bodies, etc) were included in the GIS data collection exercise. Secondly, complementary data was also acquired via key informant interviews (KII) and focus group discussion (FGD) with local stakeholders, SDAE, the project implementer (DAI) to identify affiliation with InovAgro and modality of service delivery of each value chain intervention or agribusiness stakeholder. Based on this information,

⁵ Value chain interventions included during the geo-referenced data collection were agro-dealers, lead farmers, and a demo-plot that were operational (functional) in all the 16 communities included in the two study districts (Molumbo and Alto Molocue).

we are able to group all geo-referenced value chain intervention into three groups: (1) MSD – InovAgro facilitated; (2) MSD – Non-InovAgro facilitated; and (3) Non-MSD value chain interventions. Table 3.3 below presents the breakdown of the geo-referenced value chain interventions by these three groups.

Table 3.3 Distribution of geo-referenced value chain interventions

	Seed Company or NGO facilitating access to seed	Type of Organization	Number of value chain interventions with geo-reference data	1= MSD - InovAgro partner; 2= MSD - non InovAgro partner; 3= Non-MSD (direct service delivery, subsidy, or voucher)
1	Phoenix	Seed company	25	1
2	Pannar	Seed company	17	1
3	Syngenta	Seed company	16	1
4	Seed Co	Seed company	14	1
5	CLUSA (PROMAC)	Donor funded project or NGO	57	2
6	AENA-AGRA	Donor funded project or NGO	8	3
7	ADRA	Donor funded project or NGO	10	3
8	PROMER	Donor funded project or NGO	9	3
9	PROMOVE (FAO)	Donor Funded Project	29	3
Total number of geo-referenced value chain interventions			185	

Source: Authors' computation using the InovAgro geo-spatial data (2019)

Based on this, we utilize the “median terrain adjusted walking distance” as a cut-off point (i.e., 60 minutes) to categorize households as treated or not. Accordingly, households with in a 60 minute “terrain adjusted walking distance” to a nearest value chain intervention are, hereafter, defined as treatment households (i.e., households exposed to treatment) and those that are located further than 60 minutes “terrain adjusted walking distance” as control households (indicated as group 3 in Figure 3.1). Treatment households are further sub-grouped as MSD and non-MSD households depending on whether the value chain intervention to which they are exposed adopts an MSD approach or not (group 1 and 2, respectively, in Figure 3.1).

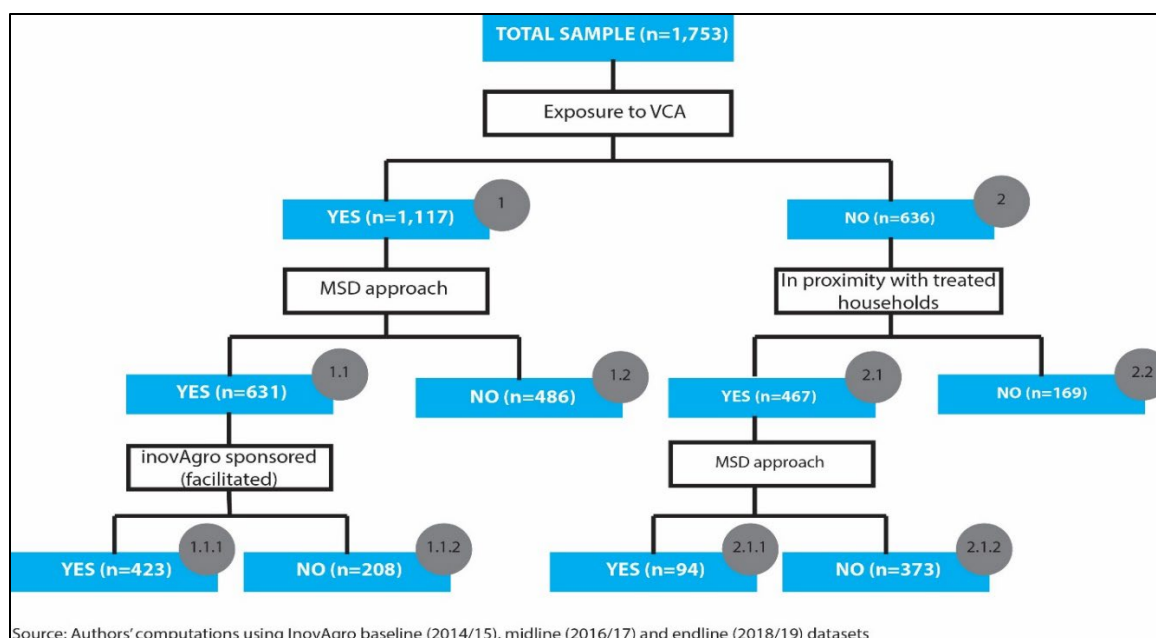


Figure 3.1 Overview of the study design and sample groups

Overall, to assess the macro (market) level impacts of InovAgro project, the following treatment groups are identified using the observational (household survey) and GIS data (as shown in Figure 3.1):

Treatment groups:

- Group 1: A household is located within 60 minutes of “terrain adjusted walking distance” to a value chain intervention (hereafter called **treatment/exposed households**)
 - Group 1.1: A household is located within 60 minutes of “terrain adjusted walking distance” to a value chain intervention that adopts an MSD model (hereafter called **MSD treated/exposed households**)
 - Group 1.1.1: A household is located within 60 minutes of “terrain adjusted walking distance” to a value chain intervention that adopts an MSD model and is sponsored/facilitated by InovAgro (hereafter called **InovAgro treated/exposed households**)
 - Group 1.1.2: A household is located within 60 minutes of “terrain adjusted walking distance” to a value chain intervention that adopts an MSD model but is not directly affiliated with or sponsored/facilitated by InovAgro (hereafter called **Non-InovAgro treated/exposed households**)

- Group 1.2: A household is located within 60 minutes of “terrain adjusted walking distance” to a value chain intervention that adopts an MSD model (hereafter called **non-MSD treated/exposed households**)
- Group 2: A household is located further than 60 minutes “terrain adjusted walking distance” to a value chain intervention (hereafter called **control households**)
 - Group 2.1: A household is located further than 60 minutes “terrain adjusted walking distance” to a value chain intervention but in proximity (within 60 minutes walking distance) to a treated household (hereafter called **control-indirect households**)
 - Group 2.1.1: A household is located further than 60 minutes “terrain adjusted walking distance” to a value chain intervention but in proximity (within 60 minutes walking distance) to MSD treated/exposed household (hereafter called **control MSD households**)
 - Group 2.1.2: A household is located further than 60 minutes “terrain adjusted walking distance” to a value chain intervention but in proximity (within 60 minutes walking distance) to a non-MSD treated/exposed household (hereafter called **control non-MSD households**)
 - Group 2.2: A household is located further than 60 minutes “terrain adjusted walking distance” to a value chain intervention and any of the treated household (hereafter called **pure control households**)

4 DATA AND DESCRIPTIVE RESULTS

4.1 Data

The treatment unit of this evaluation is the community (*comunidad*) level. Communities are administrative units within localities (*localidades*), which in turn are administrative units inside administrative posts (*postos administrativos*)—the largest units on a district level. Initially the International Food Policy Research Institute (IFPRI), SDC, and the implementing agency Development Alternatives Inc. (DAI) agreed that a randomized controlled trial (RCT) (or experimental) approach would be used in the impact evaluation, and the research proposal was designed based on this approach. Shortly before conducting the baseline survey, however, it was determined that the experimental design, in which the treatment and control areas are selected randomly, was not feasible due to the factors explained earlier: (1) ethical issues were involved with the exclusion of subjects for a control group; (2) the MSD (systemic) approach adopted by InovAgro project made strict exclusion criteria impossible (it was hard to contain treatment activities from spilling over into control group areas); and (3) the adaptive nature of the MSD approach (which is highly responsive to supply and demand forces) made it difficult to randomize treatment (exposure to the program).

Instead, the implementing agency selected four communities in each district where InovAgro's intervention would be carried out. All selected treatment communities were located in the same administrative post within each district. The control communities were selected from comparable⁶ localities in a different administrative post from where the treatment communities are located. We chose a different administrative post for the control communities to limit spillovers effects. The household listing exercise in both treatment and control areas secured information about the households regarding age and gender of household head and their soybean and/or pigeon pea production. This listing information was used to select the final set of control communities based on the extent of soybean and/or pigeon pea cultivation. The final sample is drawn from 16 communities in four administrative posts in two districts. The communities are listed in Table 4.1.

⁶ As defined by the implementing agency.

Table 4.1 Study area and sample size

			2015		2017		2019	
District	Administrative post	Community	N	%	N	%	N	%
Molumbo	Treatment Molumbo-Sede	Benesse	117	6.2	114	6.5	111	6.4
		Macolocotxo	100	5.3	89	5.1	88	5.1
		Mugoliua	120	6.4	105	6.0	103	5.9
		Nandie	108	5.7	97	5.6	96	5.5
	Control Corromana-Sede	Bediua	96	5.1	78	4.5	78	4.5
		Corromana-Sede	119	6.3	107	6.1	107	6.2
		Impindula-Sede	121	6.4	109	6.2	109	6.3
		Mucoco	125	6.6	116	6.6	115	6.6
Alto Molocue	Treatment Nauela	Mohiua	124	6.6	123	7.0	123	7.1
		Namilepe	120	6.4	114	6.5	112	6.5
		Carmano	123	6.5	123	7.0	123	7.1
		Caperula	125	6.6	124	7.1	124	7.2
	Control Alto-Molócue Sede	Murico	119	6.3	116	6.6	113	6.5
		Napalaca	122	6.5	108	6.2	108	6.2
		Lugela	125	6.6	124	7.1	123	7.1
		Inrule	122	6.5	102	5.8	100	5.8
Total			1,886	100	1,749	100	1,733	100

Source: Authors' computation using InovAgro baseline (2014/15) and midline (2016/17) and endline (2018/19) datasets

Note: N stands for number of observations.

Power calculations during the planning stage of this project—which were based on the more demanding methodology of a randomized controlled trial, rather than the quasi-experimental approach ultimately pursued—indicated that about 2,000 households were needed, which is the approximate number generated when adjusting for design effect and attrition rate. As evidenced from the total number in Table 4.1, a total of 1,886 households were interviewed during the IIES 2015 (baseline survey); of which 937 were from the treatment communities and 949 from the control communities. The number of interviewed households dropped to 1,749 (889 from the treatment communities and 860 from the control communities) during the IIES 2017 (midline survey) and to 1,733 (880 from the treatment communities and 853 from the control communities) during the IIES 2019 (endline survey). These lower numbers of households reinterviewed during the IIES 2017 and the IIES 2019 are due to attrition. Attrition rates stood at 7.3% between the IIES 2015 and IIES 2017 and at 0.9% between the IIES 2017 and IIES 2019; with an overall attrition rate of 8.1% between the IIES 2015 and IIES 2019.

For all three rounds of the IIES, enumerators used Computer-Assisted Personal Interviewing (CAPI) to collect the data and the survey instrument was designed using the Census and Survey Processing System (CSPRO). Enumerators took an average of 45 minutes to administer each survey. The field team consisted

of 12 enumerators for the IIES 2015 and 16 enumerators for the IIES 2017 and IIES 2019. For all three rounds of the IIES, the field teams were supervised by two team leaders and managed by two field coordinators. Data collection took place between August and September of 2015 for the IIES 2015, between October and November of 2017 for the IIES 2017, and between July and August of 2019 for the IIES 2019; and all three rounds of the IIES were implemented by IFPRI.

4.1.1 Spatial (GIS) data

Despite the original study design of keeping the randomization of treatment at community level (where the baseline survey was conducted 8 treatment and another 8 control communities from the two study districts), the study team encountered a major methodological challenge with using a geographic boundary (community boundary) to define treatment. This was mainly so since a household presumably residing in a control community (hence, considered as a control household) could be located within close proximity to an InovAgro sponsored/facilitated intervention in one of our treatment communities. As a result, ignoring the challenge due to such rigid identification strategy will result in an understatement of potential impacts of InovAgro since the presumed control household is fairly exposed to the intervention due to their proximity to the value chain intervention (treatment). Such scenario became more apparent during joint IFPRI-DAI scoping field visits conducted post-baseline to monitor compliance of the program implementation to the agreed study design (randomization at community level).

