Learning from a publicly subsidised agricultural insurance: evidence from Bolivia

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Summary

Adverse climate shocks negatively affect small-holder farmers in developing countries keeping them trapped in poverty. Such shocks not only affect their productivity and investments, but also force them to divert resources from other priorities like nutrition, children's education and healthcare leading to long term human capital losses. Located in the Andean region of South America, with an average altitude of 1,192 meters and three distinct ecological zones, Bolivia is particularly vulnerable to the vagaries of nature. Clearly agricultural insurance can provide a much-needed safety net to farmers, protecting them from adverse climate shocks. However, like elsewhere in the developing world, take-up of micro-insurance has remained stubbornly low in Bolivia with only 3.1% of productive units purchasing agricultural insurance.

To mitigate the climate risk keeping small holder farmers trapped in poverty, the Government of Bolivia pioneered the PIRWA crop insurance program in the year 2012, to be administered by its National Institute of Agricultural Insurance (INSA). The PIRWA program is a publicly funded, zero-fee insurance program for farmers who own less than 3 ha of land. It guarantees participating households a pay-out of 1000 Bs (146 USD) per hectare in case of damages caused by natural disasters including floods, droughts, hail and frost.

Since its inception in 2012, it has been expanding across municipalities in phases, scaled-up in 142 municipalities (out of 339) in the 2015/16 campaign corresponding to 135,450 families insured. For the 2016/17 campaign, PIRWA is expected to be reaching 203 municipalities and around 155,000 families insured in 5,576 communities.

In this report, we provide the first impact evaluation of the PIRWA program. While the primary aim of our study is to understand barriers to take-up of agricultural micro insurance, we are able to go beyond take-up and evaluate the impacts of climate change on Bolivian agriculture in general and also evaluate the PIRWA program on other dimensions including productivity and welfare.

We put together a comprehensive database on weather shocks, agricultural yields, investments and household welfare variables, drawing on several different sources of data. We evaluate the impacts of weather shocks on agriculture using a municipality level fixed effects model. Similarly, exploiting the phased implementation of the PIRWA program, we estimate its impact using a difference-in-differences (DID) strategy. We supplement our quantitative analysis with 10 focus group discussions in participating and non-participating municipalities, spread across five departments of Bolivia. These qualitative views help in the interpretation of causal effects computed in the quantitative analysis.

We find that weather shocks are an important determinant of farmers' productivity. Both temperature and rainfall shocks have large impacts on farmers' yields and investments in agricultural inputs. These large effects of weather shocks on yields, do not translate into large effects on welfare as measured by total household expenditure. This suggests that farmers tend to smooth consumption significantly.

Demographic characteristics like poverty, agricultural dependence and production of the nine crops which were targeted by the PIRWA program are important determinants of its

take-up. Interestingly, extreme poverty, access to sewerage and average schooling reduce take-up. This could be related to the decision of these municipalities to focus on alternative programs instead of PIRWA. We also find that weather conditions are important. Municipalities that had a positive temperature or rainfall shock in the year before the program decided not to enrol in the program. On the other hand, extreme rainfall in the previous year increases take-up.

We find that being exposed to the PIRWA program has significant and robust effects on agricultural productivity increasing yields, particularly in municipalities with higher agricultural intensity. It also leads to large increases in total expenditure on agricultural inputs. However, we do not find any effects of access to PIRWA on total household expenditure, food expenditure or food budget shares. This again highlights possible consumption smoothing. On the other hand, we find that PIRWA significantly reduces the incidence of extreme poverty.

From our qualitative analysis, we find results which not only reinforce our quantitative findings, but also provide some other interesting insights. In line with the quantitative analysis, we first find that Bolivian famers face widespread climatic risks. Adverse climatic events affect them negatively and climate shocks force them to curtail expenditure. A large proportion of farmers, however, have only vague ideas of what insurance is what it could offer them, sometimes even confusing them with loans. This coupled with their rudimentary perception and understanding of risk pose serious barriers to the take-up of insurance. In general, the farmers express interest in financial education and technical training for management of water, irrigation, seeds, and animals (which they use for diversifying risk). Finally, farmers who are part of PIRWA use the pay-outs for subsistence.

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Abbreviations and acronyms

Bs	Bolivian Bolivianos
DD	Degree Day
DID	Difference in differences
FGD	Focus Group Discussion
FTR	Risk Transfer Funds (*Fondos de Transferencia de Riesgos* in Spanish)
HDD	Harmful Degree Day
INE	State Statistical Office (*Instituto Nacional de Estadística* in Spanish)
INESAD	Instituto de Estudios Avanzados en Desarrollo
INSA	Institute for Agricultural Insurance (*Instituto del Seguro Agrario* in Spanish)
NCID	Navarra Center for International Development
NDVI	Normalized Difference Vegetation Index
RAC	Communal Agrarian Registry (*Registro Agrícola Comunal* in Spanish)
SPEI	Standardized Precipitation-Evapotranspiration
UNAV	University of Navarra
USD	United States Dollars

1. Introduction

“There are now 400 extreme weather events every year, four times as many as in 1970” (The Economist, 2017). The direct costs of these extreme events in the form of resulting loss of lives, assets, and habitat are obvious. For farmers in developing countries in particular, these shocks lead to a loss of financial resources and productive assets with knock-on effects on investments and returns from their farms, trapping them into poverty. The resultant financial uncertainty has deep repercussions on both households' welfare and investments in productive activities. Such adverse shocks also force these individuals to divert resources from other priorities like nutrition, children’s education and healthcare and lead to persistent damages to their lives in the longer term. The need for agricultural insurance under such situations cannot be over emphasized as they can provide the much-needed safety net to these farmers vulnerable to climate shocks.

Our focus is the on Andean country of Bolivia. Bolivia is characterised by the prominence of agriculture in its economy and by a growing climatic risk. Approximately 30% of its labour force works in agriculture and is prone to extreme weather (with a mean altitude of 1,192 meters). The agricultural sector is also the main source of income for 72.4% of the rural population of Bolivia (UDAPE, 2015). At the same time, Bolivia faces high poverty rates, with a GDP per capita of 2,867 USD (World Bank), the lowest in the South American continent.

To mitigate the risk that farmers face in developing countries, micro-insurance has become an increasingly popular solution. In Bolivia, the Government pioneered this strategy to support smallholder farmers in deprived areas in the form of the PIRWA crop insurance program.[1] In 2011, the Government of Bolivia enacted the Law of the Productive Community Agricultural and Livestock Revolution (Law No. 144), which led to the creation of the National Institute of Agricultural Insurance (INSA, for its acronym in Spanish) as a decentralized public institution with its own assets and autonomy of management under the patronage of the Ministry of Rural Development and Lands.

The creation of INSA in turn led to the birth of the *Pachamama* program. The main goal of this program is to protect rural producers against losses resulting from natural phenomena and to stabilize incomes, generate employment and promote technological development in rural areas. The PIRWA insurance program, which is the focus of this report, was later born under these broader initiatives in the year 2012 as a national insurance plan, targeted specifically at smallholder farmers, and to be managed by INSA.

The PIRWA program is fully subsidized, publicly funded, and guarantees participating households a pay-out of Bs 1000 per hectare in case of damage caused by adverse climatic events. It differs from many programs studied in empirical research on agricultural micro-insurance (Carter and Janzen, 2013; Karlan, et al., 2014) in that participation bears no financial cost for farmers and is implemented nationwide. Since its inception in 2012, it has been expanding across municipalities in phases, scaled-up in 142 municipalities (out of 339) in the 2015/16 campaign corresponding to 135,450 families insured. For the 2016/17 campaign, PIRWA is expected to be reaching 203 municipalities and around 155,000 families insured in 5, 576 communities.

[1] PIRWA is Quechua word that means food store or warehouse.

All farmers in the selected municipalities who own less than 3 hectares of land and produce one of the nine crops covered by the program and eligible to register for the PIRWA insurance. The insurance covers all four of the major adverse natural shocks faced by Bolivian farmers viz. floods, droughts, hail and frost. The verification and evaluation of damages follows a two-step process. First, the presence of a natural catastrophe is verified using satellite data. Following this, there is an on-field verifications phase where experts visit the affected areas to identify and verify damage.

The PIRWA program has in general been considered successful with about one-quarter of participating producers eventually receiving a pay-out. However, while INSA has been able to track participation and expenses, no empirical assessment of impact of the program on welfare and behaviour of affected farmers existed so far. Establishing a general relationship between the intervention and impacts on participants, as well as identifying the returns of this public investment, is of fundamental interest not only to policymakers in Bolivia, but also to other countries with a large share of the population living in rural areas and facing high risks of natural disasters. In this study, we attempt to fill this gap by providing the first empirical assessment of the PIRWA program.

Using mixed methods and drawing on myriad sources of data, we provide the first empirical evaluation of the impacts of the PIRWA program. While the primary aim of the study is to understand how to increase demand and take-up for agricultural micro insurance, given the nature of the PIRWA program and the data we have put together, we are able to go beyond studying take-up and contribute to the general literature on the impacts of climate change on agriculture. Furthermore, we contribute to the literature how agricultural insurance can mitigate the effects of adverse climate events and also in particular affect the behaviour of farmers.

For evaluating the impact of weather shocks on lives of farmers we draw on high resolution, high frequency satellite data and construct two types of measures for weather shocks. First, following the methodology pioneered by Schlenker et al. (2006), we measure temperature shocks using Degree-days (DDs) and Harmful Degree Days (HDDs). DDs are favourable temperature shocks while HDDs are unfavourable (extreme) temperature shocks. The actual bounds for defining these are determined endogenously from within the data (Aragon et al., 2017). Second, we also use the Standardized Precipitation-Evapotranspiration Index (SPEI), developed by Vicente-Serrano et al. (2010).

To evaluate the PIRWA insurance program, we draw on a range of datasets. Our primary PIRWA related data come from the INSA. Our data on agricultural yields and input use come from multiple agricultural surveys, while household consumption and food expenditure data come from the annual household surveys.

We evaluate the impacts of weather shocks on agriculture using a municipality level fixed effects model, exploiting the fact that weather shocks are exogenous to the farmer level outcomes within the municipalities. Similarly, exploiting the phased implementation of the PIRWA program across new municipalities over time, we estimate its impact using a we use a difference-in-difference-in-differences (DDD) strategy (Wooldridge 2010).. We supplement our quantitative analysis with 10 focus group interviews in participating and non-participating municipalities, spread across five departments of Bolivia. These qualitative views help in the interpretation of causal effects computed in the quantitative analysis. It also helps us understand which households participate and what experiences different families and groups have with the program.

We make several contributions through this study. First, mixed methods allow us to provide relevant guidance on program management with a granularity presently absent from the literature on agricultural micro-insurance. This study complements existing literature by providing some of the first empirical evidence from a scaled-up implementation on impact of an agricultural micro-insurance. While other studies, and in particular experimental studies, are very effective at answering key behavioural questions, their limited geographic scope places hard limits on their external validity and applicability in other contexts. In particular, there exists no evidence related to a national-level agricultural micro-insurance program to date. All relevant experimental papers, including Karlan et al. (2014), Carter and Janzen (2013), and Giné and Yang (2009), are based in limited geographical regions and have limited value when discussing external validity. Our study yields the first large-scale empirical approach to an agricultural insurance program to measure what reducing risk and subsequent changes in investment do to improve income and welfare at both the local, regional, and national level. Hence, through our study we make available rigorous, scalable evidence on the determinants of micro-insurance take-up and impact.

Another crucial aspect of our study is that it contributes to the understanding of take-up in situations where liquidity constraints do not play an important role, since the insurance is publicly funded and is close to free (except the time costs associated to the administrative enrolment in the program). This allows us to go beyond the liquidity constraint and trust barriers and understand what other barriers might impede take-up.

We provide a preview of the main findings. We first look at the effects of weather shocks on the lives of farmers and then move on to the impacts of the PIRWA program.

1.1 Effect of Weather Shocks

We find that weather shocks matter for Bolivian farmers, particularly leading to sharp impacts on yields. An extra day with favourable temperature during the growing season leads to an increase in yields of around 25%, reaching 36% in areas of medium-to-high risk of drought and frost. An extra day with extremely high temperatures, which are harmful for crops, leads to a reduction in yields of around 20% and a reduction in expenditure on agricultural inputs by roughly 60%.

On the other hand, these shocks do not to translate into large differences in farmers' consumption expenditures. This could be explained by consumption smoothing. In areas where risks are more frequent, farmers might tend to spend less in order to save more and smooth consumption due to the possibility of future shocks. However, access to informal insurance networks could also be another possible explanation.

1.2 Determinants of Take-up

We have administrative data on take-up from the INSA at the municipality level, which allows us to probe the determinants of take-up of PIRWA at the municipality level. Our first finding is that the main determinants of participation in the PIRWA program are the demographic characteristics targeted by the program. A higher share of land cultivated with any of the nine eligible crops leads to a 40% increase in take-up. Similarly, higher poverty rates also increase take-up. These are not surprising since PIRWA targeted municipalities with agricultural dependence on these nine crops and also municipalities which were poorer.

Interestingly, extreme poverty on the other hand reduces take-up. While it is not entirely clear why this should be the case, it could be related to the decision of these municipalities to focus on alternative programs instead of PIRWA. Also, related is the finding that access to services do not affect take-up, apart from access to sewerage and average schooling, both of which significantly reduces take-up. This is probably also related to higher poverty in PIRWA municipalities.

We also find that weather conditions are important determinants of take-up. Municipalities that had a positive temperature shock in the year before the program decided not to enrol in the program. Similarly, municipalities that had extreme temperature shocks in the year of the program were more likely to be enrolled in the program whereas such shocks in the previous year reduced the probability of being enrolled, but these results with extreme temperature shocks are not significant. As far as precipitation is concerned, we observe that higher precipitation in the past year reduces take-up, but extreme rainfall in the past year increases take-up. This is related to the finding of Karlan et al. (2014), who show that recent poor rain in the village increases the demand for insurance.

In the above results. we were looking at the determinants of a municipality being enrolled in PIRWA. Now we move on to looking at take-up within municipalities that are enrolled. For doing so we focus on the percentage of eligible land that is registered in PIRWA within these municipalities. Using this variable, we find that take-up within each municipality is mainly driven by its dependence on PIRWA crops. Surprisingly, larger areas farmed with these crops reduces the take-up. This could be due to the difficulty to reach all farmers if there is a large number of them. On the other hand, a larger relative dependence of agriculture on these crops increases take-up significantly. This could be because, while PIRWA managed to target municipalities where the dependence on targeted crops is larger, but the reach was higher where the overall extent of these crops in terms of hectares was smaller.

Even within municipalities we find that a higher share of extreme poor population reduces take-up. This might be explained by the limited ability of farmers in these municipalities to obtain information about the program or due to the high cost of travelling to register for PIRWA. Weather shocks do not seem to matter for within-municipality take-up, even if average conditions in terms of average temperature and daily precipitation in the 2000-15 period are positively correlated with take-up.

1.3 Impact of PIRWA

We find that being exposed to the PIRWA program has significant and robust effects on agricultural productivity in the treated municipalities. First, we find that PIRWA is beneficial in terms of yields. An extra year of eligibility leads to an increase in yields by approximately 7% to 9%. And farmers exposed to PIRWA in 2015 exhibit an increase in yield of 15% to 20%, depending on the comparison sample. While we do not find any heterogeneity in the estimates by poverty rates, we find significant heterogeneity by agricultural intensity (defined as % of total land that is agricultural land). We find that the highest increase in yields is happening in municipalities with larger agricultural intensity. While our estimates are large, they are unfortunately not robust across specifications, with the most robust results coming from municipalities with larger agricultural intensity.