As a result, geo-spatial data was collected during the 2016/17 midline and 2018/19 endline survey to compile a census of value chain interventions that were operational in all the 16 communities (two districts) included in our study collection. Such spatial database on the location of these value chain interventions also included further data on the type of value chain interventions (MSD approach versus direct service delivery approach), years of establishment and the type of value chain intervention or service provision (namely, agro-dealer, lead farmer and demo plot). As shown in Table 4.2, the supplemental spatial data collection has covered Global Positioning System (GPS) coordinates of a census of 185 value chain interventions that were operational in Molumbo (72) and Alto Molocue (113). The availability of such data enabled us to use “physical accessibility” as an identification strategy to define comparable treatment and control households. Figure 4.1 below shows GPS coordinates (locations) of all value chain interventions as well as residences of our sampled households from the two districts.

Table 4.2 Distribution of value chain interventions by study district

District	Value chain interventions			Total
	Agro dealer	Lead farmer	Demo plot	
Alto Molocue	14	14	85	113
Molumbo	17	24	31	72
Total	31	38	116	185

Source: Authors' computation using the InovAgro geo-spatial data (2019)

To quantitatively measure the level of physical accessibility various studies, employ distance and time model approaches. It is well argued that in a diverse geographic situation traditional straight-line distance measure tend to overlook local topographic variations and impedances (Kosmidou-Bradley and Blankespoor, 2019; Banick and Kawasoe 2019). Accessibility measure that employ travel time-based model built in Geographic Information System (GIS) environments integrates on-road and off-road geospatial layers including roads, landcovers, rivers, land cover, digital elevations grids (Weiss, 2018; Uchida and Nelson 2009; Schmidt and Kedir 2009) improves accessibility computation more accurately than the former. Unlike other comprehensive market accessibility models this analysis however estimate merely on-foot travel to the nearest value chain interventions accounting topographic factor as the main impedance of movement. The study area dominated by agricultural land where walking speed likely affected more by down and up slope.

In general, the model computes off-road travel time over approximately 30m x 30m grid cell resolution-Shuttle Radar Topography Mission (SRTM) data model to adjust the walking speed. Despite land covers impede traverse speed differently given the size of the study area a uniform of 5km/hour average walking speed was used to estimate the on-foot mode of travel. For the terrain (topographic) variation adjustment Tobler's hiking function (Tobler, 1993) were used to account the up and down slope movement.

The GPS location of household and value chain interventions in Molumbo and Alto Molocue districts were collected during mid and end-line survey, respectively. At the time of end line survey Collector for ArcGIS application implemented to capture the entire spatial location of value chain interventions and approximately a third of household location.

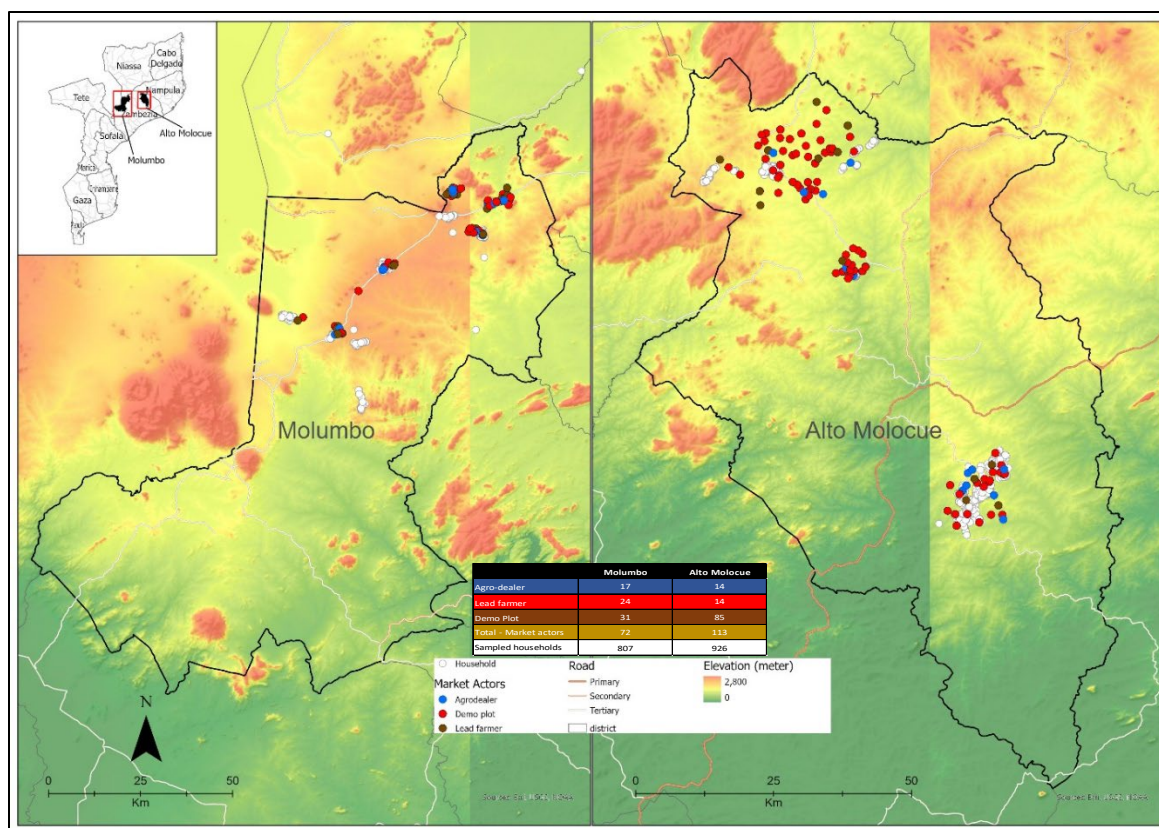


Figure 4.1 Locations of value chain interventions and sampled households in Molumbo and Alto Molocue

The accessibility model was constructed and computed in ArcGIS environment using ArcPy python script. In the analysis value chain interventions as a target service provider where households get the respective services, treated in different attribute category mainly by actor type (Agro dealer, Lead farmer and demo plot) and farther by year of establishment, belongingness and affiliations. Travel time from households to each market type and other attribute-based scenarios was computed.

4.2 Descriptive results

Table 4.3 and 4.4 summarize descriptive statistics of key variables of interest and selected outcome variables at baseline (2014/15) and endline (2018/19), respectively. Results from Table 4.3 reveals stark (statistically significant) differences in key household characteristics (such as age, marital status, gender and education of the head of households, etc.) and selected outcome variables (such as access to agricultural input and output market information, volume of production, income and crop diversification, etc.). Overall, results show treatment households are younger, more female headed, with a relatively larger farm holding and better adoption of improved seed variety. On the other hand, with a particular

relevance to our concern of selection (endogeneity) bias, control (non-beneficiary) households start from a favorable baseline condition in all of the core outcome variables except the three adoption variables i.e., adoption of fertilizer, agro-chemicals (showing no significant difference) and adoption of improved seed variety (favoring the treatment group before any intervention started on the ground). Such stark differences on key variables of interest at baseline reinforces the validity of the endogeneity concern highlighted in section 3 with a potential downward bias into our estimates given control (non-beneficiary) households are starting with a favorable condition compared to treatment (beneficiary) households. Hence, after accounting for such potential selection bias issues (either due to self-selection or program targeting) using a Propensity Score Matching (PSM) method, descriptive results from the reduced sample with treatment and control households that are comparable based on observable household and parcel characteristics at baseline is presented in Table 4.4.

Four years since the launch of the program, the results show that household head's age in both treatment and control groups between baseline and endline increased by two years in the treatment group and by four years in the control group. This increase in household head's age was expected given that time has elapsed. Between the baseline and endline, the share of households whose head had completed at least primary education declined from 15.6% to 9.6% in the treatment group and from 19.5% to 6.4% in the control group; higher decline in education levels in the control group than in the treatment group (13.1 percentage points versus 6 percentage points). On the other hand, during the same period, the proportion of household heads who can read and write increased substantially in the treatment group (from 2.7% to 46.9%) compared with the increase in the control group (from 10.1% to 48.7%). Between 2015 and 2019, land holding size trended upward and was consistently higher among households in the treatment group than among those in the control group.

Usage of yield-enhancing agricultural inputs among households in the treatment group increased substantially from 2014/15 to 2018/19, compared with those in the control group. The share of households who used agrochemicals (insecticide or herbicide) increased from 0.0% in 2014/15 to 13.8% in 2018/19 in treatment group, compared to an increase from 0.0% to 3.9% in the control group. Similar patterns were registered for fertilizer adoption (with an increase from 0.0% to 20.8% for treatment households while the control households, on average, registered an increase from 0.0% to 8.2%); and use of improved seed (with an increase in adoption from 4.9% to 27.0% for treatment households while the change for control households is only from 0.0% to 13.6%). However, during the same period, household's perception of demand (revealed willingness of future use) for improved seed has declined in both

treatment and control **groups**⁷; but the reduction was considerably higher among households in the control group (37.6 percentage points from 52.6% to 15.0%) than among those in the treatment group (7.9 percentage points from 36.2% to 28.3%).

⁷ Such result could be perhaps due to an overall behavioral effect of external factors that affected both treatment and control households (e.g., weather shock, flood, price inflation, etc).

Table 4.3 Household and parcel level descriptive statistics by treatment using 2014/15 baseline survey (pre-program implementation)

	Treatment= any value chain intervention		Control		Total		p-value for mean difference (treatment vs control)
	mean	Standard error	mean	Standard error	mean	Standard error	
Household (HH) head's age (years)	39	12	34	12	37	12	0.0000
HH head is married	0.605	0.489	0.700	0.459	0.646	0.478	0.0011
HH head has identification card	0.564	0.496	0.529	0.500	0.549	0.498	0.2388
Female headed household	0.277	0.448	0.198	0.399	0.243	0.429	0.0020
HH head has at least primary education	0.156	0.363	0.195	0.396	0.173	0.378	0.0956
HH head can read and write	0.027	0.162	0.101	0.301	0.059	0.236	0.0000
Land holdings (hectares)	1.767	1.061	1.621	1.673	1.703	1.367	0.0833
HH used agro chemicals (insecticide or herbicide)	0.000	0.000	0.002	0.047	0.001	0.031	0.2534
HH used fertilizer	0.002	0.041	0.002	0.047	0.002	0.044	0.8508
HH used improved seed	0.049	0.215	0.004	0.066	0.029	0.169	0.0000
Received input market information	0.325	0.469	0.424	0.495	0.368	0.482	0.0007
Received output market information	0.173	0.378	0.337	0.473	0.244	0.430	0.0000
Maize production value per hectare (MZN)	11,481	9,316	5,449	3,216	9,029	8,028	0.0000
Pigeon peas production value per hectare (MZN)	12,458	9,244	10,114	6,906	11,350	8,299	0.0001
HH sold maize	0.271	0.445	0.136	0.343	0.217	0.413	0.0000
HH sold pigeon peas	0.509	0.501	0.653	0.477	0.579	0.494	0.0002
Maize sales as a share of production	0.480	0.256	0.551	0.215	0.498	0.248	0.0970
Pigeon peas sales as a share of production	0.583	0.273	0.567	0.239	0.574	0.255	0.5387
Crop diversification Total crops cultivated	2.203	0.965	2.652	0.960	2.402	0.988	0.0000
Wealth index	-0.178	1.278	0.247	1.340	0.007	1.321	0.0000
A HH member in nonagricultural sector	0.366	0.482	0.613	0.488	0.474	0.500	0.0000
A HH member is a temporary migrant	0.111	0.314	0.163	0.369	0.133	0.340	0.0119
A HH member has credit access	0.068	0.252	0.101	0.301	0.082	0.275	0.0489
Number of observations	762		1,124		1,886		

Source: Authors' computation using InovAgro baseline household survey (2014/15) and supplemental geo-spatial (2019) datasets

Between 2014/15 and 2018/19, access to output market information jumped from 17.3% to 70.1% in the treatment group, compared to an increase from 33.7% to 61.9% in the control group showing much higher increase in the treatment than control group. Similar pattern was registered for access to input market information (from 32.5% to 65.7% in the treatment group versus from 42.4% to 60.2% in the control group). During the same period, values of production per hectare for maize and pigeon peas are consistently higher in the treatment (MZN 11,481 versus MZN 10,962 for maize and MZN 12,458 versus MZN 12,103 for pigeon peas) than in the control group (MZN 5,449 versus MZN 8,885 for maize and MZN 10,114 versus MZN 7,353 for pigeon peas). This could be an indication of higher profitability from land use for maize, compared with pigeon peas.

Between 2014/15 and 2018/19, increase in the proportion of households who sold maize was higher in the treatment group (35.9 percentage points from 27.1% to 63.0%) than in the control group (32.7% percentage points from 13.6% to 46.3%). By contrast, during the same period, the proportion of households who sold pigeon peas dropped in both treatment and control groups, but a larger fall was registered in the control rather than treatment group (47.7 percentage points from 65.3% to 17.6% versus 18 percentage points from 50.9% to 32.9%). It is worth noting that the maize sales as a share of production were slightly higher in the control group (55.1%) than in the treatment group (48.0%) in the baseline potentially as a result of being better informed; however, by the endline, maize sales as a share of production were comparable in treatment and control groups (46.8% versus 42.9%). In the case of pigeon peas, there were no statistical differences between treatment and control groups in both years (2014/15 and 2018/19).

For both treatment and control groups, crop diversification remained basically unchanged between 2015 and 2019. However, in both 2014/15 and 2019, crop diversification was slightly lower in the treatment than control group (2.2 versus 2.7 in 2015 and 2.3 versus 2.5 in 2019). Findings presented in tables 4.3 and 4.4 suggest that households in the treatment group were worse off (measured by wealth index) than those in the control group during the baseline; however, by the endline, the situation reversed: Households in the treatment group became better off than those in the control group.

Exposure to MSD appeared to have increased participation in the nonagricultural sector and temporary migration. Findings from tables 4.3 and 4.4 show that the share of household members who engaged in the nonagricultural sector increased considerably from 36.6% in 2015 to 57.9% in 2019 in treatment group, while it slightly increased from 61.3% in 2015 to 62.9% in 2019 in the control group. On the other hand, the proportion of household members who engaged in temporary migration jumped from 11.1% in 2015 to 20.6% in 2019 in the treatment group. By contrast, during the same period, it dropped from 16.3% to 10.4% in the control group. Furthermore, exposure to MSD might have increased access to credit. The share of household members who had access to credit increased by 13.3 percentage points from 6.8% in 2015 to 20.1% in 2019 in the treatment group and by 5.6 percentage points from 10.1% in 2015 to 15.7% in 2019 in the control group.

Table 4.4 Household and parcel level descriptive statistics by treatment using 2018/19 endline survey (four years after program implementation)

	Treatment= any value chain intervention		Control		Total		p-value for mean difference (treatment vs control)
	mean	Standard error	mean	Standard error	mean	Standard error	
Household (HH) head's age (years)	41	11	38	12	40	11	0.0000
HH head is married	0.319	0.466	0.284	0.451	0.304	0.460	0.2148
HH head has identification card	0.587	0.493	0.472	0.500	0.538	0.499	0.0002
Female headed household	0.220	0.415	0.197	0.398	0.210	0.408	0.3550
HH head has at least primary education	0.096	0.295	0.064	0.245	0.082	0.274	0.0572
HH head can read and write	0.469	0.499	0.487	0.500	0.477	0.500	0.5548
Land holdings (hectares)	2.586	2.583	2.365	1.322	2.491	2.133	0.0923
HH used agro chemicals (insecticide or herbicide)	0.138	0.345	0.039	0.193	0.095	0.293	0.0000
HH used fertilizer	0.208	0.406	0.082	0.275	0.154	0.361	0.0000
HH used improved seed	0.270	0.444	0.136	0.343	0.212	0.409	0.0000
Received input market information	0.657	0.475	0.602	0.490	0.633	0.482	0.0607
Received output market information	0.701	0.458	0.619	0.486	0.665	0.472	0.0045
Maize production value per hectare (MZN)	10,962	7,064	8,885	6,464	10,050	6,880	0.0000
Pigeon peas production value per hectare (MZN)	12,103	11,098	7,353	9,304	9,922	10,571	0.0000
HH sold maize	0.630	0.483	0.463	0.499	0.556	0.497	0.0000
HH sold pigeon peas	0.329	0.471	0.176	0.382	0.257	0.437	0.0000
Maize sales as a share of production	0.468	0.27	0.429	0.253	0.453	0.264	0.1226
Pigeon peas sales as a share of production	0.623	0.312	0.586	0.300	0.611	0.307	0.4828
Crop diversification Total crops cultivated	2.303	1.437	2.512	1.253	2.393	1.364	0.0130
Wealth index	0.067	1.303	-0.104	1.172	-0.007	1.250	0.0252
A HH member in nonagricultural sector	0.579	0.494	0.629	0.484	0.601	0.490	0.0952
A HH member is a temporary migrant	0.206	0.404	0.104	0.305	0.161	0.368	0.0000
A HH member has credit access	0.201	0.401	0.157	0.364	0.182	0.386	0.0627
Number of observations	689		1009		1698		

Source: Authors' computation using InovAgro endline household survey (2018/19) and supplemental geo-spatial (2019) datasets

5 RESULTS AND DISCUSSIONS:

As outlined in section 3.2, the InovAgro impact evaluation set out to evaluate impact of the InovAgro program at two levels, namely: Macro (market) level effects and Micro (household) level effects. Following the program theory of change, we first focus on documenting potential impacts of the InovAgro program at macro (market) level by assessing the extent to which the MSD approach of InovAgro project has resulted in market changes. For this, we focus on three result pathway parameters, namely: 1) systemic effects; 2) sustainability effects and 3) large-scale (spillover) effects. Section 5.1 below is dedicated to presenting and discussing the results on the potential macro benefits, while section 5.2 focuses on the micro (household) level impacts.

5.1 Macro (market) level impacts

5.1.1 Systemic (long-term) effects:

As part of the facilitative role the InovAgro program has set out to achieve, one of the major activities of the InovAgro program was focused on understanding where market systems are failing to serve the needs of the poor and take actions to correct those failings. For this purpose, a systemic change is, hereby, defined as “transformations in the structure or dynamics of a system that leads to impacts on the material conditions or behaviors of large numbers of people either through crowding in or copying by other value chain interventions due to the program’s effect on improving business environment (Ruffer and Wach, 2013).

Hence, to investigate the potential crowding-in or “copying” effect of InovAgro, we use two proxy indicators. Firstly, we compare the number of InovAgro facilitated or sponsored MSD value chain interventions versus Non-InovAgro facilitated or sponsored MSD value chain interventions before and after the launch of InovAgro activities in the study communities in 2015. To claim any systemic (crowding-in) effect of InovAgro, we expect a more significant increase in the number of Non-InovAgro facilitated MSD actors post-2015 (after the launch of InovAgro program). Secondly, we also compare the average time lapsed since the program’s launch for InovAgro facilitated or sponsored versus non-InovAgro sponsored MSD value chain interventions. Again, a significant reduction in the average time lapsed since the program began operation for non-InovAgro facilitated MSD value chain interventions is considered as indicative evidence of InovAgro having had a systemic effect.

Table 5.1 below shows results on both parameters disaggregated by the two districts included in the study. Overall, results reveal that, comparing the time before and after the launch of the InovAgro project (before and after 2015, respectively), there is a significant percentage increase in the number of non-InovAgro facilitated or sponsored value chain interventions. This trend remains consistent in both of the study districts – i.e., Molumbo and Alto Molocue. Similarly, results also show that, on average, non-InovAgro facilitated or sponsored MSD value chain interventions had significantly shorter time lapsed since the program’s launch compared to InovAgro sponsored or facilitated value chain interventions. Both results are indicative of the facilitative role InovAgro has played in bringing more MSD value chain interventions into the system (i.e., crowding-in effects). As a result, due to such overall market (systemic) effect of InovAgro, MSD effect/impact and InovAgro effect/impact are, hereafter, used interchangeably.

Table 5.1 Systemic changes/effects of InovAgro program

Districts	Groups	Number of MSD value chain interventions			Number of months since launch/ began operation (as of December 2019)
		Before 2015	After 2015	% increase	
Molumbo	InovAgro facilitated or sponsored - MSD value chain interventions	3	15	400%	39.13 months
	Non-InovAgro facilitated or sponsored - MSD value chain interventions	0	19	2,000%	26.68 months
	Mean comparison test				****
Alto Molocue	InovAgro facilitated or sponsored - MSD value chain interventions	2	25	1,150%	31.24 months
	Non-InovAgro facilitated or sponsored - MSD programs	7	58	729%	24.56 months
	Mean comparison test				***
Total sample	InovAgro facilitated or sponsored - MSD programs	5	40	700%	34.7 months
	Non-InovAgro facilitated or sponsored - MSD programs	7	77	1,000%	25.4 months
	Mean comparison test				***

Source: Authors’ computation using InovAgro baseline (2014/15), midline (2016/17) and endline (2018/19) datasets.

5.1.2 Sustainability effect:

The other potential macro (market) level effect investigated in our study is in answer to the question, to what extent does InovAgro (or MSD programs generally speaking) lead to a more long-lasting effect compared to the effects of non-MSD programs. As a result, to investigate the potential sustainability effect of InovAgro, we use the three wave IIES panel data and monitor the household adoption history of modern farming practices (such as use of fertilizer, other agro-chemicals and use of modern seed varieties), comparing those who benefit from MSD value chain interventions with those only exposed to non-MSD value chain interventions.

Using the three rounds of the IIES observational (household survey) panel data in 2014/15, 2016/17 and 2018/19, we were able to observe the status of sampled households in terms of their adoption of modern farm practices during the follow up surveys in 2016/17 and 2018/19 (after the InovAgro program was launched in the study locations in 2014/2015). The four quadrants in Table 5.2 show the trajectory of adoption of modern farm practices by sampled households, comparing 2016/17 with 2018/19, i.e., 2 and 4 years, respectively, after the program was launched in the study locations in 2014/2015.

To claim a sustainability effect of the InovAgro MSD program, we compare the four scenarios in the quadrants shown in Table 5.2. We expect the proportion of MSD treated or exposed households under quadrant-I (“continue adoption”) to be significantly larger than the proportion of households treated or exposed to non-MSD value chain interventions in the case of sustainability effects. Stated differently, if the InovAgro MSD program is indeed more sustainable than non-MSD programs, we expect the proportion of households that abandon adoption (quadrant – III) to be significantly larger for those that are treated or exposed to non-MSD value chain interventions (direct service delivery) compared to those treated or exposed to InovAgro (MSD) programs.

Table 5.2 Adoption trajectory

			2018/2019 (endline) survey	
			Adoption of modern farm practice	
			YES	NO
2016/2017 (midline) survey	Adoption of modern farm practice	YES	I (continue adoption)	III (become non-adopters)
		NO	II (become new adopters)	IV (continue non-adoption)

Source: Authors' compilation

Table 5.3 below summarizes the results of the hypothesized sustainability effects of the InovAgro MSD project⁸ using 10 alternative definitions of adoption of modern farming practices⁹ disaggregated by three types of value chain intervention (agro-dealers, lead farmers and demonstration plots). As a result, we were able to run 30 tests of the sustainability hypothesis by combining the 10 adoption definitions.

⁸ Sustainability hypothesis: The proportion of households who continue adopting is significantly larger for those who are exposed to the InovAgro (MSD) program compared to those who are exposed to non-MSD value chain interventions.

⁹ Adoption of modern farm practice is proxied by 10 alternative modern farm practices: namely, adoption of (1) NPK; (2) insecticide; (3) Herbicide; (4) Inoculant; (5) improved seed – Soybean; (6) improved seed – Pigeon pea; (7) improved seed – Maize; (8) Fertilizer – for Soybean; (9) fertilizer – for Pigeon pea; and (10) fertilizer – for Maize.