To understand why PIRWA has a positive effect on yields, we next focus on total expenditure on agricultural inputs. We find that that across different samples, PIRWA increases the expenditure on agricultural inputs by around 10 to 12%. This suggests that observed increases in productivity are driven by increases in inputs. As with the case of yields, while our estimates are large, they are not robust across specifications.

After yields and agricultural inputs, we move on to studying the impacts of PIRWA on actual welfare outcomes like individual level consumption and food expenditure.[2] We do not find any significant effects of PIRWA on either total household expenditure or food expenditure. Next, we look at the impacts on the food budget share, which is defined as total food expenditure divided by total household expenditure. We observe that increasing the share of insured land does not affect the way farmers allocate expenditure to food. However, we cannot actually identify the eligible farmers for this analysis, nor can we distinguish between small-holder farmers and larger farmers.

We complete our analysis by focusing on poverty. We make use of two indicator variables, one for whether the household is living below the poverty line and the other for whether the household is living below the extreme poverty line. We find that, while PIRWA has a small and insignificant effect on poverty, it has a significant favourable effect on extreme poverty. Insuring all the agricultural land in the municipality leads to a reduction of 7% in the incidence of extreme poverty.

1.4 Focus groups

Now we summarize the main findings from our focus groups. In line with the quantitative analysis, we first find that Bolivian famers face widespread climatic risks. Adverse climatic events affect them negatively forcing them to curtail expenditure in the face of climate shocks.

While farmers recognize that insurance could be beneficial for them under disasters, they have limited knowledge and understanding of insurance products. A large proportion of the producers have a vague idea of what insurance is what it could offer them. Sometimes they also confuse insurance with credit products like loans. This lack of knowledge and financial education is visible among most farmers and in all municipalities. Moreover, their perception of risk is rudimentary. These pose a significant barrier to the take-up of insurance.

In general, the farmers express interest in financial education and technical training for management of water, irrigation, seeds, and animals (which they use for diversifying risk). Finally, farmers who are part of PIRWA use the pay-outs for subsistence expenditures (day to day expenditures).

[2] For this analysis, we observe information on whether a household is a farming household, but unfortunately not the exact crops they grow. Hence, we cannot measure the impact of PIRWA on eligible households. Nevertheless, we can measure the effect of varying the share of the agricultural land in a municipality that is insured under PIRWA (measured as eligible land rather than insured land).

The rest of the report is structured as follows. In section 2, we discuss in detail the context of the intervention. In section 3, we describe the details of PIRWA intervention and also provide the theory of change. In section 4, we briefly mention the monitoring plan and in section 5, we provide the main evaluation questions and describe our primary outcomes of interest. In section 6, we present the evaluation design, data and methods. In section 7, we present the study timeline. In section 8, we provide the main findings from our study, while in section 0 we discuss the implications of these findings. Finally, in section 10, we provide a brief statement about major challenges and lessons learnt.

2. Context

2.1 Bolivia in the Andean Region

Agriculture continues to be one of the main drivers of growth in the Latin American and the Caribbean (LAC) region. It is of paramount importance for this region to maintain adequate conditions for optimal production. Not surprisingly, governments in this region consider risk management and agricultural insurance to be important in their planning of public policies, especially in countries where agriculture has a higher socioeconomic impact. Yet, in 2009, only 3.5% of the world's agricultural insurance policies were from the LAC region (Hatch et al., 2012).

Located in the Andean Region of South America, along with Peru, Ecuador and Colombia, Bolivia has the lowest income per capita among them, and its incidence of rural poverty is the highest in the region (Table 1). At the same time, Bolivia is the country in the region with the highest dependence on agriculture. This sector served as the main occupation for 32.1% of the working population, and the main source of income for 72.4% of the rural population (UDAPE, 2015). While, in Bolivia, the agricultural usage of land is similar to the other countries in the same region, its agricultural productivity is the lowest.

Table 1: Cross-country comparison in the Andean Region

Indicator	Bolivia	Peru	Colombia	Ecuador
GDP per capita *Current int. PPP adjusted*	6.953,8	12.529,2	13.829,1	11.474,1
Incidence of rural poverty *% Rural population*	57,6	46,0	41,4	35,3
Employment in agriculture *% Total population*	32,1	8,1	16,3	25,3
Agricultural land *% Land area*	34,8	19,0	40,5	22,6
Agricultural value added per worker *Constant 2010 US$*	1.113,6	2.995,0	6.262,2	6.793,0
Agriculture, value added *% GDP*	13,2	7,8	6,8	10,1
Cereal yield *Kg per hectare*	1.938,0	4.006,6	3.290,5	3.626,7
Global Climate Risk index (GCRI)	52,2	69,8	59,2	64,8

Note: GCRI includes fatalities, losses in PPP-adjusted US dollars, and percentage of loses per unit of GDP. A lower value denotes higher climate risk. Sources: World Bank Development Indicators, German Watch.

2.2 Climatic Risks for Bolivian Farmers

Divided into the three distinct ecological zones viz. Highlands, Lowlands and Valleys, Bolivia is one of the riskiest countries when it comes to climate. Figure C1 in Appendix shows the geographic distribution of these regions within Bolivia's borders (left panel) and a comparison with administrative divisions (right panel). The Global Climate Risk Index, an index produced by German Watch that analyses to what extent countries have been affected by the impacts of weather-related loss events, places Bolivia at the top in the Andean Region (Kreft et al. 2016). The country is highly prone to extreme weather, often resulting in tremendous losses. Climate change has also been persistently affecting the country negatively. For example, from 1982 to 1983, *El Niño* severely impacted seven out of nine departments in Bolivia, resulting in a loss of 2,821 million USD (around 7% of GDP at the time) and 250,000 productive units. From 2009 to 2010, *El Niño* resulted instead in a 236 million USD loss, which impacted 114,806 families (UNDP Bolivia, 2011).

In our analysis, to identify areas of higher versus lower climatic risk, we need to use objective measures of risk. To divide Bolivia into areas of different objective climatic risk, we build on the work of the World Bank Global Facility for Disaster Reduction and Recovery (2014). We consider the indicators built for the following climatic risks: drought, flood, hail, and frost. The indicator for flood risk considers information such as basin characteristics,[3] drainage, elevation of the terrain, and intensity of precipitation. The indicator for drought risk is instead based mainly on information about aridity and the level of precipitation. The indicators for frost and hail risks are mainly based on terrain elevation, and the correlation between relative humidity and altitude. We then classify the municipalities in Bolivia into Low, Medium and High risk municipalities based on these criteria. Figure 1 shows the geographical distribution of these risks. We will use these classifications throughout the report to understand heterogeneities in our analysis.[4]

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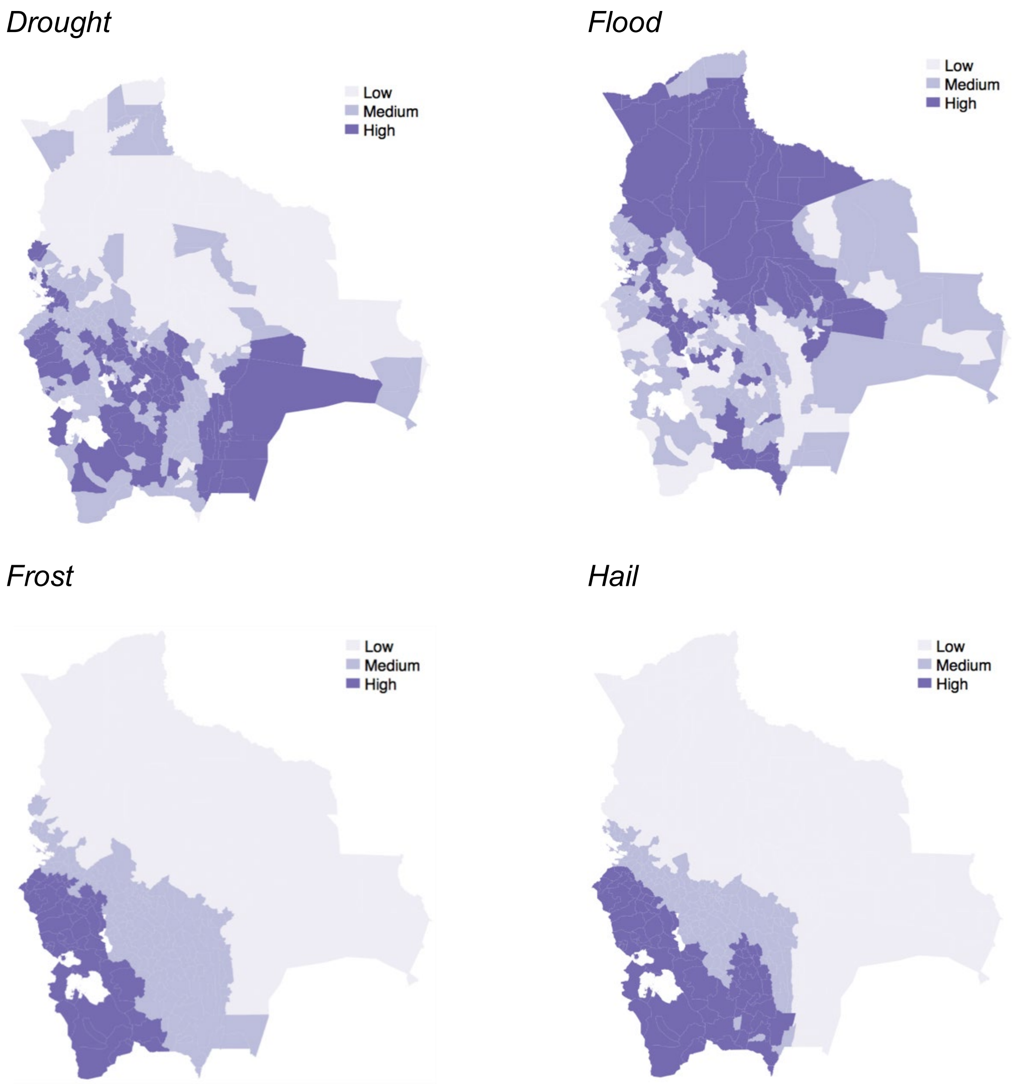
[3] If we use events during the period 2002-2012, we can observe that, out of the total extreme climatic events, 38% were floods, 18% hail storms, 14% droughts, and 8% frost. If we focus instead on vulnerability, the share of people affected by these events is slightly different. Floods affected 396,227 families (35% of the total 1.1 million affected in that period), droughts affected 320,517 families (28%), hail storms affected 169,576 families (15%) and frost affected 157,047 families (14%).

[4] Areas characterized by higher climatic risks are also areas that present higher vulnerability. See Figure 26.

Figure 1: Distribution of climatic risk in Bolivia, by event type



Note: own elaboration using the World Bank Global Facility for Disaster Reduction and Recovery (2014) classification. Darker colours indicate higher risk.

2.3 The Agricultural Insurance Market in Bolivia

Like elsewhere in the developing world, demand for agricultural insurance has been low in Bolivia. Farmers have low purchasing power and are unfamiliar with financial practices. According to the Bolivian Insurers Association (ABA), the insurance market (in all of its varieties) represents a measly 1.28% of Bolivian GDP (SDC, 2015). Only 3.1% of productive units in Bolivia have an agricultural insurance (INE, 2015). As far as the private sector is concerned, a few insurance companies, such as *Alianza Seguros, Crediform, Fortaleza Seguros, Boliviana Ciacruz, BISA Seguros y Reaseguros*, and *Sudamericana Seguros,* offer agricultural insurance to producers.

Here we present the Vine-Growing Insurance offered by Alianza Seguros in some more detail, as it focuses on small-holder farmers. This product stands in contrast with other products which tend to favour industrial or semi-industrial productions. The *Vine-Growing Insurance* has been offered since 2012 by ALIANZA in the municipalities of Tarija and Uriondo in the department of Tarija which correspond to the central valley of Bolivia. It is an insurance that only covers the risk of hail. According to information provided by PROFIN, 56% of vineyards within Tarija's central valley have less than 0.5 hectares of cultivated area of vine and 96% have less than 3 hectares. The insured value per producer is the cost of production up to Bs 17,000 (USD 2,443) per hectare. The deductible is 10% of the value of the loss. For the agricultural campaign during 2012-2013, the premium per hectare was 10% of the insured value.

3. Intervention description and the theory of change

3.1 The PIRWA Program

PIRWA is a word in Quechua which means "Food Store" (*Almacén de alimentos* in Spanish). The PIRWA insurance program is a national insurance program launched by the Bolivian Government in 2012 for smallholder farmers (less than 3 hectares of productive land). It is administered by the INSA and is primarily targeted at subsistence farmers (*agricultura familiar* in Spanish) in the poorest municipalities of Bolivia. As of 2017, there have been four campaigns that have insured 249,424 hectares, benefitting about 135,456 families, and 142 municipalities (INE 2016).

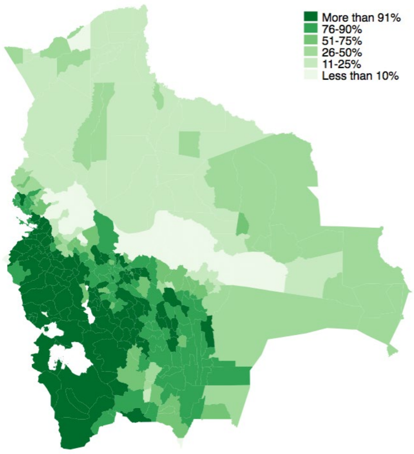
The main feature of PIRWA is the introduction of a cost-free insurance for farmers against adverse weather phenomena affecting their production (drought, flood, frost and hailstorm). Its aim is to allow families in rural areas, who rely mostly on agricultural activities, to transfer climate-related risk to the government, while also relieving urban centres from immigration pressures. Note that 94% of productive units in Bolivia are owned by families and are therefore more vulnerable to shocks (INSA 2014). While many insurance programs are touted for being a market-based solution, this program is structured around the state absorbing participation costs and risk, and taking a long position on the social and economic returns of supporting farmers.[5]

As mentioned above, the program was not universally targeted at all farmers, but it focused on four different criteria. Firstly, it targeted only small-holder farmers by making the insurance accessible only for farmers with less than 3 hectares of productive land. Secondly, it targeted municipalities with higher rates of poverty. Thirdly, it targeted municipalities with a high dependence on agriculture. Finally, it targeted farmers producing crops for local consumption, rather than exporting. Therefore, it targeted municipalities where these crops represent a larger share of the agricultural production. Specifically, it currently covers nine crops: potatoes, corn, wheat, barley, quinoa, beans, oats, alfalfa and frijoles.

Figure 2 shows the geographical distribution of the share of municipality-level agricultural land that is farmed by one the nine crops covered by PIRWA. Once the municipalities have been selected into the program, all farmers with less than 3 hectares growing one of the nine crops are eligible to register for the program. In the case of climatic catastrophes, the farmers receive a pay-out of Bs 1,000 (US$ 146) per hectare damaged.

[5] The government is also in charge of regulating the design of private agricultural insurance. For instance, INSA is in charge of vetting damage verification systems such as traditional verification or indices. See "Ley Nº144 de Revolución Productiva Comunitaria Agraria".

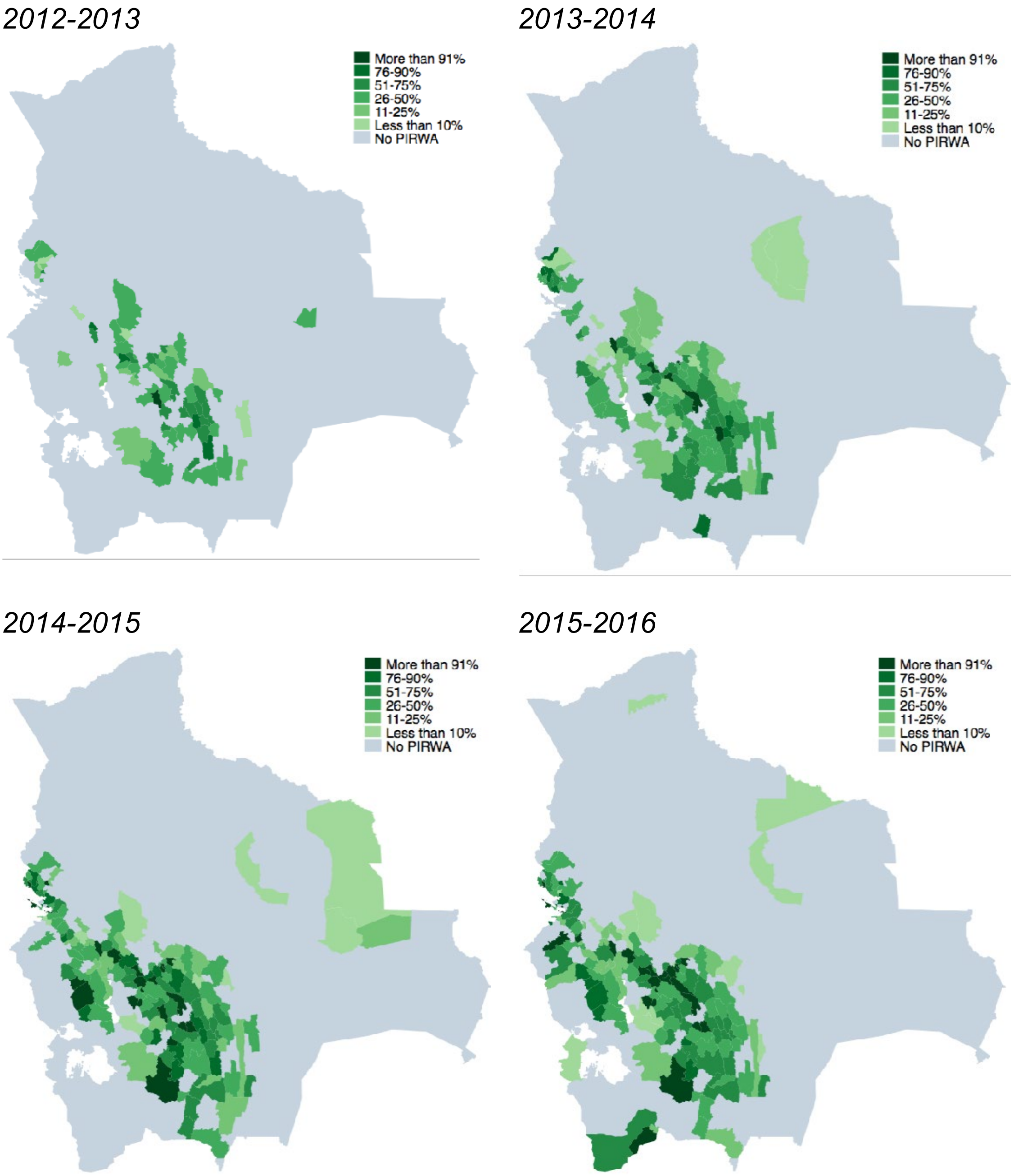
Figure 2: Share of Agricultural Land eligible for PIRWA



Note: the figure presents the share of agricultural land farmed in the summer that is covered by the crops included in the PIRWA program for the 2015-16 campaign. To compute farmed land, we consider only the land farmed in the summer as this is the main growing season. Source: own elaboration using INE's 2013 Agricultural Census.

Since its introduction, the PIRWA program has been expanded gradually over time across municipalities. Out of 339 municipalities, 63 municipalities were included in the first campaign in 2012/13, corresponding to 57,497 families insured. In the following year, the program expanded to other municipalities: 107 municipalities were enrolled in 2013/2014 (corresponding to 106,049 families insured), 141 municipalities in 2014/15 (corresponding to 146,563 families insured), and 142 municipalities in 2015/16 (corresponding to 135,450 families insured). For the 2016/17 campaign, PIRWA is expected to be reaching 203 municipalities. This corresponds to around 155,000 families, almost three times the number of families targeted in the first campaign of PIRWA. In Figure 3, we plot the phased expansion of the program during the first four years of implementation. Each map presents the geographical distribution of municipalities with access to PIRWA from the first campaign in 2012-13 to the campaign of 2015-16.

Figure 3: Expansion of the PIRWA Insurance Program, by campaign



Note: each map presents the geographical distribution of municipalities with access to PIRWA from the first campaign in 2012-13 to the campaign of 2015-16. Darker areas are municipalities where the share of eligible land registered in PIRWA is higher. Eligible land is computed using the 2013 Agricultural Census.

3.2 Administrative Procedure

Since the first campaign in 2012/2013, in each agricultural campaign, farmers with less than three hectares of cultivated land, who live in a PIRWA-selected municipality, and are willing to participate in the program, must first register their sowing plan in a document called the Communal Agrarian Registry (*Registro Agrícola Comunal* or RAC). The registry form contains basic information about the plots farmed by each farmer, but also about the crops farmed on the plot.

Once the RAC is filled and signed, it later becomes an affidavit, confirming the crops and the cultivated land that, in case of damage, would be subjected to verification. Farmers must do this procedure in the presence of the communal leader, and the process is supervised by INSA and the officials of PIRWA.

The notification of damage, verification and evaluation of claims comprises of four steps. First, in the case of hail or frost, whose damages to cultivated land are evident right after the occurrence of the shock, enrolled affected farmers must first notify the damage to their local communal leader or the municipal official in charge. Later, one of them, or both, must officially notify the damages to INSA with a claim notice called “preliminary notice of loss” within 15 days after the occurrence of the shock. For droughts and floods, the “preliminary notice of loss” must be executed after the damages to the crops are evident. If farmers fail to notify the loss within the time allowed, INSA could be discharged of its obligations.

Second, for the verification and evaluation of claims, initially, the presence of a natural catastrophe is verified using satellite data. Third, post the satellite data based verification phase, there is an on-field verification phase where experts visit the affected areas to identify and verify damage. In the lower panel of Figure 16, we plot some images from the on-field verification stage. Lastly, after the verification of damages, an evaluation file is generated by the INSA official who attended to the notification and visited the affected areas. This file contains the technical report of the evaluation, as well as other documents - among them the RAC - that could facilitate decision-making for the INSA authorities.

After the technical report of verification and evaluation is presented, INSA would order the payment compensation of 100% of the payable amount (1,000 Bs or 146 USD per hectare insured), under two circumstances.

First, when the percentage of direct damages to the cultivated land, due to a covered climatic risk, is more than or equal to the percentage determined by regulation. For example, in the case of potatoes, quinoa, and wheat, farmers that cultivate these crops receive 100% of the payable amount if the level of productive capacity loss is at least 70%; while for corn, oats, barley, bean, this percentage falls to 60%.

The second circumstance occurs when the production obtained during harvest is less than or equal to the volume established by regulation. This trigger differs by the type of crop and by municipality. For example, for potatoes in the municipality of Azurduy (Department of Chuquisaca), the trigger is 2,000 Kg of production, while for the municipality of Culpina, this same crop has a trigger of 2,500 Kg. Regularly, payment of compensation starts at the end of the agricultural campaign (July) and continues until September, when farmers are also in the process of enrolling to the program for the next agricultural campaign.

3.3 Theory of Change

The negative effects of climate change on weather shocks are now well documented in the literature (Rosenzweig and Parry, 1994; Guiteras, 2009).[6] In particular, adverse weather shocks and the subsequent severe loss of assets has been documented as a common reason for falling into a poverty trap for farmers (Carter et al. 2007; Barrett et al. 2007; Morduch, 1994). Firstly, adverse weather shocks lead to a direct loss of income and financial resources, which has immediate negative impacts on not only household finances, but also knock-on effects on investments and thus returns from the following season. Moreover, when a household receives an adverse shock it is also likely to divert resources from other priorities like nutrition, children's education and healthcare in order to smooth consumption, which leads to human capital costs (Jensen, 2000). These effects can often be persistent over time and children who face adverse weather shocks might be scarred for life (Maccini and Yang, 2009).

Clearly agricultural insurance, can provide a much-needed safety net to farmers, protecting them from the vagaries of nature, and climate change induced shocks (Barnett and Mahul, 2007; Dercon, and Christiaensen, 2011). However, take-up of micro-insurance has remained stubbornly low and increasing take-up has remained a notably difficult policy to achieve. The literature has identified various barriers to take-up including, liquidity constraints, lack of understanding of insurance, trust, and previous experience with insurance, among others (Casaburi and Willis, 2017; Cole et al., 2013). These considerations explain the *raison d'être* of the PIRWA program and its primary features. In particular, it is a free micro-insurance product covering up to three hectares of land for all households in the participating municipalities, which are themselves chosen on the basis of poverty rates, agricultural dependence, as well as the crops they produce.

First, by setting financial participation costs at zero, this program addresses the role of liquidity constraints in impeding take-up. Households, despite standing to benefit from the service, may struggle to rationalize paying a premium at the beginning of the growing season given that there is only pay-out in the case of a weather shock. Not surprisingly, farmers state "I don't have enough cash" (Casaburi and Willis, 2015) or non- purchasers cite “lack of funds” (Cole et al., 2013) most often as their most frequent reason for not buying insurance. Prices of insurance products are high relative to expected pay-outs when compared to retail insurance in developing countries discouraging take-up (Cole et al., 2013). Also, given the competing uses of the limited funds that households have at the start of the growing season, the opportunity cost of insurance is high (Cole et al., 2013, Rampini and Vishwanathan, 2010). Hence, being a zero-cost program the PIRWA directly removed the liquidity constraint barrier.

The liquidity constraint barrier is crucial but it is not the only barrier. Even under large price discounts and an expected return which is significantly better than actuarially fair, increasing take-up has remained a challenge (Cole et al., 2013). Hence, one needs to understand non-price frictions that limit insurance demand over and above liquidity

[6] More recently, Aragon et al. (2017) highlight the role of extreme weather events on agriculture in another Andean country, Peru.

constraints.[7] Lack of trust usually follows liquidity constraints, as the other major barrier to take-up (Casaburi and Willis, 2015). Households with little financial capital may be reluctant to invest resources in insurance if they are unsure that the insurer can be held accountable to indemnify losses when claims are made. The importance of trust is further borne by the fact previous experience with insurance products has been found to be important for take-up. (Karlan, et al., 2014). However, setting price to zero should not only address liquidity constraints, but also address the lack of trust.

The lack of trust often goes hand in hand with other non-price frictions such as low levels of insurance awareness and literacy, and difficulty to understand and use insurance policies properly (Churchill, 2013). More importantly, lack of insurance awareness among the poorer populations has been impeding take-up among these populations (Coydon and Véronique, 2011). Not surprisingly, intensive education campaigns have been found to improve insurance demand (Gaurav et al., 2011). INSA tackles this barrier head-on through its intensive sensitization sessions carried out at the village-level by INSA.

In sum, through prioritizing take-up above other performance indicators, we hypothesize that over several years the program has increased trust in the insurer and demonstrated the benefits of participation and by extension significantly increased demand for insurance overall.

Turning to welfare aspects of the program, the insurance begins to improve welfare through behavioural channels, driven by the transfer of risk from the household to an external party, in this case the state insurance program. Risk aversion is a central barrier preventing farmers from investing more and increasing profits. This was dually emphasized when they found simply mitigating risk, without any infusion of capital had significant positive effects on investment (Karlan, et al., 2014). We expect households' smoothing of consumption and assets which normally begins with the growing season to become less frequent and severe. Asset and consumption smoothing in anticipation of bad harvest due to adverse weather is a crucial factor in the context of smallholder farmers (Karlan, et al. 2013). Such farmers usually undertake anticipatory smoothing, preferring to adapt current consumption and/or assets to a level in line with a poor harvest/weather shock. Slightly wealthier households prefer to reduce assets, while slightly poorer households prefer to reduce consumption.

This is described in Karlan et al. (2013) and identified as a central mechanism in human capital losses, through poor nutrition, school attendance, and medical care. As the insurance program can potentially mitigate weather risks and provide a minimum return at the end of the season, households will be less likely to cut food consumption, and other investments, such as education and health. At the end of a poor growing season (driven by adverse weather), whereas uninsured families would be forced to either continue reducing consumption or liquidating assets, participating families are able to maintain comparatively higher level of consumption and assets. This means that in the short and medium-term, welfare remains stable, measured in terms of school attendance, food expenditure, healthcare expenditure, and other key indicators that are intimately related to later life outcomes for children, as well as the health of adult

[7] The reader is directed to Cole et al., 2013; Giné, Townsend and Vickery, 2008; and Giné et al., 2012, for a more detailed discussion of these non-price frictions.

household members. We predict that this shift will be observable in several key outcome variables measured in the annual surveys.

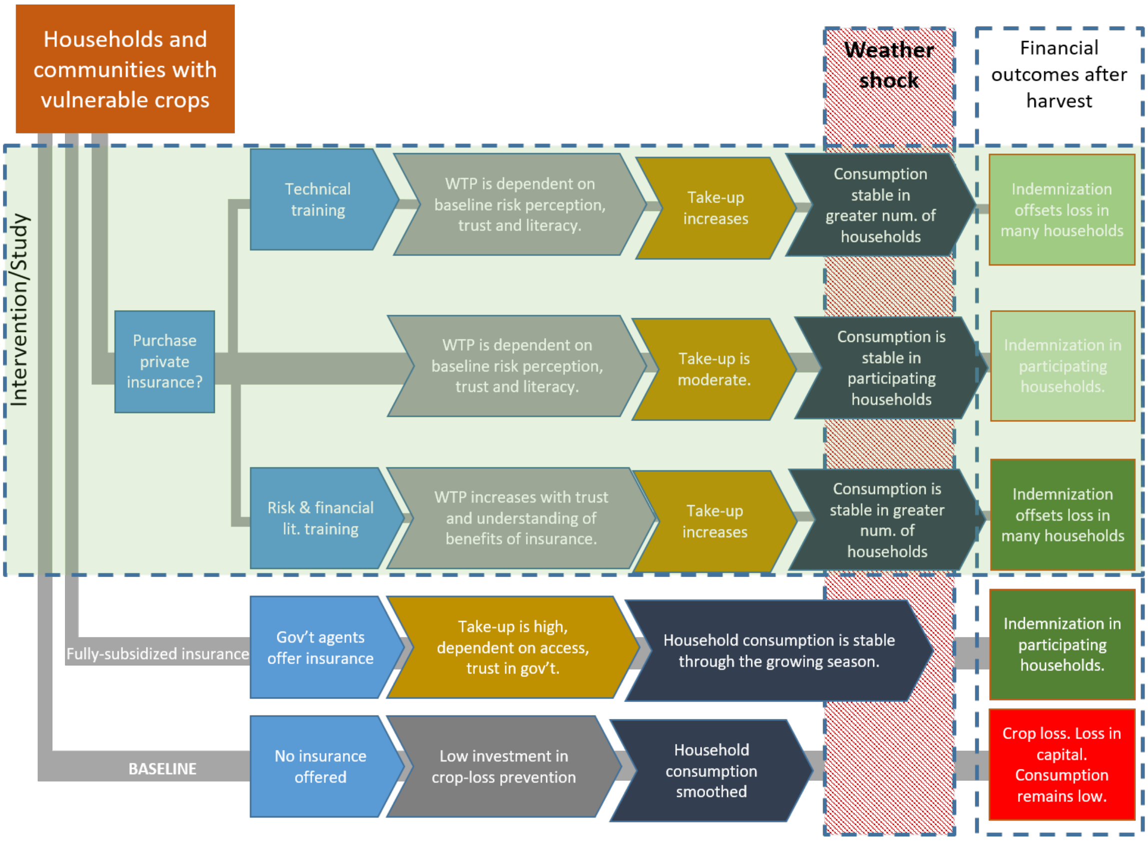
The second major effect we predict is a shift in investment strategies. In the presence of financial constraints and uncertainty, households under-invest in potentially productivity-boosting changes. The ability of the household to invest in productivity improvements grows significantly from the baseline scenario. As households are able to externalize and reduce risk, productivity investments, such as planting a wider area or new crops, are more likely to have positive returns. Given that program costs are zero and risk has been externalized, we expect a noticeable increase in productivity and profit boosting investment.