Table 5.3 Sustainability effects: Proportion of households who continue adopting (2016/17 – 2018/19) – by type of value chain intervention

Adoption	Treatment = Agro-dealer				Treatment = Demo plot				Treatment = Lead farmer			
	MSD	Non-MSD	p-value for difference		MSD	Non-MSD	p-value for difference		MSD	Non-MSD	p-value for difference	
NPK	18.8%	11.1%	0.0314	++	18.8%	13.1%	0.0536	++	21.0%	3.6%	0.0060	++
Insecticide	22.2%	20.3%	0.1310		36.9%	11.6%	0.0080	++	21.5%	7.9%	0.0314	++
Herbicide	4.5%	0.0%	0.0380	++	2.9%	0.0%	0.5942		4.2%	0.0%	0.3819	
InoculantInoculant	5.3%	5.3%	0.6886		5.2%	4.9%	0.2316		5.3%	0.0%	0.0000	++
Improved seed												
Soya beans	8.0%	3.3%	0.0341	++	6.4%	2.5%	0.0330	++	5.9%	3.2%	0.0052	++
Pigeon peas	8.0%	0.0%	0.0018	++	7.7%	0.0%	0.0938	++	8.5%	0.0%	0.0240	++
Maize	100.0%	100.0%	0.2482		100.0%	100.0%	0.3084		100.0%	0.0%	0.0000	++
Fertilizer												
Soya beans	16.7%	5.2%	0.0098	++	12.3%	7.2%	0.0685	++	11.1%	6.8%	0.0087	++
Pigeon peas	3.3%	0.0%	0.0271	++	2.1%	0.0%	0.2513		0.0%	0.0%	0.0544	++
Maize	28.6%	28.6%	0.7368		30.5%	23.3%	0.0292	++	12.5%	0.0%	0.0000	++

Source: Authors' computation using InovAgro baseline (2014/15) and midline (2016/17) and endline (2018/19) datasets

Note: ++ stands for hypothesis supported at least with 10% level of significance

As shown in Table 5.3, overall, the results support our hypothesis that the InovAgro MSD program is more sustainable than non-MSD programs. Of the 30 hypotheses tests conducted, 21 cases show that the proportion of households that continue to adopt modern farm practices was significantly (at least at 10% level of statistical significance) larger for households treated or exposed to the InovAgro MSD program compared to those that are treated or exposed to non-MSD programs. More interestingly, the result is more robust and consistent for the two value chain crops selected by InovAgro, as the proportion of smallholder farmers who continued use of the modern seed varieties of soya and pigeon pea is significantly larger for those beneficiary households of the InovAgro MSD project compared to those who benefited from direct service delivery or subsidy programs (non-MSD programs). The result remains robust regardless of the type of value chain intervention. This result reinforces the skepticism around non-MSD programs which focus on free or subsidized delivery of services that are prone to dropouts as soon as such supports are withdrawn.

5.1.3 Spillover or multiplier effects

Due to the expected facilitative role MSD programs like InovAgro play, such programs are expected to have a positive spillover benefit on households that are not necessarily direct beneficiaries of the program. For this purpose, we, hereby, define spillover/multiplier effects to refer to wider changes resulting from InovAgro by benefitting larger numbers of smallholder farmers beyond InovAgro's direct domain of intervention (beyond its intended beneficiaries)".

Again, comparing the four scenarios (quadrants) shown in Table 5.2, we investigated possible spillover/multiplier effects of the InovAgro MSD program by focusing on the non-beneficiary households (households that are not exposed to any MSD or non-MSD value chain interventions). Using our unique spatial database of the locations of all our sampled respondents and relevant value chain interventions (agro-dealers, lead farmers and demonstration plots), we were able to compare the adoption practices of non-beneficiary households that are located in close proximity to an MSD beneficiary household (those within a 60-minute buffer cutoff) versus non-beneficiary households who are not in close proximity to an MSD beneficiary household¹⁰.

¹⁰ Due to lack of enough observations in our data of non-beneficiary households that are in close proximity to non-MSD beneficiary households, we are not able to test potential spillover benefits of non-MSD programs and, hence, not able to compare potential spillover benefits of MSD programs over non-MSD programs.

Table 5.4 Spillover effects: Proportion of households who become new adopters (2016/17 – 2018/19) – by type of value chain intervention

	Treatment = Agro-dealer				Treatment = Demo plot				Treatment = Lead farmer			
	Control but in proximity to MSD household	Pure control	p-value for difference		Control but in proximity to MSD household	Pure control	p-value for difference		Control but in proximity to MSD household	Pure control	p-value for difference	
NPK	1.9%	1.6%	0.4370		13.5%	13.4%	0.8965		15.3%	7.4%	0.0004	++
Insecticide	17.8%	0.8%	0.0000	++	14.2%	12.3%	0.6117		19.0%	6.5%	0.0000	++
Herbicide	0.4%	0.0%	0.0079		4.7%	2.4%	0.0986	++	5.1%	2.0%	0.0094	++
Inoculant	5.7%	5.6%	0.6854		6.7%	6.5%	0.9521		11.0%	4.1%	0.0000	++
Improved seed												
Maize	10.8%	2.1%	0.0000	++	11.6%	10.4%	0.0453	++	13.4%	4.8%	0.0000	++
Pigeon peas	4.5%	0.0%	0.0146	++	3.2%	2.8%	0.2880		4.8%	1.8%	0.0000	++
Soya beans	13.4%	0.0%	0.0000	++	11.4%	7.3%	0.0001	++	13.1%	6.1%	0.0000	++
Fertilizer												
Maize	25.4%	6.3%	0.0001	++	23.2%	17.9%	0.0854	++	28.0%	7.3%	0.0033	++
Pigeon peas	6.4%	2.7%	0.0001	++	5.6%	5.7%	0.9625		6.0%	0.5%	0.0133	++
Soya beans	15.7%	1.6%	0.0001	++	12.1%	10.5%	0.2815		14.0%	7.9%	0.0094	++

Source: Authors' computation using InovAgro baseline (2014/15) and midline (2016/17) and endline (2018/19) datasets

Note: ++ stands for hypothesis supported at least with 10% level of significance

Therefore, to claim spillover/multiplier effects of InovAgro (MSD) program, we expect the proportion of households under quadrant-II (“become new adopters”) to be significantly larger for non-beneficiary households who are located in close proximity to MSD treated or exposed households compared to the non-beneficiary households located further away (i.e. those who are pure controls). This is because we would also expect a better likelihood of peer-to-peer social learning for the MSD affiliated control households compared to the pure controls.

Similarly, to the sustainability effects tests in section 5.1.2, we used 10 alternative definitions of adoption of modern farming practices disaggregated by three types of value chain intervention and were able to run 30 tests of the spillover/multiplier hypotheses¹¹ by combining the 10 adoption definitions. Table 5.4 summarizes the results for the possible spillover/multiplier effect of InovAgro MSD program. Overall, the results support the hypothesis, showing the potential effect of InovAgro in benefitting large numbers of smallholder farmers beyond the program’s direct sphere of influence and intended beneficiaries. Of the 30 hypotheses tests conducted, 23 cases show that the proportion of households who were new adopters of modern farm practices (those who did not adopt during the midline survey in 2016/17 but adopted in 2018/19) was significantly larger (at least at a 10% level of statistical significance) for non-beneficiary households who resided in close proximity to households treated or exposed to the InovAgro MSD program compared to those who resided further away (more pure controls). Regardless of the proxy variables used to capture adoption of modern farm practices, the result is more robust and consistent for those beneficiaries with access to a lead farmer as a value chain intervention compared to those who are benefited by access to agro-dealers and demonstration plots. This is perhaps not surprising given the role social capital can play in magnifying the potential spillover benefits where lead farmers have better comparative advantages compared to those of agro-dealers or access only to a demonstration plot.

Such empirical evidence demands the need for future design and implementation of similar programs to integrate a proper focus on the “lead farmer modality of MSD service provision” and ensuring that program outcomes remain desirable not only for intended beneficiary smallholder farmers but also as they benefit those beyond the program’s direct sphere of influence.

¹¹ The proportion of households who become new adopters is significantly larger for non-beneficiary households who are located in close proximity to MSD treated /exposed households compared to the non-beneficiary households located further away (pure controls).

5.1.4 Potential unintended effects

By unintended effects we mean any program effect (positive or negative) not identified by the program's theory of change. For this purpose, we used potential effects of the program on crop diversification, household income diversification, intra-household bargaining power and land rights of vulnerable groups (such as women and youth) as potential unintended effects of the InovAgro program. Table 5.5 below presents a summary of the results on these potential unintended effects of the InovAgro program.

Overall, descriptive summary results from Table 5.5 show that a negative unintended effect of both MSD and non-MSD programs on households' crop diversification. This is expected since these programs encouraged smallholder farmers to specialize rather than diversify. We consider this as a potential unintended effect of the program given smallholder farmers often use crop diversification as a risk-coping or mitigation strategy to deal with potential crop failure. Results also show a potential negative effect of MSD programs on youth access to or control over land, while the opposite is true for non-MSD programs. Other results show a contrasting evidence on household income diversification and migration where such unintended effect is positive for InovAgro MSD beneficiary households while the opposite (a negative effect) is the case for non-MSD beneficiary households.

Table 5.5 Unintended effects of InovAgro

		Change over time (2015 --> 2019) is statistically significant ⁺⁺	
	Proxy variables	InovAgro/MSD programs	Non-MSD programs
CROP DIVERSIFICATION	Total number of crops cultivated	(Negative)	(Negative)
	Head in non-agricultural	(Positive)	(Negative)
	Spouse in non-agricultural	(Positive)	(Negative)
INCOME DIVERSIFICATION	Female in non-agricultural	(Positive)	(Negative)
	Youth in non-agricultural	(Positive)	(Negative)
	A household member in non-agricultural	(Positive)	(Negative)
MIGRATION	A temporary migrant member	(Positive)	(Negative)
	A permanent migrant member	(Positive)	(negative)
INTRA-HOUSEHOLD BARGAINING	Head has credit access		
	Female has credit access	(Positive)	
	Youth has credit access		
	A family member has credit access	(Positive)	
LAND RIGHTS OF VULNERABLE GROUPS	Spouse has access to/control over land	(Positive)	(Positive)
	Female has access to/control over land	(Positive)	(Positive)
	Youth has access to/control over land	(Negative)	(Positive)

Source: Authors' computation using InovAgro baseline (2014/15) and midline (2016/17) and endline (2018/19) datasets

However, it is worth noting that such results are with caveats since they take no account of other factors that might have affected such outcomes. After controlling for potential selection bias (due to self-selection or program targeting) and other factors that might influence the outcome variables of interest, we use regression analysis to obtain econometric estimates in a further investigation on the direct benefits of the InovAgro program on beneficiary households and its potential unintended effects (positive or negative). These are discussed in the following section (section 5.2).

5.2 Micro (household) level effects

As discussed in section three, an attempt was made to differentiate whether the channel of intervention (i.e., exposure to a specific value chain intervention versus exposure to a complete package) plays any role in dictating the magnitude of program outcome. For this, we compare independent regression estimates by defining treatment based on exposure to each of three value chain interventions where spatial location data were available (an agro-dealer, a lead farmer or a demonstration plot) and compare if there exists a significant change in magnitude of impact where we only focus on those households that have benefited from exposure to the three value chain interventions simultaneously. Model T1 – T3 in Table 5.6 through Table 5.10 represent results when treatment is defined based on exposure to an agro-dealer, lead farmer and demonstration plot, respectively, while Model T4 represents results for the more complete package (i.e., where the treatment is defined as a household being exposed to all three value chain interventions simultaneously).

Furthermore, depending on the outcome variable under investigation, the econometric analysis also was conducted with the aim to differentiate potential differences on short-term versus long-term impacts. Such disaggregation informs the design and implementation of future impact evaluation programs of MSD programs and determination of the impact evaluation time period needed to capture respective outcome variables. As a result, differential analysis was conducted by interacting the treatment variable with the year the survey data was collected to define:

- o Short-term impact: using a two-year gap i.e., restricting the sample of analysis to comparison of effects between baseline (2014/15) with mid-line (2016/17), and
- o Long-term impact: using a 4-year gap i.e., restricting the sample of analysis to comparison of effects between baseline (2014/15) with the endline (2018/19).

5.2.1 Impact on adoption of modern farming practices:

The first set of micro-outcome indicators our study investigated was the impact of InovAgro on the household likelihood of adopting modern farming practices. Three proxy outcome variables were used to investigate the potential impact of InovAgro on household adoption of modern farm practices, namely: use of fertilizer, use of agro-chemicals (pesticide, herbicide, etc.) and use of modern (selected) seed varieties.

5.2.1.1 Adoption of Agro-chemicals

Econometric results presented under Table 5.6 shows that, regardless of the value chain intervention households are exposed to, InovAgro has a positive and significant impact on households' likelihood of adopting (using) agro-chemicals like pesticide, herbicide, etc. Such positive impact on adoption of agro-chemicals remains robust whether households are exposed to a single value chain intervention or the complete package. Such impact also appears to be consistent when comparison is made between short term versus long term, i.e., 2 and 4 years after the program was launched, respectively.