We predict that over the medium term participating households will significantly improve their financial situation and make greater investments in revenue generating activities, as well as essential household goods. This is driven by participating households being more likely to be able to sustain productivity levels year over year, even in the case of a shock, as they end the growing season with enough capital to purchase seed and inputs for the following season, since they do not have to siphon off resources from the following year's investment, therein avoiding a common poverty trap. We anticipate this effect will be observable in income from farming activities, surface area cultivated, and a normalized vegetation index. All variables, but particularly medium and long-term outcomes, are dependent on low-attrition rates, which we assume to be low given there is no premium for participation.

Improvements in each growing cycle driven by risk transferring will then lead to long-run welfare improvements. Households would accumulate better investments over time, which would lead to better income and improvements in human capital.

Figure 4 summarizes the theory of change linked to the use of insurance among small-holder farmers in Bolivia.

Figure 4: Theory of Change



Note: we represent positive outcomes in green and negative outcomes in red.

4. Monitoring plan

In this report, we evaluate the PIRWA agricultural insurance program which is being implemented by the Government of Bolivia through its National Institute of Agricultural Insurance (INSA). Hence, this section is not applicable for our report.

5. Evaluation questions and primary outcomes

The overall goal of this project is to understand the determinants of take-up of agricultural insurance, particularly focussing on the PIRWA program. However, given our framework and the nature of the dataset we put together, we are able to go beyond take-up and also look at related issues of how weather shocks and insurance affect farmers.

In particular, we ask the following research questions:

1. How do weather shocks affect the productivity, behaviour and welfare of farmers in Bolivia?
2. What determines the take-up of micro-insurance once we remove the liquidity constraints that small-holder farmers face?
3. What are the welfare and productivity effects of the PIRWA program?

Hence, our main outcomes of interest are take-up of the PIRWA insurance program, total consumption expenditure, food expenditure, and food share of expenditure. We explain each of these variables in more detail in the following sections.

6. Evaluation design, data and methods

6.1 Data

As mentioned in the introduction, our study is comprised of a qualitative and a quantitative section. In this section, we present the main variables used in the quantitative analysis and discuss the data sources. We also provide information regarding the qualitative component of our study.

6.1.1 Insurance Treatment and Take-up

For the PIRWA intervention related data, including insurance treatment and take-up, we use data from INSA (*Instituto de Seguro Agrario* in Spanish). INSA, which is the Bolivian Institute for Agricultural Insurance, is the implementing agency. In particular, we gathered information on municipalities treated in each of the years starting from the growing season 2012/13, which was the first year of implementation of the program, to the latest year of implementation of the program, which is the campaign 2015/2016.

We also have administrative data on the exact number of farmers registering for the program, the quantity of land insured in hectares, and the exact amounts and hectares of repayment. This information is made available at municipality level for each year of the program. The data on the exact crops which were eligible to be insured was available publicly. These aforementioned data from the INSA allows us to construct at the municipality level the program take-up, both in terms of individuals insured as well as hectares insured and the exact repayment figures. We describe the data in detail in Section 8.1.

6.1.2 Household Surveys

For individual level outcomes, we use the annual Bolivian Household survey data for the years 2005-2014 available annually with municipality identifiers. This dataset contains information on different socio-economic variables for all 339 Bolivian municipalities. This dataset is provided by INE (*Instituto Nacional de Estadistica* in Spanish), which is the Bolivian State Statistical Office. INE also provided us with municipality identifiers, which are normally unavailable in the public version of the database. This allowed to us construct repeated cross sections at the individual level, as well as panel data at the municipality level.

In Table 2, we provide the descriptive statistics from the Household Survey for the period 2005-2015, both at the household level and the individual level. While in the table we also report descriptive statistics for non-farmers, throughout the report we will focus only on farmers. We define as farmer households, all households where at least one member is reporting being a small-holder farmer as main occupation.

Table 2: Demographic Indicators

Municipalities:	All		Municipalities with Medium-High Risk of…					
			Flood		Drought		Frost	
Sub-sample:	*Farmers*	*Other*	*Farmers*	*Other*	*Farmers*	*Other*	*Farmers*	*Other*
Household Characteristics								
Number of Members	4.07	1.73	4.55	1.56	4.58	1.72	3.91	1.76
	(2.30)	(1.04)	(2.41)	(0.91)	(2.55)	(1.01)	(2.21)	(1.07)
Urban Area	0.14	0.84	0.18	0.66	0.24	0.93	0.12	0.84
	(0.35)	(0.36)	(0.38)	(0.47)	(0.43)	(0.26)	(0.33)	(0.36)
Number of Children	3.15	0.73	3.72	0.56	3.71	0.72	2.96	0.76
	(2.39)	(1.04)	(2.61)	(0.91)	(2.72)	(1.01)	(2.25)	(1.07)
Access to Electricity	0.61	0.96	0.59	0.91	0.61	0.97	0.61	0.96
	(0.49)	(0.20)	(0.49)	(0.29)	(0.49)	(0.17)	(0.49)	(0.19)
Durable Wall Material	0.18	0.69	0.23	0.65	0.38	0.89	0.14	0.64
	(0.39)	(0.46)	(0.42)	(0.48)	(0.48)	(0.31)	(0.35)	(0.48)
HoH Gender	0.83	0.67	0.90	0.75	0.90	0.70	0.81	0.65
	(0.37)	(0.47)	(0.30)	(0.44)	(0.30)	(0.46)	(0.39)	(0.48)
Individual Characteristics								
Sex	0.56	0.56	0.72	0.60	0.72	0.58	0.52	0.55
	(0.50)	(0.50)	(0.45)	(0.49)	(0.45)	(0.49)	(0.50)	(0.50)
Marital Status	0.36	0.39	0.31	0.36	0.34	0.39	0.37	0.39
	(0.48)	(0.49)	(0.46)	(0.48)	(0.47)	(0.49)	(0.48)	(0.49)
Literacy	0.82	0.97	0.90	0.96	0.91	0.98	0.80	0.96
	(0.38)	(0.18)	(0.30)	(0.19)	(0.28)	(0.13)	(0.40)	(0.19)
Age	40.09	36.47	38.37	34.91	38.94	35.85	40.49	36.87
	(19.52)	(14.97)	(16.68)	(14.52)	(17.01)	(13.72)	(20.21)	(15.35)
Years of Schooling	4.88	10.35	6.01	9.22	6.29	10.86	4.52	10.36
	(3.93)	(5.47)	(4.02)	(4.99)	(4.06)	(4.96)	(3.83)	(5.66)

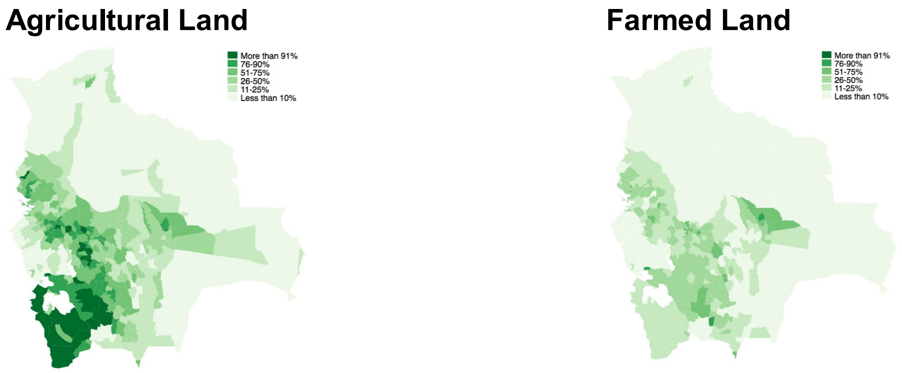
Note: standard deviations are in parentheses. Agricultural households are those in which the household head’s main occupation is related to agriculture. Climatic risk regions are stated as defined by a World Bank report. Gender indicators are defined such that male=1 and female=0. Marital status is defined as single=1 and otherwise engaged=0.

6.1.3 Agricultural Census and Surveys

In terms of agriculture and farmers' decisions, we collate different sources of information. Firstly, we make use of the 2013 Agricultural Census, collected by INE. The census provides information about land use, crop production and yields, and members involved in agricultural production. The census covers 18,589 communities and 871,927 Agricultural Productive Units (APU).[8] Agriculture is distributed throughout the country, but is highly concentrated in the Highlands and Valleys. Figure 5 shows the geographical distribution of the share of agricultural land over total land in the municipality (left panel) and the share of agricultural land farmed in the summer that is covered by the crops included in the PIRWA program for the 2015-16 campaign (right panel).

[8] An Agricultural Productive Units (APU) (Unidades de Producción Agropecuaria, UPA) is defined as ``all land that is used totally or partially in agricultural or livestock activities, regardless of size, tenure or legal status.''

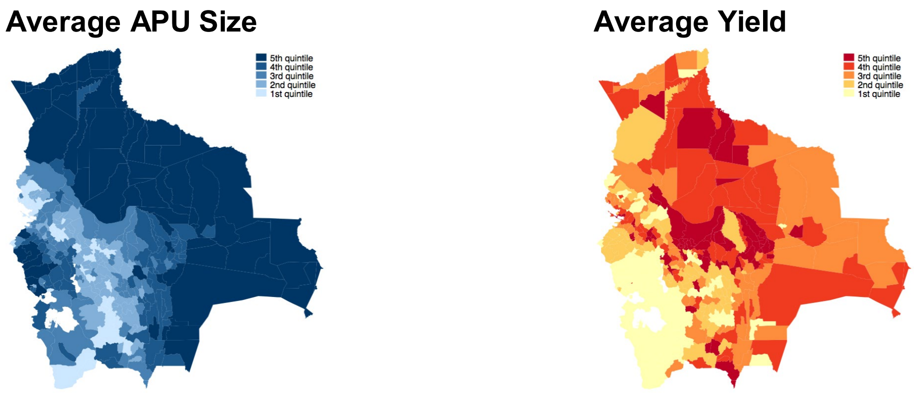
Figure 5: Agriculture in Bolivia



Note: the left panel presents the share of agricultural land over total land in the municipality. The right panel presents instead the share of agricultural land farmed in the summer that is covered by the crops included in the PIRWA program for the 2015-16 campaign. To compute farmed land, we consider only the land farmed in the summer as this is the main growing season. Source: own elaboration using INE's 2013 Agricultural Census.

In terms of farmers' characteristics and productivity, Bolivia also presents a large heterogeneity across different regions. Figure 6 shows the geographic distribution of the average APU size (in quintiles of the national distribution) and the average yield. Highlands are characterized by smaller and less productive APUs, while larger and productive APUs are based in the Lowlands.

Figure 6: Size of agricultural units and average yield



Note: each map presents the geographical distribution of the selected indicators reported at municipality level. The source of information is the 2013 Agricultural Census. Source: own elaboration using INE's 2013 Agricultural Census.

Secondly, we exploit the 2008 and 2015 Agricultural Surveys, also collected by INE. These surveys provide detailed information about farmers' characteristics, and inputs and outputs related to agricultural production. In each survey, information refers to the agricultural season starting in July of the year before and ending in June of the year of the interview. In Table 3, we provide the descriptive statistics of the household survey data.

Table 3: Descriptive Statistics of Farmers in the Agricultural Survey

	All	Municipalities with Medium-High Risk		
		Flood	Drought	Frost
Members in the household	4.14	4.32	4.37	4.05
	(2.24)	(2.32)	(2.34)	(2.19)
Sex of household head	0.88	0.90	0.89	0.87
	(0.33)	(0.31)	(0.31)	(0.34)
Age of household head	49.69	47.88	48.52	50.48
	(14.90)	(14.20)	(15.38)	(14.97)
Lives in Highlands	0.34	0.11	0.21	0.43
	(0.47)	(0.31)	(0.41)	(0.50)
Lives in Valleys	0.37	0.29	0.04	0.47
	(0.48)	(0.45)	(0.18)	(0.50)
Lives in Lowlands	0.29	0.61	As 0.76	0.10
	(0.45)	(0.49)	(0.43)	(0.29)
Hired workers	3.08	4.11	3.11	2.80
	(9.17)	(9.81)	(5.52)	(9.45)
UPA uses irrigation (%)	0.19	0.02	0.06	0.26
	(0.39)	(0.12)	(0.24)	(0.44)
Total Cultivated Land During Summer	18.95	53.17	67.72	2.38
	(204.44)	(396.49)	(330.03)	(8.63)
Average yield (kg/ha)	3488.57	5388.17	3091.80	3050.86
	(5446.25)	(8520.62)	(4539.19)	(4313.54)

Note: own calculations using the INE Agricultural Surveys 2008 and 2015.

6.1.4 Climate Data

As far as climate data is concerned, our objective was to build growing season specific weather shocks at geographically disaggregated level for the whole of Bolivia. To this purpose, we obtain satellite based weather data, in particular information about temperature and precipitation.[9]

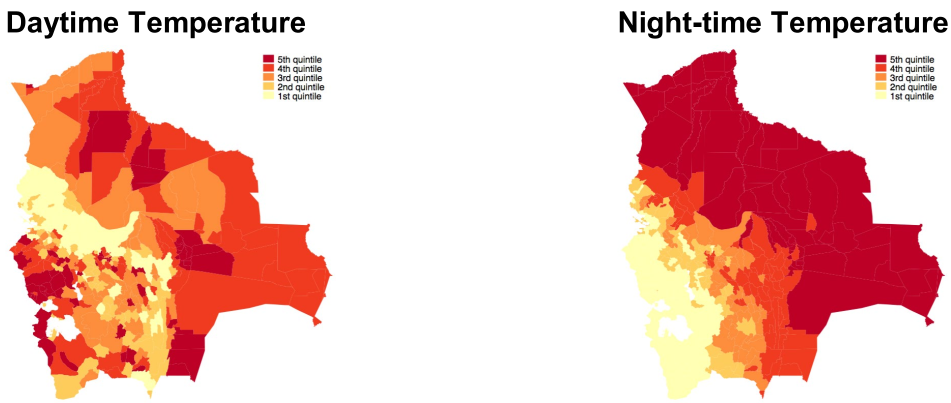
We obtain **Land Surface Temperature (LST)** using the MODIS/Terra Land Surface Temperature and Emissivity 8-Day L3 Global 0.05Deg CMG (MOD11C2) module. The MODIS/Terra Land Surface Temperature and Emissivity (LST/E) products provide pixel level temperature and emissivity values in a sequence of swath-based to grid-based global products. The MODIS/Terra LST/E 8-Day L3 Global 0.05Deg CMG is configured on a 0.05 degrees' latitude/longitude climate modelling grid (CMG).