Table 5.6 Summary of results - impact on adoption of modern farming practice

	Agro dealer (T1)	Lead farmer (T2)	Demo plot (T3)	Complete package (T4)
Agro-chemicals				
Short term (2016/17)	(Positive)***	(Positive)***	(Positive)***	(Positive)****
Long term (2018/19)	(Positive)**	(Positive)**	(Positive)***	(Positive)**
Fertilizer use				
Short term (2016/17)	-	(Positive)**	-	(Positive)****
Long term (2018/19)	(Positive)****	(Positive)**	(Positive)***	(Positive)**
Modern seed variety				
Short term (2016/17)	(Positive)**	(Positive)***	(Positive)****	(Positive)**
Long term (2018/19)	-	-	-	-

Source: Authors' computation using InovAgro baseline (2014/15) and midline (2016/17) and endline (2018/19) datasets
Figure in parenthesis are signs (directions) of the effect; ****, ***, ** and * indicates significance at 0.1%; 1%; 5%; and 10%
Note: All regression estimations include household and parcel level characteristics. Regression results with detailed coefficients and signs of all variables included are presented in Appendix Table A1 and Table A2.

5.2.1.2 Adoption of fertilizer

In contrast with the findings of the InovAgro impact on adoption of agro-chemicals, empirical results show no evidence of short-term impact of the InovAgro program on households' likelihood of fertilizer adoption (use). However, the likelihood of fertilizer adoption within 2-years after program exposure seems to depend on program beneficiaries getting exposure to the complete package (exposure to all value chain interventions). Similar to the positive outcome on adoption of agro-chemicals, such dependence on intensity of treatment (whether or not households benefit from the complete package) seems to matter

little when it comes to the likelihood of fertilizer adoption in the long-term. This is shown by the positive and significant coefficient of the treatment variable 4 years after the program is launched (long-term benefit) for all the model specification reported in Table 5.6.

5.2.1.3 Adoption of modern seed variety

Results show that 2 years after program exposure, adoption of modern seed variety seems to be positive and significant for program beneficiary households as compared to non-beneficiary households. Again, consistent to the short-term benefits of the program on adoption of agro-chemicals, such short-term benefits of the program on use of modern seed variety seems to depend less on the type or intensity of treatment (exposure). However, interestingly, such positive effect of the program is wiped out in the long-term as the coefficient remains positive but not significant. Such result is indicative of the potential long-term spillover benefits of the program as non-beneficiary households may be catch-up on adoption of the modern seed varieties learning from program beneficiary households. Detail discussion on potential spillover benefits of the program is presented in section 5.1.3.

5.2.2 Impact on agricultural (input and output) market information

Program impact on productivity, income and overall welfare of smallholder farmers depend on the quality and timely information farmers get regarding agricultural input and output market information (such as where they can buy modern farm inputs, how to differentiate various qualities and prices, where they can sell their produce, etc.). As a result, we investigated household access to agricultural input and output market information as potential intermediary outcome of the program. Table 5.7 below presents econometric results for the two program outcomes with a similar disaggregated analysis (approach) to differential program outcomes by the type and intensity of exposure. Models T1-T3 presents results for exposure to agro-dealer, lead farmer and demo plot, respectively, and model T4 presents results for the complete package (exposure to the three value chain interventions simultaneously).

5.2.2.1 Access to input market information

Overall, as reported under Model T4, results show a positive and significant effect of InovAgro program on access to agricultural input and output market information for beneficiary households who are exposed to all three value chain interventions. However, signifying the importance of our methodological approach in differentiating the treatment by the type of exposure, results in Table 5.7 shows that program impact on access to agricultural input market information depends on the type of value chain intervention households are exposed to. This is mainly so since we found no evidence of program effects on access to

input market information for beneficiary households that are only exposed to a lead farmer or a demonstration plot but long-term positive effects for those who are exposed to an agro-dealer.

Table 5.7 Summary of results - impact on access to agricultural market information

	Agro dealer (T1)	Lead farmer (T2)	Demo plot (T3)	Complete package (T4)
Input - Agricultural market information				
Short term (2016/17)	-	-	-	(Positive)****
Long term (2018/19)	(Positive)****	-	-	(Positive)****
Output-Agricultural market information				
Short term (2016/17)	-	(Positive)****	(Positive)**	(Positive)****
Long term (2018/19)	(Positive)***	(Positive)***	(Positive)***	(Positive)****

Source: Authors' computation using InovAgro baseline (2014/15) and midline (2016/17) and endline (2018/19) datasets
Figure in parenthesis are signs (directions) of the effect; ****, ***, ** and * indicates significance at 0.1%; 1%; 5%; and 10%
Note: All regression estimations include household and parcel level characteristics. Regression results with detailed coefficients and signs of all variables included are presented in Appendix Table A3 and Table A4.

5.2.2.2 Access to output market information:

Unlike the program effect on access to input market information, results show a positive and significant impact of InovAgro on access to output market information by beneficiary households compared to non-beneficiary households. The positive impact remains robust whether households are exposed to a single value chain intervention or the complete package. Such impact also appears to be consistent when comparison is made between short term versus long term, i.e., 2 and 4 years after the program launch, respectively.

5.2.3 Impact on agricultural productivity and agricultural marketing

The fact that we missed production (input and output) data during the baseline survey limits the productivity analysis from investigating long-term benefits of the program on agricultural productivity. As a result, this section only focuses on program effects comparing production data from 2016/7 with 2018/19 (short-term only). With this caveat, results from Table 5.8 shows no evidence of InovAgro effect in enhancing agricultural productivity of program beneficiaries compared to non-beneficiary smallholders. This remains to be so regardless of the type and intensity of treatment (exposure). However, we also conducted similar analysis focusing on the most common crop produced by most of our study subjects (respondents) – i.e., Maize (also one of the three value chain crops included under the InovAgro program). In contrast, results show a positive and significant effect of InovAgro on not only in boosting agricultural productivity of beneficiary households but also their likelihood of agricultural output market participation

(likelihood of selling maize produce) as well as the ratio of marketable surplus. Such positive impact on productivity and agricultural market participation remains robust whether or not households are exposed to a single value chain intervention or the complete package.

Table 5.8 Summary of results - impact on agricultural productivity and market participation (maize)

	Agro dealer (T1)	Lead farmer (T2)	Demo plot (T3)	Complete package (T4)
Productivity (output per ha) ⁺				
Short term (2018/19)	(Positive)****	(Positive)****	(Positive)****	(Positive)****
Sell of agricultural output ⁺				
Short term (2018/19)	(Positive)****	(Positive)****	(Positive)****	(Positive)****
Ratio of marketable surplus ⁺				
Short term (2018/19)	(Positive)***	(Positive)****	(Positive)***	(Positive)**

Source: Authors' computation using InovAgro baseline (2014/15) and midline (2016/17) and endline (2018/19) datasets

Figure in parenthesis are signs (directions) of the effect; ****, ***, ** and * indicates significance at 0.1%; 1%; 5%; and 10%

Note: All regression estimations include household and parcel level characteristics. Regression results with detailed coefficients and signs of all variables included are presented in Appendix Table A5 and Table A6.

5.2.4 Impact on income diversification and overall household welfare

Following the program theory of change, the study also investigated potential effect of the program on household income diversification and overall household welfare. We used two indicators as a proxy to measure household income diversification, namely: (1) if a household has at least one member who is involved in the non-agricultural sector; and (2) if a household has at least one member who has been absent for at least one month (temporary migrant). Household overall welfare is proxied by index variable constructed using a principal component analysis (PCA) from assets a household is reported to have out of 17 list included in our survey.

5.2.4.1 Household welfare

Results from Table 5.9 shows no evidence of welfare impact of InovAgro when beneficiary households are only exposed to either of the three types of value chain interventions. Such no effect remains to be so both under the short-term as well as the long-term scenario. However, a positive and statistically significant effect of InovAgro on household welfare (wealth) is only shown when beneficiary household is exposed to the most intense (complete package) treatment (as shown by the results from Model T4 in Table 5.9). This result is indicative that the designing and implementation of future similar MSD programs like InovAgro needs an integrated approach in complementing (packaging) such interventions insuring the forward and backward linkages. This is mainly so since welfare outcome of these programs remains

shallow (non-existent) when households are not benefiting from such intense treatments (exposure to a more complete package).

Table 5.9 Summary of results - impact on household welfare and income diversification

	Agro dealer (T1)	Lead farmer (T2)	Demo plot (T3)	Complete package (T4)
Household wealth ⁺⁺				
Short term (2016/17)	-	-	-	(Positive)***
Long term (2018/19)	-	-	-	(Positive)**
Has a member involved in non-agriculture				
Short term (2016/17)	-	(Positive)****	-	-
Long term (2018/19)	(Positive)****	(Positive)****	(Positive)****	(Positive)****
Has a member who is a temporary migrant				
Short term (2016/17)	(Positive)****	(Positive)****	(Positive)****	(Positive)****
Long term (2018/19)	-	-	-	-

Source: Authors' computation using InovAgro baseline (2014/15) and midline (2016/17) and endline (2018/19) datasets
Figure in parenthesis are signs (directions) of the effect; ****, ***, ** and * indicates significance at 0.1%; 1%; 5%; and 10%
Note: All regression estimations include household and parcel level characteristics. Regression results with detailed coefficients and signs of all variables included are presented in Appendix Table A7 and Table A8.

5.2.4.2 Income diversification – migration and non-agricultural income

Results from Table 5.9 show a positive and significant effect of InovAgro program for beneficiary households having at least one member who has migrated temporarily (at least one month of the previous 12 months) in the short term (2 years after the program was launched) while no evidence of such effect in the long-term. Contrary to this, the reverse appears to be the case when it comes the likelihood of having at least one member of the household generating income from a non-agricultural source. Result show, unlike the short-term program effect on temporary migration, program effect impact on generating income from non-agricultural is only positive and significant in the long run (4 years after the program was launched). Such finding is consistent with the notion that entry to (employment in) the non-agricultural sector is costly (both financially and socially) and requires payment of up-front cash finance it (Carrington et al., 1996). This is in contrast with a temporary migration which involves less cost (both socially and financially), and, hence, with more instant (short-term) impact compared to non-agricultural income generation (employment).

5.2.5 Impact on empowerment of women and other vulnerable groups (youth)

In addition to the intended effects of the InovAgro program discussed under sections 5.2.1 – 5.2.4, an attempt has also been done to evaluate program effects on a host of selected unintended outcome

variables. This section discusses potential impact of the program (positive or negative) on land rights, non-agricultural income generating and temporary migration of vulnerable members of a household – more specifically, women and youth (age 25 – 34).

5.2.5.1 Land rights of women and youth

Results from Table 5.10 show the potential unintended negative effect of InovAgro program on access to and control over land by vulnerable groups such as women and youth in the short term (2 years since launch of the program) while such adverse effect of the program on women land rights is reversed (with a positive and significant effect) in the longer term.

Table 5.10 Summary of results – impact on empowerment of vulnerable groups – women and youth

	Agro dealer (T1)	Lead farmer (T2)	Demo plot (T3)	Complete package (T4)
Women land access				
Short term (2016/17)	(Negative)****	(Negative)****	(Negative)****	(Negative)****
Long term (2018/19)	(Positive)***	(Positive)****	(Positive)****	(Positive)****
youth land access				
Short term (2016/17)	(Negative)****	(Negative)****	(Negative)****	(Negative)****
Long term (2018/19)	-	-	-	-
Female in non-agriculture				
Short term (2016/17)	(Negative)****	(Positive)****	(Negative)****	(Negative)****
Long term (2018/19)	-	(Positive)****		-
youth in non-agriculture				
Short term (2016/17)	(Negative)****	(Positive)****	(Negative)****	(Negative)****
Long term (2018/19)	-	(Positive)**	-	-
Female is a temporary migrant				
Short term (2016/17)	(Positive)****	(Positive)****	(Positive)****	(Positive)****
Long term (2018/19)	-	-		-
youth is a temporary migrant				
Short term (2016/17)	(Positive)****	(Positive)****	-	(Positive)****
Long term (2018/19)	-	-	-	-

Source: Authors' computation using InovAgro baseline (2014/15) and midline (2016/17) and endline (2018/19) datasets
Figure in parenthesis are signs (directions) of the effect; ****, ***, ** and * indicates significance at 0.1%; 1%; 5%; and 10%
Note: All regression estimations include household and parcel level characteristics. Regression results with detailed coefficients and signs of all variables included are presented in Appendix Table A9 and Table A10 for women and Table A11 and Table A12 for youth.

Such short-term adverse effect of the program on land rights of women and youth could be associated with fact that a more commercialized/modernized agricultural practice may not always guarantee a desirable/favorable outcome for land tenure security of vulnerable groups such as women and youth since more profitability in agriculture could mean more competition for land and exclusive control such

resources by the head of the household (usually male) (Ghebru 2019; Ghebru and Girmachew 2020). Hence, unless deliberate measures are taken to mainstream gender and youth issues into the designing and implementation of similar programs like InovAgro, such negative effects of the program on land rights of these groups may undermine the full potential of MSD programs in generating desirable outcomes for all.