We first obtain the information at the grid cell level for all of Bolivia and we then average cells at the municipality level. This allows observing, for each day of the year, the average temperature in a specific municipality for both daytime and night-time. Figure 8 shows the geographical distribution of the average daytime and night-time LST for the period 2000-2015. Darker colours represent warmer temperatures, while lighter colours represent colder temperatures. We present this division using the temperature distribution in the whole country and for the whole period, and by dividing municipalities into quintiles of the temperature distribution. During daytime, temperature presents a less spatially clustered pattern, with warmer temperatures in the tropical lowlands and in the western Highlands, and with colder temperatures in the Valleys. During night-time,

[9] We also looked at weather station based data from the Bolivian Met Office, Senhami, however, the quality of the satellite data was better due to fewer missing observations. For this reason, we opted for the use of satellite data.

temperature tends to be more spatially correlated and to represent the division in elevation between Lowlands and Highlands.

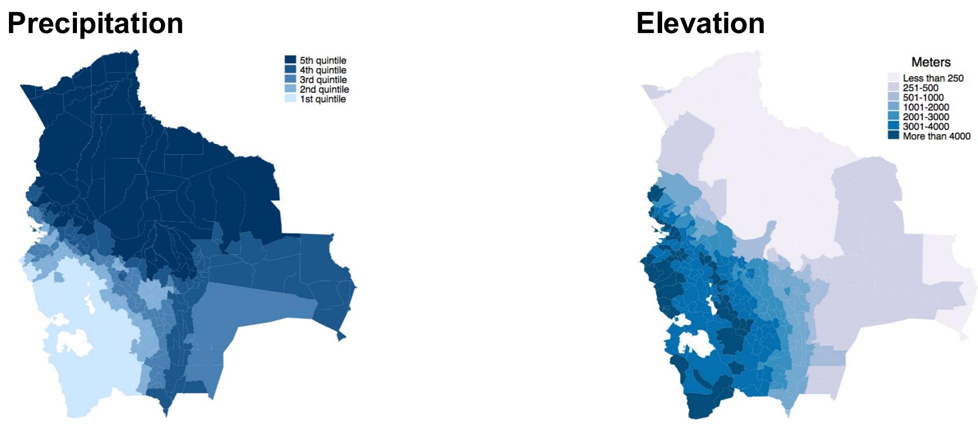
Figure 7: Land Surface Temperature (2000-2015)



Note: each map presents the geographical distribution of municipality-level averages of the corresponding variables in the period 2000-2015. Source: own elaboration using MODIS MOD11C2 module.

To obtain information about **daily precipitation** at the highest possible resolution, we use the Climate Hazards Group Infra-Red Precipitation with Station data (CHIRPS) database. CHIRPS provide 0.05-degree resolution satellite imagery supplemented with in-situ monitoring station data (Funk et al., 2015). Similar to temperature, we first obtain the information at the grid cell level for all of Bolivia and we then average cells at the municipality level. This allows observing for each day of the year, the precipitation in a specific municipality. In the left panel of Figure 8 we show the geographical distribution of daily precipitation for the period 2000-2015, measured in millimetres per day. In the right panel, we present the average elevation in each municipality, measured in meters. We can observe that higher precipitation also tends to be concentrated in areas with lower elevation, which is the tropical lowlands region.

Figure 8: Precipitation and Elevation



Note: each map presents the geographical distribution of municipality-level averages of the corresponding variables. Source: own elaboration using CHIRPS dataset.

To capture weather shocks, we build the following indicators of weather shocks that could have influenced farmers' lives. To measure shocks related to temperature, we first define weather shocks using **Degree-days (DDs)**, **Harmful Degree Days (HDDs)**, and

Cold Degree Days (CDDs). Similar to Aragon et al. (2017), we use a piece-wise linear specification for temperature by building degree-days, and harmful degree-days. This approach was first implemented by Schlenker et al. (2006). If average daytime temperature for day *t* is denoted by t_d, we can define DDs using the following rule:

$$\mathrm{DD_t} = \begin{cases} 0, & \mathrm{t_d} \leq \mathrm{t_l} \\ \mathrm{t_d} - \mathrm{t_l}, & \mathrm{t_l} < \mathrm{t_d} \geq \mathrm{t_u} \\ \mathrm{t_u} - \mathrm{t_l}, & \mathrm{t_u} < \mathrm{t_d} \end{cases}$$

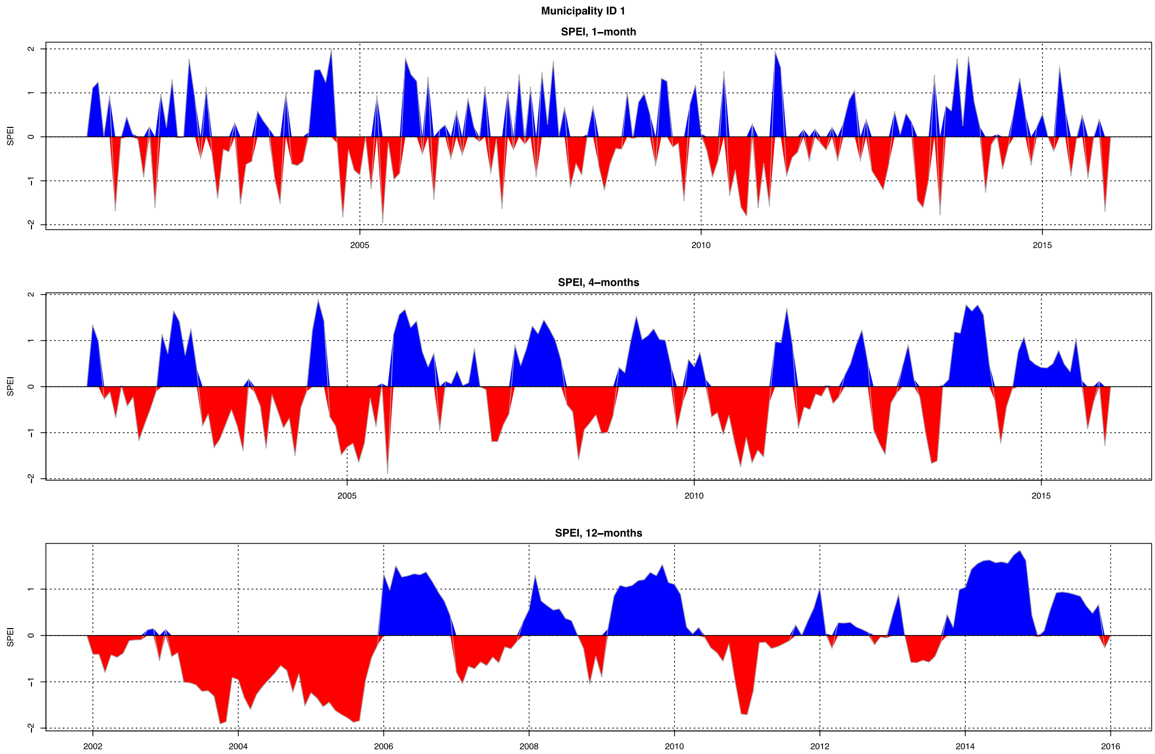
where t_u is the threshold between DDs and HDDs and t_l is the threshold between DDs and CDDs. DDs capture the positive effect of temperature on plant growth and agricultural yields and indicates the number of degrees in one day that are in between t_u and t_l. If the temperature is below the lower bound, it will account for zero DDs, while if the temperature is above the upper bound, it will account for the upper bound degrees, independently from how hot the day has been. HDDs measure instead the degrees in excess from the upper bound and will capture the stock of temperature in abnormally warm days. It is computed using the same rule as DDs but using the upper bound of DDs as lower bound and positive infinity as upper bound. Following Aragon et. al. (2017), we also distinguish between extreme weather shocks and standard weather shocks. While DDs picks up variation in temperature that is not extreme, HDDs are instead measuring variation in extreme temperature, which can in turns generate more destructive damage to agriculture.

Similar to the situation for Peru in Aragon et al. (2017), Bolivia presents a wide heterogeneity in terms of crops, but also in terms on elevation. To face this heterogeneity, we do not use estimates of the bounds from the agronomic literature, but we rely on this data-driven approach. To build municipality-level measures for DDs and HDDs, we estimate the lower and upper bounds using available information about yields form the Agricultural Survey. For each department in Bolivia, we regress average yields at farmer-level for the years 2008 and 2015 on our indicators and on average precipitation. We then select the lower and upper bounds that maximize the R^2 of these linear regressions. In terms of controls, we also include municipality fixed effects and year fixed effects. Figure C3 in Appendix presents the distribution of DDs and HDDs in the Household Survey sample. Each observation in the distribution is a farmer.

Since a second type of climatic risk in Bolivia is associated with precipitation, we also build measures on **precipitation** shocks. In all specifications, we always include a non-linear function of the average daily precipitation in a municipality during the growing season. We include a linear and a quadratic term to capture the positive effect of rainfall on agriculture, but also the negative effect of extremely low or extremely high levels of precipitation.

As an alternative measure for weather shock, we use the **Standardized Precipitation-Evapotranspiration Index (SPEI)**, developed by Vicente-Serrano et al. (2010). This is a climatic proxy that is widely used for drought quantification and monitoring, but whose analysis can also be extended to proxy flooding. The advantage of using SPEI over precipitation is that it accounts for the Potential Evapotranspiration (PET), which is defined as the amount of water that could be evaporated and transpired if there were sufficient water available. This depends on additional variables that pick up the extent to which water can be retained by the soil, such as temperature, latitude, sunshine exposure, and wind speed. We compute PET using the Thornwaite approximation, which uses monthly temperature and the latitude to adjust for the number of sunlight hours over the course of the year.

Figure 9: An example of SPEI: Colquechaca Municipality, Potosí



Note: the upper panel shows the time variation in SPEI computed using a 1-month time horizon, while the middle and the lower panels use 4 and 12 months as time horizons. Source: own elaboration.

We compute the SPEI at municipality level after averaging available information by the administrative unit. Figure 9 presents an example of variation of SPEI using different time horizons (1 month, 4 months and 12 months) for the municipality of Colquechaca, in the department of Potosí. As we can observe, the 1-month SPEI picks up very short-run variation in SPEI, while the 12-months SPEI, on the other hand, picks up very long-run variation. To reflect the short- and medium-term moisture conditions of the land, we therefore select the 4-months SPEI as our measure of climatic conditions in municipalities. This is in line with other studies, such as Harari et al. (2017). We then estimate the effect on productivity and on expenditures using both the linear term of SPEI and a quadratic term in order to capture larger positive and negative deviations. In fact, a larger SPEI indicates better conditions for plants to flourish, but extremely large SPEI indicates conditions with risk of water excess or flooding. Similarly, extremely negative values indicate situations where the risk of drought is larger.

6.2 Empirical Strategy

Our primary empirical strategy would be to exploit the phased implementation of the PIRWA program to new municipalities over time. We primarily rely on a Difference-in-differences (DID) strategy.[10] We detail in this section the empirical strategy followed for the different outcome variables analysed in this report.

To study **program take-up** our analysis is at the municipality level since we observe take-up and repayments only at the municipality level. Our primary specification at the municipality level is given by:

$$Y_{mt} = \alpha_m + I'_{mt}\beta + \sum_{t=1}^{T} \mu_t d_t + X'_{mt}\gamma + \varepsilon_{mt} \qquad (1)$$

where Y_{mt} is take-up for municipality *m* in year *t*, I_{mt} is a matrix with indicators of variables that are targeted by PIRWA for its eligibility (such agricultural intensity and intensity of crops for local consumption), X_{mt} is a vector of additional controls, including household and individual characteristics and geographical controls. α_m is a set of municipality fixed effects and ε_{mt} is a residual idiosyncratic error term picking up unobserved determinants of the outcome of interest, and that we assume to be clustered at the municipality level.

We make use of different indicators of take-up, such as whether a municipality is enrolled in PIRWA, but also the share of eligible land (computed using the 2012 Agricultural Census) that is reported as insured in PIRWA.

To study the impact of PIRWA on **farmers' productivity**, we can rely on information from the two waves of the agricultural survey (2008 and 2015) and we base our analysis on farmer-level observations. We can observe not only information on whether a household resides in a municipality enrolled in PIRWA, but also whether the farmer in farming less than 3 hectares of land and whether the farmer is producing crops that are covered by PIRWA. We create a variable P_m which is equal to the number of years a municipality *m* is enrolled in PIRWA in the year 2015. We create an indicator variable T_i which is equal to one if the farmer is of a type targeted by PIRWA (a small-holder farmer with a total farmed area smaller than 3 hectares and producing one of the nine crops covered by PIRWA in 2015) and zero otherwise. We indicate instead with $Y2015_t$ an indicator variable equal to one if the year of observation is post-introduction of PIRWA (the year is the 2015). To measure the impact of PIRWA of a farmer, we use a difference-in-difference-in-differences (DDD) strategy (Wooldridge 2010). This methodology allows estimating the impact of the insurance program by comparing trends not only across municipalities, but also within municipalities using non-eligible farmers as comparison group. In this setting, the effect of the program is given by the coefficient of the interaction between P_m, T_i, and $Y2015_t$, that we indicate by E_{imt}. This variable indicates whether at time *t*, farmer *i* is eligible to enrol in PIRWA. Our specification is the following:

$$Y_{imt} = \alpha_m + \beta E_{imt} + \delta_P P_m + \delta_T T_i + \delta_Y Y2015_t + \delta_{PT} P_m T_i + \delta_{YP} Y2015_t P_m + \delta_{YT} Y2015_t T_i + \sum_{t=1}^{T} \mu_t d_t + X'_{imt}\gamma + \varepsilon_{imt} \qquad (2)$$

where Y_{imt} is an outcome of interest for farmer *i* living in municipality *m*, X_{imt} is a vector of control variables, including household and individual characteristics, α_m is a set of

[10] We cannot use a regression discontinuity design strategy since multiple criteria were used to choose the municipalities. Given the information available to us, we cannot identify whether a cut-off exists or whether some discretion was allowed in the selection of the eligible municipalities.

municipality fixed effects and ε_{imt} is a residual idiosyncratic error term picking up unobserved determinants of the outcome of interest, and that we assume to be clustered at the municipality level. In terms of outcomes, Y_{imt} includes variables like yield and total inputs used in agriculture. Note that, since we estimate the equation using municipality fixed effects, the coefficients on time invariant variables will not be identified since they are captured by the fixed effects.

To study the impact of PIRWA on **welfare**, we can rely uniquely on information about whether a household resides in a municipality enrolled in PIRWA and whether members of the households are working as small-holder farmers. In this case, we base our analysis at the household level. For our welfare analysis, our primary specification is the following:

$$Y_{imt} = \alpha_m + \beta_0 INS_{mt} + \beta_1 PL_{mt} + \sum_{t=1}^{T} \mu_t d_t + X'_{imt}\gamma + \varepsilon_{imt} \quad (3)$$

where Y_{imt} is an outcome of interest for respondent *i* living in municipality m, PL_{mt} indicates the share of agricultural land that is farmed with crops covered by PIRWA in municipality m at time t, independently of whether the municipality is enrolled in PIRWA at time t, and INS_{mt} is measuring the share of agricultural land that is eligible under PIRWA in municipality m at time t i.e. the interaction between PL_{mt} and a dummy indicating whether the municipality is a PIRWA municipality or not. X_{imt} is a vector of control variables that include household and individual characteristics. α_m is a set of municipality fixed effects and ε_{imt} is a residual idiosyncratic error term picking up unobserved determinants of the outcome of interest, and that we assume to be clustered at the municipality level. In terms of outcomes, Y_{imt} includes variables like household consumption expenditure and household food expenditure.

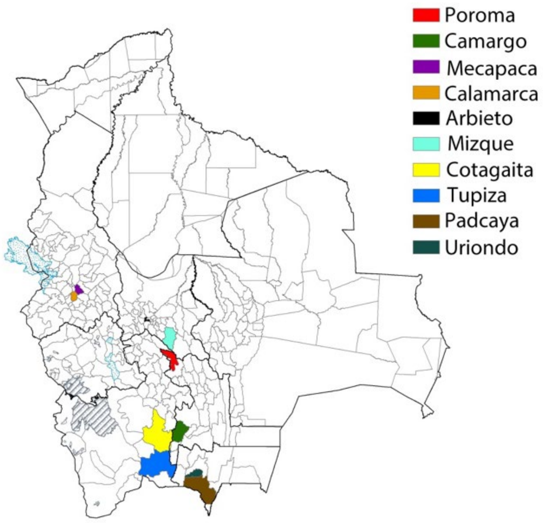
6.3 Focus Group Discussions

We supplement quantitative data with a series of focus group discussions (FGDs) among farmers. The dialogue within the FGDs was designed to gather information about the knowledge and experiences with agricultural insurance. The main objective of the focus groups was to collect information about the main climatic threats to crops and their consequences in each municipality, the farmer's perception of agricultural risk, the usefulness of agricultural insurance while trying to deal with the damage caused by these threats, and, finally, the expectations they had about the possibility of accessing agricultural insurance. Under these parameters, the execution of each focus group was mainly directed towards documenting risk perceptions of producers and identify the positive and negative experiences of farmers in their daily lives, especially the ones related to climate risks. At the same time, the objective was to compare the profile of farmers who own agricultural insurance with those who do not, understand the limitations related to the PIRWA Crop Insurance registration and understanding how farmers make investment decisions when insured and when not insured.

To select participants for FGDs coming from a variety of backgrounds, two municipalities, one with access to insurance and one without access to insurance, were selected in five departments of Bolivia: 1) Chuquisaca (Poroma and Camargo); 2) Potosí (Cotagaita and Tupiza); 3) Tarija (Padcaya and Uriondo); 4) Cochabamba (Mizque and Arbieto); and 5) La Paz (Calamarca and Mecapaca). In the case of the department of

Tarija, farmers had access to two types of crop insurances, but in different municipalities. In Padcaya farmers had access to PIRWA, while in Uriondo, farmers had access to the Vine-Growing Insurance of ALIANZA Seguros, the latter being the only case where that insurance was being offered. Figure 10 shows the location of these 10 municipalities.

Figure 10: Selected Municipalities for the FGDs



Note: own elaboration.

Three types of questionnaires were developed for each type of municipality. Furthermore, individual record sheets that were completed by the participants at the beginning of each session collected the following data: gender of the participant, age of participant, marital status of the participant, language in which the participant learned to speak during childhood, highest educational level reached by the participant, number of people who make up the participant's home and how many of them work, main agricultural product, and secondary economic activities. Table 4 presents summary statistics for the Municipalities selected for the FGDs.

Table 4: General Indicators of Selected Municipalities

Municipality	Total Population	Rural Population (%)	Households with Access to Electricity (%)	Literacy Rate (%)	Poor Population (%)
Arbieto	17,445	79.5	82.0	93.6	58.5
Calamarca	12,413	100.0	74.4	94.5	81.1
Camargo	15,644	66.4	71.8	88.6	62.5
Cotagaita	31,801	79.8	75.2	89.7	69.7
Mecapaca	16,086	100.0	87.4	94.0	63.1
Mizque	26,900	87.0	55.0	84.1	84.5
Padcaya	18,681	100.0	86.5	90.8	59.0
Poroma	17,377	100.0	14.8	78.4	95.9
Tupiza	44,814	38.7	88.9	92.5	39.4
Uriondo	14,781	100.0	79.0	90.9	56.1
BOLIVIA	**1,059,856**	**32.5**	**85.4**	**94.9**	**44.9**

Source: Own elaboration based on the 2012 National Census (INE).

With the aim of reaching out to more farmers we got in touch with Mr. Jerjes Mercado, the Executive Director of the Federation of Municipal Associations of Bolivia (FAM, for its acronym in Spanish). After being briefed about the study, he authorized and supported the coordination with the mayors of the selected municipalities. Letters of request for support, were sent to the ten municipal offices, addressed to the mayors and, later, to the secretaries of productive development in the municipality, under the instructions of the former. Once the secretaries were contacted, they delegated a technician to coordinate all actions directly with INESAD. In most cases, except for Camargo and Arbieto, the technicians were present in the implementation of the focus groups and supported all the logistics in each place.

On the other hand, meetings were held with specialists from the PROFIN Foundation, both before and after the implementation of the focus groups, to be able to share more details about the characteristics of the analysed insurance products. This is how the existence of a pilot scheme of the Risk Transfer Funds, which was carried out almost five years ago, and was reported in two municipalities, Camargo and Arbieto, which were considered as uninsured municipalities, was acknowledged. This caused a small change in the application of the questions and analysis in these two municipalities, and finally only two (Tupiza and Mecapaca) were considered as municipalities without any agricultural insurance.

In total, 141 farmers participated in the FGDs, of whom 16 belonged to the municipality of Poroma, 10 to the municipality of Camargo, 11 to the municipality of Tupiza, 12 to the municipality of Cotagaita, 17 to the municipality of Padcaya, 14 to the municipality of Uriondo, 18 to municipality of Mizque, 10 to the municipality of Arbieto, 12 to the municipality of Calamarca and 21 to the municipality of Mecapaca. Figure 11 shows a moment from the FGDs.

Figure 11: A moment during the FGDs

Note. The picture shows the FGD in the Municipality of Calamarca. Source: Daniela Romero (INESAD).

Table 1 presents an aggregate matrix with the general characteristics of the producers that participated in the ten focus groups. We can observe that most of the participants are men (70.2%), the average age is 46 years, the average number of members in households is 5 and the main economic activity of the participants is agriculture (92.9%). In terms of education, the highest educational level reached by most of the participants is incomplete elementary school (36.9%). Most participants are married (72.3%) and the majority speaks Quechua as their mother tongue (36.9%).

Table 5: General Characteristics Matrix of FGDs Participants

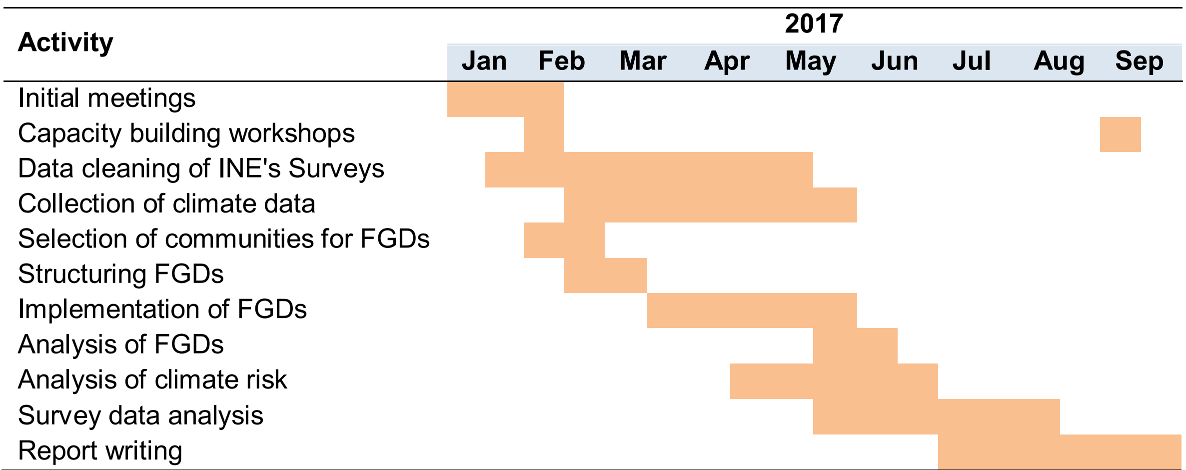
Gender		**Age**		**Marital Status**		**Mother Tongue**		**Education**		**Economic Activity**	
Women		**< 20 years old**		**Single**		**Aymara**		**None**		**Agriculture**	
42	30%	2	1%	33	23%	29	21%	3	2%	131	93%
Men		**21-30 years old**		**Married**		**Quechua**		**Incomplete Primary**		**Breeding**	
99	70%	11	8%	102	72%	52	37%	52	37%	3	2%
		31-40 years old		**Divorced**		**Spanish**		**Complete Primary**		**Mining**	
		32	23%	1	1%	49	35%	20	14%	1	1%
		41- 50 years old		**Widower**		**Bilingual**		**Incomplete Secondary**		**Construction**	
		50	36%	5	4%	11	8%	20	14%	2	1%
		51-60 years old						**Complete Secondary**		**Trade**	
		27	19%					18	13%	1	1%
		60+ years old						**Technical education**		**Professional**	
		19	14%					12	9%	2	1%
								University		**Others**	
								16	11%	1	1%
TOTAL		**TOTAL**		**TOTAL**		**TOTAL**		**TOTAL**		**TOTAL**	
141	**100**	**141**	**100%**	**141**	**100**	**141**	**100**	**141**	**100**	**141**	**100**

Source: Own elaboration.

7. Study timeline

Table 6 shows the timeline of the key activities that were undertaken as part of this report. For each major activity, we highlight its duration throughout the project timeframe.

Table 6: Timeline of Activities

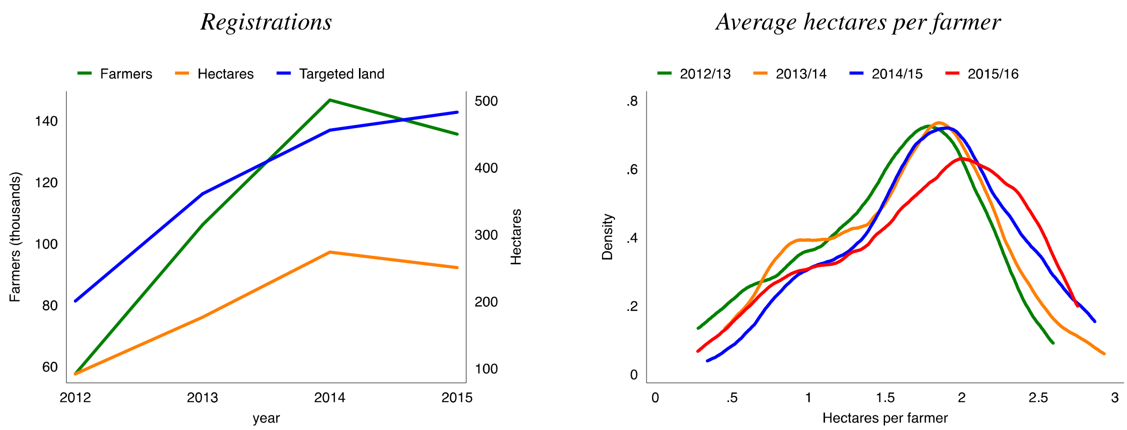


8. Findings from the evaluation

8.1 The 2012-2015 Campaigns: what drives take-up?

In this section, we study the descriptive statistics for take-up and the evolution of the PIRWA program. We begin by focusing on registrations and coverage of the program by making use of administrative data at the municipality level on the number of registered farmers and the amount of land insured. In Figure 12, we present the main features in terms of take-up in the program. In the left panel, we present a plot of the series of the number of registrations in the program by year, both in terms of number of farmers and area in hectares. On the other hand, in the right panel we present the distribution of the average amount of land per farmer that is registered in the PIRWA program. We firstly notice that the average hectares insured per farmer is smaller than 3 hectares, which is the upper bound for eligibility in the program. Secondly, we can observe that, from the 2015/16 campaign, the distribution tends to shift upwards, with the average number of hectares insured per farmer becoming larger.

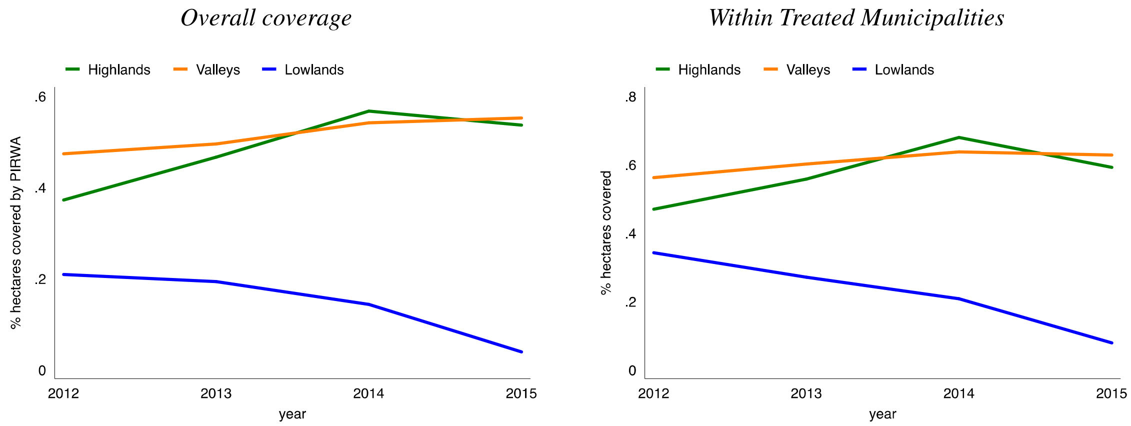
Figure 12: Farmers and hectares registered in PIRWA



Note: the number of hectares is computed at municipality level as the total number of hectares registered in PIRWA divided by the number of farmers registered. Distributions are estimated using a Kernel density. The number of hectares is computed at municipality level as the total number of hectares registered in PIRWA divided by the number of farmers registered. Distributions are estimated using a Kernel density. Source: own elaboration using PIRWA administrative data.

In Figure 13, we present plots of the coverage of the PIRWA program by the three main regions of Bolivia viz. Highlands, Valleys and Lowlands. Coverage is defined as the number of hectares insured under the PIRWA program divided by the number of hectares farmed in the summer, computed using the 2013 Agricultural Census. In the left panel of Figure 13 we present the coverage of the PIRWA program over the total farmed land in Bolivia, while in the right panel we restrict the sample to only the treated municipalities. We can observe large differences between the Highlands and Valleys on the one hand, which present similarities, and the Lowlands on the other hand, where the coverage is low.