5.2.5.2 Migration and non-agricultural employment of women and youth

Unlike the overall positive long-term benefits of the program exposure on household non-agricultural income generating activities, no evidence of such impact on women and youth as long-term coefficients remains statistically insignificant. The potential negative differential effect of the program on non-agricultural employment generating activity is more pronounced by the negative and statistically significant impact on program beneficiary households compared to non-beneficiary households. Such findings remain robust regardless of the type and intensity of treatment (exposure) except exposure to a lead farmer. Results on potential unintended effect on temporary migration by women and/or youth shows no evidence of differential effect as the results remain consistent with the overall short-term positive effect reported under section 5.2.4.

6 SUMMARY AND CONCLUSION

This paper presents results from an impact evaluation of the Innovation for Agribusiness (InovAgro) project in northern Mozambique. The InovAgro project is funded by the Swiss Agency for Development and Cooperation (SDC) and implemented by Development Alternatives Inc. (DAI) in partnership with COWI. Data from three rounds of panel surveys—collected by the International Food Policy Research Institute (IFPRI)—were employed in the impact evaluation: the baseline survey undertaken in 2015 covering the 2014/2015 agricultural season, the midline survey undertaken in 2017 covering the 2016/2017 agricultural season and an endline survey in 2019, covering the 2018/2019 agricultural season. Although InovAgro projects operate in 11 districts—namely Mocuba, Ile, Namarroi, Molumbo, Gurúe and Alto Molócue in Zambézia province; Malema, Ribáuè and Erati in Nampula province; and Namuno and Chiúre in Cabo Delgado province—this impact evaluation focuses on two districts in Zambézia province (Alto Molócue and Molumbo). The evaluation also focuses on three high-potential value chain crops (namely, soybean, pigeon pea and maize), even though the overall InovAgro project interventions also sesame and groundnut.

The impact evaluation study faced numerous empirical challenges in its evaluation, such as ensuring ethical issues as well as challenges associated with the implementation of the program and assessing its scope of impact were adequately mitigated and addressed. Ultimately, both difference-in-difference (DID) and propensity score matching (PSM) approaches were used as innovative, mitigative measures.

The study area is comprised of four treatment communities and four control communities in each of the two sampled districts, totaling eight treatment and eight control communities. Treatment communities include Benesse, Macolocotxo, Mugoliua, and Nandie in Molumbo, and Mohiua, Namilepe, Carmano and Caperula in Alto Molócue, while the control communities are Bediua, Corromana-Sede, Impidula-Sede and Mucoco in Molumbo, and Murico, Napalaca, Lugela and Inrule in Alto Molócue. A total of 1,733 households were interviewed in all three rounds of the surveys. Moreover, to shed some light on four potential channels through which the InovAgro project could have impacted markets (macro level effects); namely systemic (long-term) effects, sustainability effects, large-scale (spillover or multiplier) effects and unintended (positive or negative) effects, the study also employed a supplemental geo-spatial data collecting census data of all value chain interventions (185 value chain interventions) operational in all the 16 communities from the two districts included in our study.

Macro (market level) effects: To investigate the potential market level effects of the InovAgro program, the analyses focus on the following three result pathway parameters: systemic effects; sustainability effects and large-scale (spillover) effects.

Systemic effects: We find evidence in support of the project's having a systemic market effect. In both study districts, this was shown by the significant percentage increase in the number of non-InovAgro facilitated or sponsored value chain interventions after the launch of the InovAgro program in 2015 than before the project launch. On average, non-InovAgro facilitated or sponsored MSD value chain interventions have been active for a significantly shorter time than a significantly shorter time lapsed since the program launch compared to InovAgro sponsored or facilitated value chain interventions.

Sustainability effects: We also find evidence in support of the project's producing more sustainable long-term adoption of good agricultural practices than non-MSD programs: 21 of 30 hypotheses tested show that the proportion of households that continue to adopt modern farm practices was significantly larger for households treated or exposed to the InovAgro MSD program compared to those treated or exposed to non-MSD programs (eg. direct service delivery or subsidy programs), regardless of the type of value chain intervention. We found this result even more robust when it came to the proportion of smallholder farmers continuing to use modern seed varieties of soya and pigeon pea, the two selected InovAgro value chain crops included in the study.

Large-scale (spillover) effects: With regards to the project's larger-scale spillover or multiplier effects, our results also show support that the InovAgro project is benefitting large numbers of smallholder farmers beyond the program's direct sphere of influence and targeted beneficiaries: 23 of 30 hypotheses tested show that the proportion of households who were new adopters of modern farm practices (those who did not adopt during the midline survey in 2016/17 but adopted in 2018/19) was significantly larger for non-beneficiary households who resided in close proximity to households treated or exposed to the InovAgro MSD program compared to those who resided further away (more pure controls).

Unintended effects: In addition to these tests, we comment on the negative unintended effects of both MSD and non-MSD programs on households' crop diversification, a result which is expected given these programs encourage smallholder farmers to specialize rather than diversify. As mentioned above, one could argue that this is in fact a positive. We also find unintended negative effects of MSD programs on youth access to or control over land, while we find the opposite effect for non-MSD programs.

Micro (household level) effects: The study also examines program impacts on beneficiary households with respect to: (1) decisions to adopt modern farming practices, (2) access to input and output market information, (3) agricultural productivity and marketing, (4) income diversification and overall household welfare and (5) women and youth empowerment effects.

Adoption: We find that regardless of which value chain interventions the households are exposed to, the InovAgro interventions have a positive and significant impact on households' likelihood of using agro-chemicals like pesticide and herbicide, and this result is robust regardless of whether the households are exposed to a single value chain intervention (an agro-dealer, lead farmer or a demonstration plot) or all three together, and to whether the comparison is made between a two year term effect after the program launch in 2015, or a four year term.

Access to market information: Consistent with the above finding, there are also positive and significant effects of the InovAgro interventions on access to agricultural input and output markets for beneficiary households exposed to all three value chain interventions. Specifically, there were long-term positive effects on access to input markets among those who engaged with an agro-dealer, and both short- and long-term positive effects on access to output markets among those who engaged with any value chain intervention.

Agricultural productivity: Our analysis shows that the InovAgro program boosted the agricultural productivity of maize among beneficiary households, increased their likelihood to sell maize produce in an agricultural output market, and led to an increased ratio of marketable surplus, all with significant effects, however there were no short term positive or negative effects on overall agricultural productivity among beneficiary households beyond this singular look at the effects on maize.

Welfare: With regards to the overall household welfare only in the case of households who engaged with a complete package of value chain interventions: a lead farmer, an agro-dealer and visiting a demonstration plot, did the interventions show positive effects on overall welfare for these households, with welfare proxied by using a principal component analysis (PCA) of the assets the household reported owning out of a list of 17 included in our survey.

Household income diversification: Household income diversification was by using two indicators: (1) if a household has at least one member who is involved in the non-agricultural sector; and (2) if a household has at least one member who has been absent for at least one month (is a temporary migrant).

- We find a positive and significant effect of the InovAgro program on beneficiary households having at least one member who migrated temporarily (for at least one month of the previous 12 months) and only in the 2-year span following the launch of the program after the 2015 baseline, while no evidence of such effects in the long-term (by the 2019 endline survey round).
- When it comes to the effects of the program on household's likelihood of having at least one member that generates income from a non-agricultural source, however, a significant positive effect only becomes evident in the long run (4 years after the launch of the project) and not in the short run. This evidences the greater challenges involved in achieving what are also longer-lasting impacts of a transition by rural household members from farm to non-farm employment.

Land access: Finally, we find that the InovAgro interventions also have unintended negative effects on access to and control over land by women and youth in the short term, however these adverse effects are reversed with a positive and significant effect in the longer term. The short-term adverse effects of the program on land rights of women and youth could be associated with fact that more commercialized agricultural practices may not always guarantee a desirable outcome for vulnerable groups such as women and youth, since more profitability in agriculture could mean exclusive control of resources, such as land, by the head of the household, who is usually a male above the age of 35.

Overall, the study provides evidence in support of the project's having a systemic market-level effect, benefitting large numbers of smallholder farmers beyond the program's direct sphere of influence, as well as sustainable long-term effects on household's adoption of good agricultural practices and access to input and output market information, as compared to non-MSD programs. Further, one key takeaway from our findings is that a more intense, combination approach of using agro-dealers, lead farmers and demonstration plots appears to be necessary to achieve long-term positive effects on the overall welfare of households.

Moreover, the negative short-term effect of InovAgro program on access to and control over land by women and youth also indicates that a more commercialized agricultural practice (due to intensive MSD interventions) may not always guarantee a favorable outcome for such vulnerable groups since more profitability in agriculture could mean exclusive control of resources (such as land) by the head of the household (usually male above the age of 35). Hence, we recommend that future MSD programs like InovAgro mitigate the negative effects on land rights of vulnerable groups such as women and youth, by taking deliberate measures to mainstream gender and youth issues into their design and implementation. Unless these deliberate measures are taken to mainstream gender and youth issues into the designing

and implementation of similar programs like InovAgro, such negative effects of the program on land rights of these groups may undermine the full potential of MSD programs in generating desirable outcomes for all.

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ANNEX

Table A 1: Fixed effects estimates of impacts of InovAgro on adoption of modern farming practices – agro-dealer and demo plot

Variables	Treatment = Agro dealer			Treatment = Demo plot		
	Adopt fertilizer	Adopt agro-chemicals	Adopt improved seed variety	Adopt fertilizer	Adopt agro-chemicals	Adopt improved seed variety
	b/ (se)	b/ (se)	b/ (se)	b/ (se)	b/ (se)	b/ (se)
Treatment_2017	0.042*** (0.012)	0.058*** (0.011)	0.107*** (0.015)	0.049*** (0.012)	0.063*** (0.011)	0.107*** (0.016)
Treatment_2019	0.153*** (0.016)	0.149*** (0.015)	0.014 (0.014)	0.144*** (0.016)	0.143*** (0.015)	0.009 (0.014)
Treatment_non_msd_2017	0.008 (0.023)	0.047* (0.025)	0.127*** (0.037)	-0.031** (0.014)	-0.023* (0.012)	0.012 (0.020)
Treatment_non_msd_2017	-0.022 (0.023)	-0.022 (0.018)	-0.015 (0.027)	0.100*** (0.026)	0.061*** (0.023)	0.045** (0.021)
lhhsz	0.074*** (0.015)	0.055*** (0.014)	0.034* (0.019)	0.071*** (0.015)	0.055*** (0.014)	0.035* (0.019)
lheadage	0.099** (0.039)	0.062 (0.050)	0.058 (0.043)	0.076** (0.038)	0.045 (0.049)	0.043 (0.042)
headfemale	0.017 (0.031)	-0.012 (0.031)	-0.085** (0.034)	0.013 (0.030)	-0.014 (0.030)	-0.088*** (0.033)
lheadscool	0.030*** (0.007)	0.031*** (0.006)	0.020*** (0.007)	0.032*** (0.007)	0.032*** (0.006)	0.020*** (0.007)
lareatot	0.110*** (0.018)	0.135*** (0.017)	0.140*** (0.018)	0.104*** (0.018)	0.131*** (0.017)	0.137*** (0.018)
_cons	-0.706*** (0.142)	-0.531*** (0.177)	-0.416*** (0.146)	-0.460*** (0.137)	-0.363** (0.175)	-0.276* (0.145)
N	4945	4945	4945	4945	4945	4945

Source: Authors' computation using InovAgro baseline (2014/15) and midline (2016/17) and endline (2018/19) datasets

Figure in parenthesis are robust standard errors; **** significant at 0.1%; *** significant at 1%; ** significant at 5%; * significant at 10%

Table A2: The impacts of InovAgro on adoption of modern farming practices: lead farmer and complete package