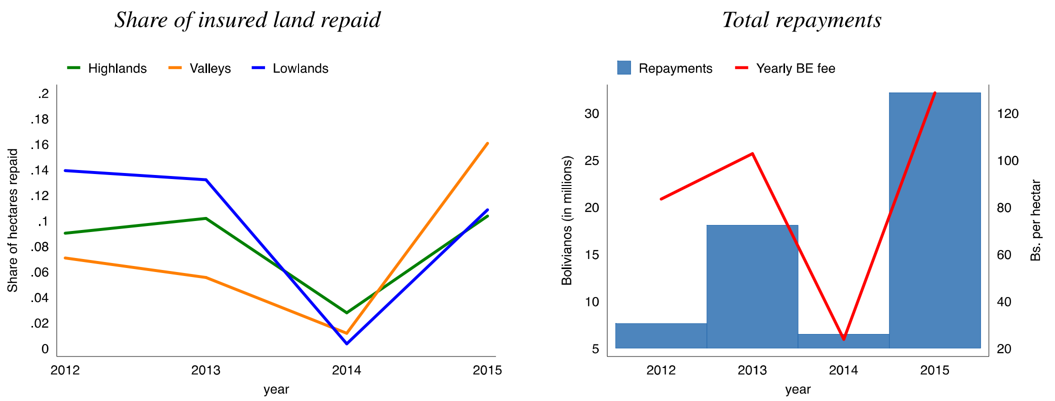
Figure 13: Share of eligible agricultural land covered by PIRWA



Note: the figures show the share of eligible land (defined as hectares farmed with PIRWA-covered crops) that is registered in PIRWA. The share of eligible land is computed using the Agricultural Census in 2012, while the land registered in PIRWA is computed using administrative data. In the left panel, we include all municipalities, while in the right panel, the sample is restricted to municipalities enrolled in PIRWA. Source: own elaboration using PIRWA administrative data.

In Figure 14, we plot the actual compensations from the PIRWA program. In the left panel of Figure 5 we present the share of insured land that is recognized as damaged due to adverse climatic events and hence receives repayment under the PIRWA program.

Figure 14: Compensations

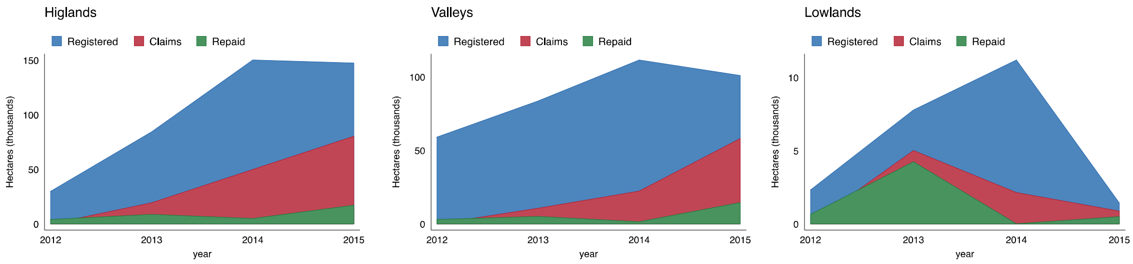


Note: the share of insured land repaid is computed as the number of hectares for which repayments were recognized divided by the hectares registered in the PIRWA program. The total repayments are computed as number of hectares for which repayment was recognized, multiplied by 1000 Bs, the compensation fixed under the PIRWA program. Source: own elaboration using PIRWA administrative data.

The 2014/15 campaign hits a minimum in terms of repayments, with a share of around 1 to 4% of insured land. The right panel presents instead total repayments for each campaign of the PIRWA program. Repayments are computed as the number of hectares for which repayment was recognized, multiplied by 1 000 Bs, the compensation fixed under the PIRWA program. The break-even fee is computed by balancing total repayments with a hypothetical fee paid for each registered hectare. This fee is therefore not considering the costs for running the program.

In terms of registrations, claims and repayments, the program presents very distinctive characteristics in Highlands, Valleys and Lowlands. Figure 15 presents the composition of these components over time by distinguishing between the different geographic areas.

Figure 15: Registered, claimed and repaid land



Note: the figure shows the composition of registered, claimed and repaid land using PIRWA administrative data. Source: own elaboration using PIRWA administrative data.

We then study what determined take-up in PIRWA. We estimate the role of determinants of take-up using the models presented in section 5.3.1. We begin by analysing program participation at the municipality-level. We first focus on descriptive characteristics of municipalities, depending on their participation in the PIRWA program. Table 7 presents demographic and agricultural characteristics of municipalities that never participated in PIRWA and of municipalities that participated in different campaigns of the program.

PIRWA municipalities tend to be smaller and have a much larger share of agricultural land. At the same time, the number of APUs is comparable, but in PIRWA municipalities these tend to be very small (the average size of APUs in PIRWA municipalities is 8 hectares versus 145 hectares in non-PIRWA municipalities). As expected, PIRWA municipalities tend to depend more on the production of crops covered by the insurance program and have larger shares of poor and extreme poor population. This is also reflected in a lower access to public services (such as access to piped water, electricity and sewerage) and in a worse average asset ownership. In terms of human capital, PIRWA municipalities have lower literacy rates (around 85% versus 95% in non-PIRWA municipalities) and a smaller number of average years of schooling (6 versus 8 years in non-PIRWA municipalities). The overall figure suggests that PIRWA municipalities have all the characteristics, in terms of demographics and agricultural production, of being poorer compared to non-PIRWA municipalities.

Table 7: Municipality-level demographics, by year of participation

	Participation in the PIRWA Program				
	Never	**2012/13**	**2013/14**	**2014/15**	**2015/16**
Total Area (ha, log)	10.48	9.56	9.68	9.6	9.47
	[2.08]	[1.24]	[1.23]	[1.49]	[1.56]
Agricultural share of land	0.35	0.53	0.53	0.52	0.53
	[0.30]	[0.29]	[0.28]	[0.28]	[0.28]
Number of APUs (log)	7.26	7.73	7.80	7.78	7.69
	[1.06]	[0.67]	[0.71]	[0.71]	[0.79]
Hectares per APU	144.82	13.59	18.28	26.06	20.62
	[289.80]	[20.89]	[44.55]	[112.10]	[60.82]
Share using irrigation	0.16	0.22	0.22	0.23	0.23
	[0.23]	[0.20]	[0.22]	[0.24]	[0.25]
Sh. of agricultural land eligible	0.43	0.81	0.80	0.76	0.78
	[0.35]	[0.14]	[0.16]	[0.19]	[0.18]
Sh. of Poor Population	0.61	0.85	0.83	0.80	0.80
	[0.20]	[0.08]	[0.09]	[0.11]	[0.11]
Sh. of Extreme Poor Population	0.12	0.28	0.27	0.25	0.25
	[0.10]	[0.11]	[0.11]	[0.12]	[0.12]
Access to Piped Water	0.69	0.65	0.63	0.64	0.63
	[0.24]	[0.17]	[0.16]	[0.16]	[0.17]
Access to Electricity	0.76	0.53	0.57	0.61	0.61
	[0.17]	[0.17]	[0.17]	[0.18]	[0.18]
Access to Sewage	0.46	0.25	0.25	0.28	0.28
	[0.22]	[0.14]	[0.13]	[0.16]	[0.16]
Sh. owning TV	0.51	0.25	0.26	0.30	0.30
	[0.23]	[0.10]	[0.12]	[0.14]	[0.15]
Sh. owning Telephone	0.51	0.28	0.31	0.35	0.34
	[0.20]	[0.10]	[0.11]	[0.13]	[0.14]
Sh. owning computer	0.12	0.03	0.04	0.04	0.04
	[0.10]	[0.02]	[0.03]	[0.03]	[0.03]
Access to Internet	0.04	0.00	0.01	0.01	0.01
	[0.04]	[0.00]	[0.01]	[0.01]	[0.01]
Literacy rate	0.95	0.84	0.86	0.88	0.88
	[0.03]	[0.06]	[0.06]	[0.06]	[0.06]
Average years of schooling	8.00	5.07	5.52	5.83	5.93
	[1.18]	[1.20]	[1.31]	[1.32]	[1.38]

Note: standard deviations in parenthesis.

Since PIRWA is an insurance program that is targeting adverse weather events, we now focus on the comparison between PIRWA and non-PIRWA municipalities in terms of climate-related variables. Table 8 presents summary statistics for these variables according to the participation in PIRWA. PIRWA municipalities tend to be colder, with lower daytime and night-time temperatures, but also drier and with less extreme rainfalls. Degree-days (DD) are on average around 9 degrees per day in PIRWA municipalities and 11 degrees in non-PIRWA municipalities. In terms of Harmful Degree-days (HDD), the groups are relatively more comparable, with around 2.5 degrees per day in PIRWA municipalities and around 3 degrees in non-PIRWA municipalities. In terms of precipitation during the growing season, the difference is of around 1.5 millimetres per day, with 3.5 millimetres per day in PIRWA municipalities and around 5 millimetres per day in non-PIRWA municipalities.

Table 8: Municipality-level weather characteristics, by year of participation

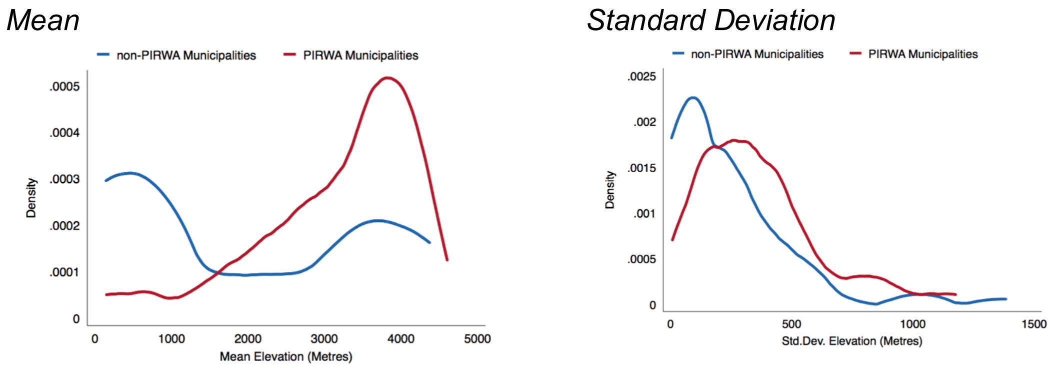
	Participation in the PIRWA Program				
	Never	**2012/13**	**2013/14**	**2014/15**	**2015/16**
DD (lagged)	11.28	9.44	8.99	9.05	8.6
	[4.93]	[5.98]	[5.56]	[5.60]	[5.38]
DD	11.33	9.44	8.98	9.05	8.61
	[4.96]	[5.98]	[5.59]	[5.63]	[5.41]
HDD (lagged)	3.1	2.55	2.73	2.63	2.86
	[3.38]	[2.19]	[2.50]	[2.48]	[2.58]
HDD	3	2.42	2.6	2.51	2.75
	[3.37]	[2.13]	[2.44]	[2.42]	[2.52]
Precipitation (lagged)	4.88	3.56	3.41	3.32	3.31
	[2.68]	[1.02]	[1.11]	[1.03]	[1.21]
Precipitation Squared (lagged)	30.95	13.72	12.88	12.09	12.44
	[34.04]	[8.45]	[9.13]	[8.21]	[10.78]
Precipitation	4.92	3.58	3.43	3.35	3.34
	[2.72]	[1.02]	[1.10]	[1.01]	[1.21]
Precipitation Squared	31.56	13.85	12.99	12.24	12.64
	[34.43]	[8.38]	[8.99]	[8.05]	[10.82]
Elevation (mean)	1.83	2.99	3.15	3.16	3.27
	[1.61]	[0.84]	[0.90]	[0.95]	[0.91]
Elevation (std. dev.)	0.23	0.44	0.39	0.35	0.35
	[0.25]	[0.24]	[0.25]	[0.23]	[0.24]
Daytime LST (2000-15)	26.25	23.78	24.01	24.02	23.99
	[3.21]	[2.84]	[2.83]	[2.99]	[3.20]
Night-time LST (2000-15)	12	6.88	5.75	5.77	5.14
	[8.93]	[4.53]	[5.16]	[5.35]	[5.30]
Precipitation (2000-15)	2.8	1.83	1.74	1.7	1.68
	[1.58]	[0.58]	[0.66]	[0.62]	[0.71]

Note: standard deviations in parenthesis.

The association between weather and municipality-level take-up is possibly related to elevation, since as we previously discussed PIRWA is targeting crops that are mainly produced in the region of the country with higher elevations. In fact, PIRWA municipalities are on average 1000 meters higher in term of average elevation, but also the standard deviation of elevation is double, therefore showing a higher degree of roughness or ruggedness of the territory.

Figure 16 shows a comparison in terms of mean (left panel) and standard deviation (right panel) of elevation at the municipality level. PIRWA municipalities are concentrated in high-elevation areas, while non-PIRWA municipalities are concentrated in both high- and low-elevation areas. In terms of territory roughness, measured by the standard deviation of elevation within a municipality, we can observe that PIRWA municipalities have a slightly higher standard deviation. Both results are also suggestive of agricultural characteristics of the areas enrolled in PIRWA. In fact, crops covered by PIRWA are farmed especially in areas of the country characterized by higher altitude and in the valleys.

Figure 16: PIRWA Participation and Elevation



Note: own calculations using world elevation maps at cell-level (NASA: ASTER).

Next, we analyse how these characteristics affect the **take-up at the municipality level**. In columns (1) to (3) of Table 9, we present the results estimating equation 2 to understand the determinants of program participation. The dependent variable is an indicator variable equal to 1 if the municipality is enrolled in PIRWA at time *t* and zero otherwise. We use department fixed effects in columns 1 and 2, and in column 3, we include municipality fixed effects. While, our aim is primarily to estimate a municipality level fixed effects model, we leave out the municipality fixed effects in some of the specifications due to the time invariant nature of some of our control variables of interest. All specifications always include year fixed effects which control for annual macro-economic shocks affecting the whole country.

From Table 13, we notice that the main determinants of participation in PIRWA are the demographic characteristics targeted by the program. A higher share of agricultural land that is farmed with the crops targeted by PIRWA leads to an increase of 40% in take-up of the program. Similarly, higher poverty rates also increase take-up. We need to note that extreme poverty instead has a negative effect on participation. This can be related to the decision of these municipalities to focus on alternative programs instead of PIRWA. We can also observe that PIRWA targeted specifically a certain type of crops. However, larger dependence on agriculture (independently from the crops farmed), while being targeted by PIRWA, do not predict take-up.

Weather conditions also predict take-up. Considering the municipality fixed effects model in column 3, we notice that degree days and it lagged values reduce take-up. In other words, municipalities that had a positive weather shock in the year before the program decided not to enrol in the program. Similarly, municipalities that had extreme weather shocks (increases in HDD) in the year of the program were more likely to be enrolled in the program whereas such shocks in the previous year reduced the probability of being enrolled, but these results with HDD are not significant. As far as precipitation is concerned, we observe that higher precipitation reduces take-up (similar to DD), but extreme rain increases take-up. This suggests there might be heterogeneities in the effect of weather shocks on take-up.