	Treatment = Lead farmer			Treatment = All value chain interventions		
	Adopt fertilizer	Adopt agro-chemicals	Adopt modern seed variety	Adopt fertilizer	Adopt agro-chemicals	Adopt modern seed variety
	b/ (se)	b/ (se)	b/ (se)	b/ (se)	b/ (se)	b/ (se)
Treatment_2017	0.060*** (0.015)	0.080*** (0.013)	0.153*** (0.019)	0.045*** (0.013)	0.062*** (0.012)	0.116*** (0.017)
Treatment_2019	0.130*** (0.018)	0.174*** (0.018)	0.011 (0.016)	0.144*** (0.017)	0.144*** (0.016)	0.009 (0.015)
Treatment_non_msd_2017	0.009 (0.014)	0.036*** (0.014)	0.090*** (0.018)			
Treatment_non_msd_2017	0.067*** (0.019)	0.056*** (0.017)	0.012 (0.016)			
lhhsz	0.070*** (0.016)	0.041*** (0.015)	0.018 (0.019)	0.078*** (0.015)	0.059*** (0.014)	0.038** (0.018)
lheadage	0.142*** (0.040)	0.093* (0.050)	0.086** (0.042)	0.134*** (0.040)	0.085* (0.049)	0.062 (0.042)
headfemale	0.042 (0.031)	0.020 (0.030)	-0.071** (0.034)	0.032 (0.031)	-0.005 (0.031)	-0.090*** (0.032)
lheadschoo	0.034*** (0.007)	0.035*** (0.006)	0.021*** (0.007)	0.029*** (0.006)	0.028*** (0.006)	0.018*** (0.007)
lareatot	0.110*** (0.018)	0.131*** (0.018)	0.132*** (0.018)	0.109*** (0.017)	0.133*** (0.017)	0.140*** (0.018)
Cons	-0.706*** (0.142)	-0.531*** (0.177)	-0.416*** (0.146)	-0.673*** (0.143)	-0.502*** (0.174)	-0.342** (0.145)
N	4945	4945	4945	5047	5047	5047

Source: Fixed effects estimates Authors' computation using InovAgro baseline (2014/15) and midline (2016/17) and endline (2018/19) datasets. Figure in parenthesis are robust standard errors; **** significant at 0.1%; *** significant at 1%; ** significant at 5%; * significant at 10%

Table A 3: Fixed effects estimates of impacts of InovAgro on access to agricultural market information – agro-dealer and demo plot

Variables	Treatment = Agro-dealer		Treatment = Demo plot	
	Output-Agricultural market information	Input- market information	Output-Agricultural market information	Input- market information
	b/ (se)	b/ (se)	b/ (se)	b/ (se)
Treatment_2017	0.215*** (0.026)	0.179*** (0.026)	0.209*** (0.027)	0.178*** (0.027)
Treatment_2019	0.310*** (0.026)	0.288*** (0.027)	0.302*** (0.026)	0.281*** (0.027)
Treatment_non_msd_2017	0.172*** (0.062)	-0.068 (0.061)	0.032 (0.044)	0.058 (0.044)
Treatment_non_msd_2017	0.099 (0.065)	-0.116* (0.066)	0.049 (0.044)	0.120*** (0.043)
lhhsz	0.259*** (0.031)	0.210*** (0.032)	-0.084* (0.051)	0.060 (0.053)
lheadage	-0.093 (0.097)	-0.178* (0.095)	0.025** (0.010)	0.030*** (0.011)
headfemale	-0.077 (0.051)	0.060 (0.054)	0.235*** (0.026)	0.155*** (0.026)
lheadschoo	0.026** (0.010)	0.027** (0.011)	0.261*** (0.031)	0.199*** (0.032)
larcatot	0.233*** (0.026)	0.164*** (0.026)	-0.093 (0.096)	-0.214** (0.093)
Cons	0.174 (0.343)	0.628* (0.335)	0.177 (0.340)	0.762** (0.329)
N	4945	4945	4945	4945

Source: Authors' computation using InovAgro baseline (2014/15) and midline (2016/17) and endline (2018/19) datasets

Figure in parenthesis are robust standard errors; **** significant at 0.1%; *** significant at 1%; ** significant at 5%; * significant at 10%

Table A 4: Fixed effects estimates of impacts of InovAgro on access to agricultural market information – Lead farmer and all value chain interventions (complete package)

Variables	Treatment = Lead farmer		Treatment = All value chain interventions	
	Output-Agricultural market information	Input- Agricultural market information	Output-Agricultural market information	Input- Agricultural market information
	b/ (se)	b/ (se)	b/ (se)	b/ (se)
Treatment_2017	0.404*** (0.027)	0.198*** (0.030)	0.234*** (0.028)	0.196*** (0.028)
Treatment_2019	0.440*** (0.029)	0.222*** (0.032)	0.340*** (0.027)	0.298*** (0.028)
Treatment_non_msd_2017	0.404*** (0.027)	0.198*** (0.030)	0.090*** (0.018)	
Treatment_non_msd_2017	0.440*** (0.029)	0.222*** (0.032)	0.012 (0.016)	
lhhsiz	0.171*** (0.032)	0.202*** (0.034)	0.265*** (0.030)	0.212*** (0.031)
lheadage	-0.035 (0.094)	-0.061 (0.092)	-0.044 (0.096)	-0.130 (0.094)
headfemale	0.007 (0.052)	0.120** (0.054)	-0.084* (0.050)	0.063 (0.052)
lheadschoo	0.041*** (0.010)	0.032*** (0.011)	0.021** (0.010)	0.027*** (0.011)
lareatot	0.210*** (0.026)	0.162*** (0.026)	0.230*** (0.025)	0.153*** (0.026)
_cons	-0.706*** (0.142)	-0.531*** (0.177)	0.014 (0.342)	0.468 (0.330)
N	4945	4945	5047	5047

Source: Authors' computation using InovAgro baseline (2014/15) and midline (2016/17) and endline (2018/19) datasets

Figure in parenthesis are robust standard errors; **** significant at 0.1%; *** significant at 1%; ** significant at 5%; * significant at 10%

Table A 5: Fixed effects estimates of impacts of InovAgro on maize productivity and marketing – agro-dealer and demo plot

Variables	Treatment=Agro dealer			Treatment=Demo plot		
	Maize value per hectare	Has sold maize product	proportion of marketed surplus - maize	Maize value per hectare	Has sold maize product	proportion of marketed surplus - maize
	b/ (se)	b/ (se)	b/ (se)	b/ (se)	b/ (se)	b/ (se)
Treatment_2017	-0.522*** (0.067)	0.627*** (0.156)	0.065*** (0.017)	-0.484*** (0.069)	0.584*** (0.159)	0.062*** (0.017)
Treatment_2019	-0.038 (0.085)	1.502*** (0.180)	0.134*** (0.018)	-0.066 (0.088)	1.444*** (0.183)	0.132*** (0.018)
Treatment_non_msd_2017	-0.086 (0.088)	-0.088 (0.389)	-0.019 (0.040)	-0.236** (0.106)	0.480** (0.239)	0.034 (0.022)
Treatment_non_msd_2017	0.050 (0.155)	0.684* (0.408)	0.018 (0.042)	0.222* (0.129)	0.578** (0.280)	0.027 (0.026)
lhhsiz	0.005 (0.070)	1.348*** (0.182)	0.100*** (0.019)	0.009 (0.070)	1.297*** (0.183)	0.096*** (0.019)
lheadage	0.081 (0.170)	2.271*** (0.650)	0.173** (0.072)	0.056 (0.170)	2.298*** (0.644)	0.173** (0.071)
headfemale	0.402** (0.197)	0.465 (0.408)	0.016 (0.038)	0.389** (0.195)	0.420 (0.403)	0.014 (0.037)
lheadschoo	-0.036 (0.041)	-0.119 (0.072)	-0.014* (0.007)	-0.034 (0.040)	-0.105 (0.072)	-0.013* (0.007)
lareatot	-0.175*** (0.063)	0.799*** (0.191)	0.063*** (0.021)	-0.187*** (0.062)	0.794*** (0.191)	0.062*** (0.021)
_cons	7.767*** (0.615)	-8.970*** (2.302)	-0.668*** (0.253)	7.865*** (0.614)	-9.035*** (2.283)	-0.666*** (0.252)
N	3979	4158	4002	3979	4158	4002

Source: Authors' computation using InovAgro baseline (2014/15) and midline (2016/17) and endline (2018/19) datasets

Figure in parenthesis are robust standard errors; **** significant at 0.1%; *** significant at 1%; ** significant at 5%; * significant at 10%

Table A 6: Fixed effects estimates of impacts of InovAgro on maize productivity and marketing – Lead farmer and All value chain interventions (complete package)

Variables	Treatment=Lead farmer			Treatment = All value chain interventions		
	Maize value per hectare	Has sold maize product	proportion of marketed surplus - maize	Maize value per hectare	Has sold maize product	proportion of marketed surplus - maize
	b/ (se)	b/ (se)	b/ (se)	b/ (se)	b/ (se)	b/ (se)
Treatment_2017	-0.532*** (0.057)	0.212 (0.172)	0.015 (0.018)	-0.606*** (0.074)	0.570*** (0.169)	0.065*** (0.018)
Treatment_2019	0.241*** (0.091)	1.605*** (0.214)	0.115*** (0.021)	0.070 (0.094)	1.446*** (0.195)	0.134*** (0.019)
Treatment_non_msd_2017	-0.382*** (0.064)	0.563*** (0.205)	0.042** (0.021)			
Treatment_non_msd_2019	0.017 (0.083)	1.114*** (0.236)	0.068*** (0.023)			
lhhsiz	0.101 (0.076)	1.289*** (0.192)	0.104*** (0.020)	0.006 (0.068)	1.407*** (0.177)	0.103*** (0.019)
lheadage	0.116 (0.166)	2.158*** (0.637)	0.187** (0.073)	0.180 (0.200)	2.606*** (0.660)	0.194*** (0.071)
headfemale	0.318 (0.197)	0.645 (0.398)	0.034 (0.038)	0.328* (0.191)	0.593 (0.404)	0.029 (0.037)
lheadschoo	-0.042 (0.042)	-0.088 (0.072)	-0.012* (0.007)	-0.039 (0.040)	-0.114 (0.072)	-0.013* (0.007)
lareatot	-0.144** (0.065)	0.780*** (0.193)	0.063*** (0.021)	-0.167*** (0.062)	0.859*** (0.188)	0.066*** (0.021)
_cons	7.543*** (0.603)	-8.545*** (2.257)	-0.722*** (0.260)	7.415*** (0.702)	-10.257*** (2.339)	-0.750*** (0.251)
N	3979	4158	4002	4059	4241	4084

Source: Authors' computation using InovAgro baseline (2014/15) and midline (2016/17) and endline (2018/19) datasets

Figure in parenthesis are robust standard errors; **** significant at 0.1%; *** significant at 1%; ** significant at 5%; * significant at 10%

Table A 7: Fixed effects estimates of impacts of InovAgro on household welfare and income diversification – results from agro-dealer and demo plot models

	Treatment = Agro-dealer			Treatment = Demo plot		
	Household wealth	Migration	Non-agricultural employment	Household wealth	Migration	Non-agricultural employment
	b/ (se)	b/ (se)	b/ (se)	b/ (se)	b/ (se)	b/ (se)
Treatment_2017	-0.129 (0.082)	0.134*** (0.026)	-0.011 (0.031)	0.132 (0.083)	0.107*** (0.027)	0.003 (0.032)
Treatment_2019	0.082 (0.085)	0.023 (0.026)	0.181*** (0.031)	0.011 (0.084)	-0.013 (0.026)	0.177*** (0.031)
Treatment_non_msd_2017	-1.082*** (0.163)	0.306*** (0.067)	-0.393*** (0.068)	-0.484*** (0.128)	0.224*** (0.047)	-0.056 (0.052)
Treatment_non_msd_2017	-0.998*** (0.152)	-0.236*** (0.052)	-0.063 (0.060)	-0.548*** (0.133)	-0.018 (0.042)	0.077 (0.051)
lhhsiz	0.897*** (0.089)	0.216*** (0.029)	0.226*** (0.032)	0.904*** (0.088)	0.214*** (0.029)	0.212*** (0.032)
lheadage	-1.233*** (0.284)	0.057 (0.085)	-0.188* (0.113)	-1.240*** (0.275)	0.006 (0.084)	-0.186 (0.113)
headfemale	-0.164 (0.175)	-0.149** (0.067)	-0.010 (0.065)	-0.102 (0.177)	-0.136** (0.067)	-0.012 (0.065)
lheadschoo	0.118*** (0.032)	0.029*** (0.011)	0.054*** (0.013)	0.119*** (0.032)	0.027*** (0.010)	0.060*** (0.013)
lareatot	0.602*** (0.084)	0.118*** (0.028)	0.123*** (0.031)	0.603*** (0.085)	0.113*** (0.028)	0.119*** (0.031)
_cons	2.617** (1.018)	-0.379 (0.305)	0.707* (0.402)	2.604*** (0.985)	-0.198 (0.301)	0.704* (0.405)
N	4158	4158	4158	4158	4158	4158

Source: Authors' computation using InovAgro baseline (2014/15) and midline (2016/17) and endline (2018/19) datasets

Figure in parenthesis are robust standard errors; **** significant at 0.1%; *** significant at 1%; ** significant at 5%; * significant at 10%

Table A 8: Fixed effects estimates of impacts of InovAgro on household welfare and income diversification – Lead farmer and All value chain interventions (complete package)

	Treatment = Lead farmer			Treatment = All value chain interventions		
	Household wealth	Migration	Non-agricultural employment	Household wealth	Migration	Non-agricultural employment
	b/ (se)	b/ (se)	b/ (se)	b/ (se)	b/ (se)	b/ (se)
Treatment_2017	0.101 (0.084)	0.265*** (0.028)	0.015 (0.018)	0.192** (0.088)	0.135*** (0.028)	0.007 (0.033)
Treatment_2019	0.005 (0.096)	0.051* (0.028)	0.115*** (0.021)	0.183** (0.089)	-0.004 (0.027)	0.208*** (0.033)
Treatment_non_msd_2017	-0.462*** (0.103)	0.234*** (0.035)	0.042** (0.021)			
Treatment_non_msd_2017	-0.483*** (0.098)	-0.093*** (0.032)	0.068*** (0.023)			
lhhsiz	0.860*** (0.095)	0.157*** (0.030)	0.104*** (0.020)	0.806*** (0.087)	0.223*** (0.028)	0.214*** (0.032)
lheadage	-1.001*** (0.279)	0.135 (0.084)	0.187** (0.073)	-1.358*** (0.279)	-0.010 (0.085)	-0.158 (0.112)
headfemale	-0.105 (0.177)	-0.110 (0.068)	0.034 (0.038)	-0.124 (0.170)	-0.142** (0.066)	-0.005 (0.064)
lheadschoo	0.123*** (0.032)	0.034*** (0.010)	-0.012* (0.007)	0.131*** (0.032)	0.023** (0.011)	0.059*** (0.013)
lareatot	0.614*** (0.085)	0.088*** (0.028)	0.063*** (0.021)	0.599*** (0.083)	0.108*** (0.027)	0.125*** (0.031)
_cons	1.777* (1.000)	-0.598** (0.300)	-0.722*** (0.260)	3.054*** (1.001)	-0.127 (0.306)	0.593 (0.401)
N	4158	4158	4002	4241	4241	4241

Source: Authors' computation using InovAgro baseline (2014/15) and midline (2016/17) and endline (2018/19) datasets

Figure in parenthesis are robust standard errors; **** significant at 0.1%; *** significant at 1%; ** significant at 5%; * significant at 10%

Table A 9: Fixed effects estimates of impacts of InovAgro on women land rights and empowerment – results from agro-dealer and demo plot models

	Treatment = Agro-dealer			Treatment = Demo plot		
	Women land right b/ (se)	Women Migration b/ (se)	Women Non- agricultural employment b/ (se)	Women land right b/ (se)	Women Migration b/ (se)	Women Non- agricultural employment b/ (se)
Treatment_2017	-1.006*** (0.026)	-0.094*** (0.023)	0.087*** (0.017)	-0.898*** (0.028)	-0.081*** (0.023)	0.070*** (0.017)
Treatment_2019	0.119*** (0.028)	-0.028 (0.024)	-0.012 (0.015)	0.101*** (0.027)	-0.021 (0.023)	-0.009 (0.016)
Treatment_non_msd_2017	-1.127*** (0.058)	-0.358*** (0.052)	0.255*** (0.044)	-0.797*** (0.048)	-0.059 (0.039)	0.128*** (0.029)
Treatment_non_msd_2017	0.211*** (0.053)	-0.151*** (0.057)	-0.105*** (0.027)	0.030 (0.038)	-0.012 (0.041)	-0.006 (0.024)
lhhsiz	-0.002 (0.034)	0.167*** (0.023)	0.106*** (0.016)	0.018 (0.033)	0.159*** (0.024)	0.106*** (0.016)
lheadage	0.341*** (0.112)	-0.043 (0.074)	0.034 (0.046)	0.407*** (0.107)	-0.051 (0.075)	0.013 (0.047)
headfemale	0.347*** (0.068)	0.104* (0.055)	-0.083** (0.039)	0.366*** (0.065)	0.114** (0.056)	-0.083** (0.040)
lheadschoo	0.007 (0.014)	0.013 (0.009)	0.028*** (0.007)	0.007 (0.014)	0.016* (0.009)	0.028*** (0.007)
lareatot	-0.149*** (0.035)	0.028 (0.022)	0.071*** (0.018)	-0.156*** (0.033)	0.022 (0.023)	0.069*** (0.018)
_cons	-0.685* (0.393)	0.140 (0.264)	-0.252 (0.162)	-0.936** (0.376)	0.168 (0.266)	-0.176 (0.164)
N	4733	4945	4945	4733	4945	4945

Source: Authors' computation using InovAgro baseline (2014/15) and midline (2016/17) and endline (2018/19) datasets

Figure in parenthesis are robust standard errors; **** significant at 0.1%; *** significant at 1%; ** significant at 5%; * significant at 10%

Table A 10: Fixed effects estimates of impacts of InovAgro on women land rights and empowerment – Lead farmer and All value chain interventions (complete package)

	Treatment = Lead farmer			Treatment = All value chain interventions		
	Women land right b/ (se)	Women Migration b/ (se)	Women Non- agricultural employment b/ (se)	Women land right b/ (se)	Women Migration b/ (se)	Women Non- agricultural employment b/ (se)
Treatment_2017	-1.053*** (0.030)	0.078*** (0.022)	0.164*** (0.020)	-0.975*** (0.029)	-0.079*** (0.023)	0.087*** (0.018)
Treatment_2019	0.119*** (0.030)	0.086*** (0.023)	0.014 (0.017)	0.146*** (0.030)	-0.012 (0.024)	-0.003 (0.017)
Treatment_non_msd_2017	-1.116*** (0.032)	-0.225*** (0.029)	0.135*** (0.022)			
Treatment_non_msd_2017	0.115*** (0.032)	-0.055* (0.032)	-0.047*** (0.016)			
lhhsz	0.104*** (0.033)	0.129*** (0.024)	0.081*** (0.017)	-0.067* (0.034)	0.153*** (0.023)	0.113*** (0.016)
lheadage	0.181* (0.106)	-0.046 (0.073)	0.079* (0.047)	0.462*** (0.122)	-0.070 (0.074)	-0.013 (0.049)
headfemale	0.285*** (0.064)	0.130** (0.055)	-0.069* (0.039)	0.363*** (0.070)	0.112** (0.053)	-0.092** (0.038)
lheadschoo	0.008 (0.013)	0.018** (0.009)	0.030*** (0.007)	0.018 (0.015)	0.017* (0.009)	0.027*** (0.007)
lareatot	-0.072** (0.034)	0.031 (0.022)	0.055*** (0.019)	-0.135*** (0.036)	0.027 (0.022)	0.063*** (0.018)
_cons	-0.274 (0.375)	0.159 (0.259)	-0.386** (0.167)	-1.116*** (0.428)	0.229 (0.262)	-0.079 (0.173)
N	4733	4945	4945	4820	5047	5047

Source: Authors' computation using InovAgro baseline (2014/15) and midline (2016/17) and endline (2018/19) datasets

Figure in parenthesis are robust standard errors; **** significant at 0.1%; *** significant at 1%; ** significant at 5%; * significant at 10%

Table A 11: Fixed effects estimates of impacts of InovAgro on youth land rights and empowerment – results from agro-dealer and demo plot models

	Treatment = Agro-dealer			Treatment = Demo plot		
	Youth land right	Youth Migration	Youth Non-agricultural employment	Youth land right	Youth Migration	Youth Non-agricultural employment
	b/ (se)	b/ (se)	b/ (se)	b/ (se)	b/ (se)	b/ (se)
Treatment_2017	-0.099*** (0.015)	-0.105*** (0.024)	0.084*** (0.019)	-0.082*** (0.015)	-0.093*** (0.024)	0.070*** (0.020)
Treatment_2019	-0.011 (0.019)	0.008 (0.025)	-0.059*** (0.017)	-0.015 (0.019)	0.015 (0.025)	-0.052*** (0.017)
Treatment_non_msd_2017	-0.137*** (0.034)	-0.376*** (0.052)	0.164*** (0.047)	-0.153*** (0.023)	-0.053 (0.041)	0.122*** (0.033)
Treatment_non_msd_2017	0.144*** (0.042)	-0.150*** (0.053)	-0.182*** (0.038)	-0.030 (0.030)	-0.016 (0.039)	-0.016 (0.028)
lhhsiz	0.109*** (0.019)	0.163*** (0.028)	0.115*** (0.019)	0.118*** (0.019)	0.155*** (0.029)	0.112*** (0.020)
lheadage	-0.751*** (0.072)	-0.407*** (0.089)	-0.047 (0.060)	-0.716*** (0.073)	-0.413*** (0.089)	-0.073 (0.059)
headfemale	0.012 (0.040)	0.021 (0.051)	-0.075* (0.040)	0.012 (0.040)	0.031 (0.053)	-0.072* (0.041)
lheadschoo	0.010 (0.007)	0.036*** (0.010)	0.031*** (0.007)	0.008 (0.007)	0.039*** (0.010)	0.032*** (0.007)
lareatot	-0.019 (0.021)	0.079*** (0.025)	0.050*** (0.017)	-0.015 (0.021)	0.074*** (0.025)	0.046*** (0.017)
_cons	3.109*** (0.254)	1.487*** (0.316)	0.083 (0.212)	2.982*** (0.256)	1.508*** (0.317)	0.181 (0.210)
N	4733	4945	4945	4733	4945	4945

Source: Authors' computation using InovAgro baseline (2014/15) and midline (2016/17) and endline (2018/19) datasets

Figure in parenthesis are robust standard errors; **** significant at 0.1%; *** significant at 1%; ** significant at 5%; * significant at 10%

Table A 12: Fixed effects estimates of impacts of InovAgro on youth land rights and empowerment – Lead farmer and All value chain interventions (complete package)

	Treatment = Lead farmer			Treatment = All value chain interventions		
	Youth land right	Youth Migration	Youth Non-agricultural employment	Youth land right	Youth Migration	Youth Non-agricultural employment
	b/ (se)	b/ (se)	b/ (se)	b/ (se)	b/ (se)	b/ (se)
Treatment_2017	-0.095*** (0.019)	0.073*** (0.024)	0.175*** (0.021)	-0.081*** (0.016)	-0.102*** (0.025)	-0.083*** (0.020)
Treatment_2019	-0.002 (0.022)	0.068** (0.027)	-0.006 (0.017)	0.011 (0.020)	0.029 (0.026)	0.046*** (0.017)
Treatment_non_msd_2017	-0.166*** (0.019)	-0.251*** (0.032)	0.117*** (0.026)			
Treatment_non_msd_2017	0.015 (0.024)	-0.054* (0.031)	-0.099*** (0.022)			
lhhsiz	0.122*** (0.020)	0.136*** (0.029)	0.085*** (0.020)	0.098*** (0.019)	0.145*** (0.027)	0.118*** (0.019)
lheadage	-0.770*** (0.074)	-0.370*** (0.088)	-0.002 (0.061)	-0.703*** (0.071)	-0.424*** (0.087)	-0.094 (0.061)
headfemale	0.003 (0.041)	0.046 (0.051)	-0.059 (0.040)	-0.005 (0.039)	0.027 (0.051)	-0.086** (0.039)
lheadschoo	0.008 (0.007)	0.041*** (0.009)	0.032*** (0.007)	0.010 (0.007)	0.041*** (0.009)	0.031*** (0.007)
lareatot	-0.004 (0.021)	0.087*** (0.025)	0.033* (0.018)	-0.018 (0.020)	0.074*** (0.024)	0.040** (0.017)
_cons	3.158*** (0.260)	1.352*** (0.312)	-0.041 (0.215)	2.953*** (0.250)	1.549*** (0.309)	0.263 (0.215)
N	4733	4945	4945	4820	5047	5047

Source: Authors' computation using InovAgro baseline (2014/15) and midline (2016/17) and endline (2018/19) datasets

Figure in parenthesis are robust standard errors; **** significant at 0.1%; *** significant at 1%; ** significant at 5%; * significant at 10