Access to services does not seem to affect take-up, apart from access to sewerage which significantly reduces take-up. In terms of education, average schooling reduces program take-up. Analysed together, these two findings are probably related to higher poverty in PIRWA municipalities.

Table 9: Determinants of participation and take-up

Dependent Variables:	**Enrolled in PIRWA**			**Share of eligible land insured**		
Sub-sample:	*All Municipalities*			*Only PIRWA Municipalities*		
	OLS	OLS	FE	OLS	OLS	FE
	(1)	(2)	(3)	(4)	(5)	(6)
Ha. farmed with eligible crops	0.002	0.003	0.005	-0.018***	-0.024***	-0.066**
	(0.004)	(0.004)	(0.005)	(0.006)	(0.008)	(0.031)
Sh. of agricultural land eligible	0.325***	0.366***	0.424***	0.426***	0.301***	0.732**
	(0.054)	(0.062)	(0.058)	(0.087)	(0.106)	(0.361)
Sh. of Poor Population	0.631***	0.518***		0.507**	-0.095	
	(0.112)	(0.157)		(0.235)	(0.331)	
Sh. of Extreme Poor Population	0.345*	-0.636***		-0.272	-0.932***	
	(0.201)	(0.222)		(0.250)	(0.343)	
Agricultural sh. of land	0.129**	-0.014		0.071	-0.043	
	(0.057)	(0.052)		(0.088)	(0.102)	
DD (lagged)		-0.028**	-0.038**	-0.028	-0.027	-0.020
		(0.014)	(0.019)	(0.019)	(0.020)	(0.023)
DD		-0.040***	-0.042**	-0.028	-0.020	-0.008
		(0.015)	(0.019)	(0.019)	(0.019)	(0.023)
HDD (lagged)		-0.016	0.003	-0.037**	-0.030*	-0.011
		(0.011)	(0.016)	(0.017)	(0.017)	(0.026)
HDD		-0.047***	-0.020	-0.016	-0.009	0.019
		(0.012)	(0.018)	(0.017)	(0.017)	(0.027)
Precipitation (lagged)		-0.090***	-0.158***	-0.039	-0.043	-0.025
		(0.029)	(0.041)	(0.080)	(0.083)	(0.117)
Precipitation Squared (lagged)		0.002	0.006**	-0.003	-0.002	-0.005
		(0.002)	(0.002)	(0.007)	(0.008)	(0.012)
Precipitation		-0.038	-0.070*	0.052	0.069	0.147
		(0.032)	(0.042)	(0.087)	(0.083)	(0.123)
Precipitation Squared		-0.001	0.001	-0.012	-0.014*	-0.022*
		(0.002)	(0.002)	(0.009)	(0.008)	(0.013)
Elevation (mean)		-0.104*		0.110	0.047	
		(0.057)		(0.085)	(0.089)	
Daytime LST (2000-15)		0.047***		0.057***	0.061***	
		(0.012)		(0.016)	(0.017)	
Night-time LST (2000-15)		0.002		0.015	0.001	
		(0.008)		(0.011)	(0.012)	
Precipitation (2000-15)		0.126***		0.243**	0.250**	
		(0.044)		(0.093)	(0.105)	
Total Area (ha, log)		-0.008			-0.044*	
		(0.011)			(0.022)	
Number of APUs (log)		0.011			0.107***	
		(0.018)			(0.034)	
Sh. of using irrigation		0.086			-0.154*	
		(0.061)			(0.091)	
Access to Electricity		0.108			0.050	
		(0.173)			(0.213)	
Access to Sewage		-0.393***			-0.145	
		(0.060)			(0.117)	
Average years of schooling		-0.043**			-0.062	

Dependent Variables:	Enrolled in PIRWA			Share of eligible land insured		
Sub-sample:	*All Municipalities*			*Only PIRWA Municipalities*		
	OLS	OLS	FE	OLS	OLS	FE
	(1)	(2)	(3)	(4)	(5)	(6)
		(0.021)			(0.039)	
Observations	1695	1685	1685	660	660	660
R-squared	0.466	0.557	0.700	0.456	0.508	0.734
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Department FE	Yes	Yes	Yes	Yes	Yes	Yes
Municipality FE	No	No	Yes	No	No	Yes
Other Asset Controls	No	Yes	Yes	No	Yes	Yes

*Note: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.* Standard deviations in parenthesis. In columns (1)-(3), the dependent variable is a dummy variable equal to 1 if the municipality in enrolled in PIRWA at time t and zero otherwise. In columns (4)-(6), the dependent variable is the share of land registered in PIRWA out of the total land farmed crops covered by PIRWA (built using the INE 2012 Agricultural Census). Hectares farmed with eligible crops are reported in Thousands. If not otherwise reported, weather variables are measured during the growing season. Precipitation is reported in average daily millimetres. Time is restricted to the period 2012-2015.

We then analyse the **take-up of the insurance within municipalities**. We focus on the percentage of eligible land that is registered in PIRWA. To build this measure we make use of the 2012 INE Agricultural Census to build the total land farmed with crops covered by PIRWA. We assume this to be exogenous and time-invariant, since it is measured in the year before the introduction of PIRWA and because we do not want our measure to be affected by changes in the area farmed with these crops as a response of the introduction of the program.

We then make use of administrative data about the hectares of land registered in PIRWA, which we divide by the eligible land to have a measure of take-up within each municipality. The results are presented in columns (4) to (6) of Table 9. Similar to the analysis of municipality-level take-up, we use department fixed effects in columns 4 and 5, and in column 6, we include municipality fixed effects. While, our aim is primarily to estimate a municipality level fixed effects model, we again leave out the municipality fixed effects in some of the specifications due to the time invariant nature of some of our control variables of interest. All specifications always include year fixed effects which control for annual macro-economic shocks affecting the whole country.

Take-up within each municipality is mainly driven by its dependence on PIRWA crops. First, larger areas farmed with these crops reduces take-up. This is possibly explained by a limited effort of the government in advertising the program in municipalities where a larger number of farmers need to be reached. Secondly, a larger relative dependence of the agricultural sector on these crops increases take-up significantly. This suggests that PIRWA managed to target municipalities where the dependence on targeted crops is larger, but where the overall extent of these crops in terms of hectares was smaller.

Similar to municipality-level take-up analysis looking at all municipalities, focussing on only PIRWA municipalities, municipalities with a higher share of extreme poor population have a lower take-up. This might be explained by the limited ability of farmers in these municipalities to obtain information about the program or due to the high cost of travelling to register for PIRWA. Weather shocks do not seem to matter for within-municipality take-up, even if average conditions in terms of average temperature and daily precipitation in the 2000-15 period are positively correlated with take-up.

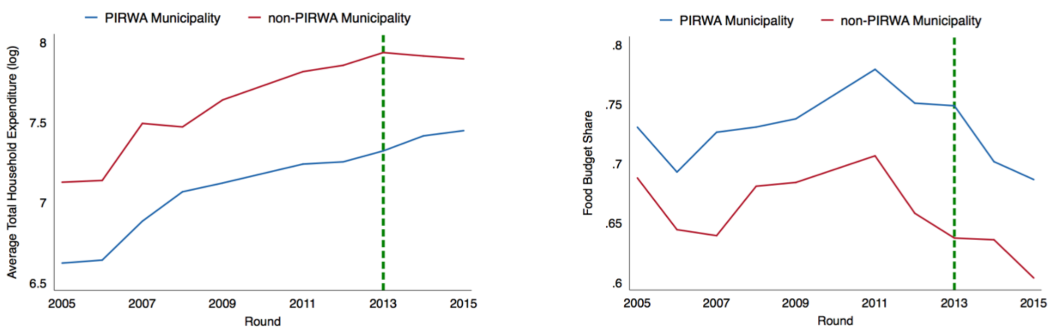
Overall, we tried to analyse potential correlates for take-up, but we cannot test for alternative mechanisms behind the lower-than-full coverage of a free insurance. Due to data limitations, we can therefore only acknowledge potential mechanisms behind these results. Firstly, one possible story behind the fact that farmers do not enrol in PIRWA is incomplete information. For instance, the lack of understanding, the presence of scepticism among farmers, or just being uninformed about the campaign or about its requirements, might lead take-up to lower levels. Informal information channels might affect take-up, which could explain why in municipalities where the number APUs is larger, take-up tends to be larger too. Secondly, cost of registration can also be another explanation. Assuming that the farmer is informed about PIRWA and about the requirements for the registration, given the geography of the country, especially in the highlands, travelling to the closest registration point and leaving the farm for a day might be an expensive cost for a highly budget constrained farmer. Due to data limitation, we cannot control for take-up by distance from the closest registration point.

PIRWA and non-PIRWA municipalities are indeed different on several dimensions. We therefore want to understand whether the differences between PIRWA and non-PIRWA municipalities are also driving the way they evolve over time. In other words, we look specifically at whether our comparison groups are comparable over time. We first focus on whether we can compare farmers across PIRWA and non-PIRWA municipalities. We consider the municipalities that have been in PIRWA in any one of the first campaigns in the period 2012-2015 as PIRWA municipalities and the municipalities that have never been enrolled in PIRWA as non-PIRWA municipalities.

Figure 17 shows a comparison over time between these two groups for four different variables: total household expenditure, and food budget share. Farmers in PIRWA municipalities tend to be poorer than the farmers in non-PIRWA municipalities, but the behaviour of the selected outcome variables over time for these two groups is comparable. Figure 18 shows instead a comparison over time in terms of weather conditions, namely daytime temperature and daily precipitation. We observe that non-PIRWA municipalities tend to have higher temperatures and more precipitation (both also linked to average). The behaviour over time of these variables is also in line with our previous results.

Figure 17: Common trend between PIRWA and non-PIRWA municipalities

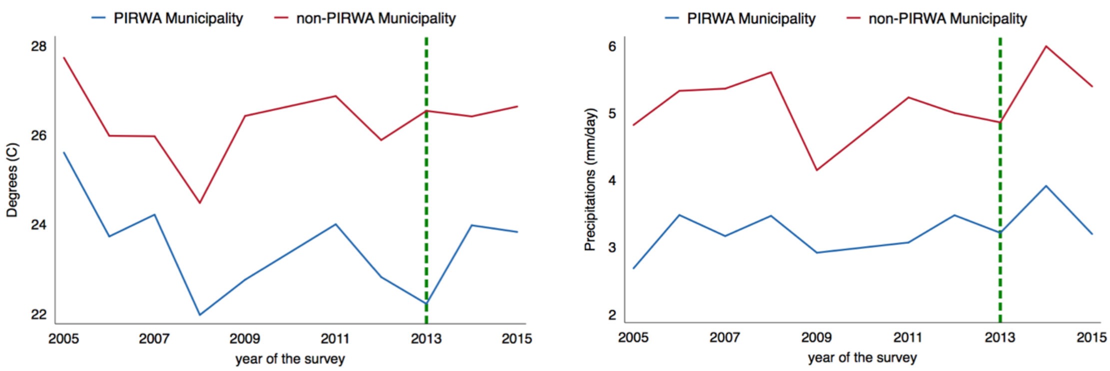
Total Household Expenditure *Food Budget Share*



Note: own calculations using INE's Household Survey in the period 2005-2015. The figures present yearly averages for each group. Each panel presents a different variable. The dotted line shows the first campaign of PIRWA. PIRWA Municipalities include all municipalities that have been enrolled in PIRWA in the period 2012-2015.

Figure 18: Weather comparison between PIRWA and non-PIRWA municipalities

Daytime Temperature *Precipitation*



Note: own calculations using INE's Household Survey in the period 2005-2015. The figures present yearly averages for each group. Each panel presents a different variable. The dotted line shows the first campaign of PIRWA. PIRWA Municipalities include all municipalities that have been enrolled in PIRWA in the period 2012-2015.

8.2 The Effect on Productivity and Agricultural Inputs

In this section, we estimate the effects of being exposed to the PIRWA program on individual level consumption and food expenditure of individuals living in the treated municipalities.

We begin by focusing on productivity of farmers by measuring the impact of being eligible for PIRWA at time *t* on average yields at farmer-level. Table 10 presents estimates of the impact on an extra year of eligibility in PIRWA on yields. We observe that PIRWA is beneficial in terms of yields, but significance is not robust to the choice of the comparison group. In fact, an extra year of eligibility leads to an increase in yields by around 15% when we include farmers up to 10 hectares of production in the sample. The estimate is reduced to around 7%, not statistically significant, when we compare only small-holder farmers.

Table 10: The Effect of Years in PIRWA on Average Yields

	Dependent Variable: Average Yield (log)					
Sub-sample:	< 10 ha.	< 10 ha.	< 10 ha.	< 5 ha.	< 3 ha.	Farming PIRWA crops
	(1)	(2)	(3)	(4)	(5)	(6)
PIRWA Effect	0.153*	0.169*	0.181**	0.128	0.065	0.085
	(0.091)	(0.092)	(0.090)	(0.107)	(0.139)	(0.084)
T x P	-0.081	-0.091	-0.101	-0.072	0.012	-0.073
	(0.089)	(0.089)	(0.088)	(0.099)	(0.131)	(0.086)
T x Y	-0.209	-0.213	-0.200	-0.323**	-0.502***	0.100
	(0.131)	(0.138)	(0.140)	(0.157)	(0.183)	(0.134)
P x Y	-0.176*	-0.184*	-0.187*	-0.138	-0.070	-0.119
	(0.089)	(0.095)	(0.097)	(0.115)	(0.143)	(0.085)
Observations	14737	14667	14667	13390	12663	12610
Municipality FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Additional Controls	No	Yes	Yes	Yes	Yes	Yes
Year x Department FE	No	No	Yes	No	Yes	Yes

Note: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. Standard errors in parenthesis are clustered at municipality level. The dependent variable is the average yield at farm-level, measured in kg/ha and reported in logarithm. PIRWA Effect is the effect of an extra year of eligibility in PIRWA. Additional controls include gender and education of the household head, household size. The time period is restricted to 2008 and 2015, when data is available.

Since PIRWA is targeted at the poorest municipalities, but also at municipalities with higher agricultural intensity (defined as % of total land that is agricultural land), we check whether the results are driven by a comparison that is too broad in terms of poverty rates and in terms of agricultural intensity. Table 11 presents estimates of the impact of years of eligibility in PIRWA on average yield when restricting the sample in terms of municipality-level poverty rates and in terms of agricultural intensity. In terms of poverty rates, we can observe that restricting the sample is not affecting the estimate, which is relatively robust when excluding municipalities where the percentage of poor households is smaller than 25% or is smaller than 75%. In terms of agricultural intensity, we can observe that the highest increase in yields is happening in municipalities with larger agricultural intensity. These results suggest that the effect of PIRWA is larger in municipalities where the national insurance was more diffused.

Table 11: The Effect of PIRWA on Average Yields, by poverty and agricultural intensity

	Dependent Variable: Average Yield (log)					
Sub-sample:	Poverty Rate			Agricultural Intensity		
	> 25%	>50%	>75%	>25%	>50%	>75%
	(1)	(2)	(3)	(4)	(5)	(6)
PIRWA Effect	0.059	0.051	0.043	0.049	0.026	0.279**
	(0.063)	(0.065)	(0.092)	(0.074)	(0.108)	(0.124)
T x P	0.010	0.024	-0.005	0.030	0.100	-0.071
	(0.058)	(0.062)	(0.098)	(0.068)	(0.105)	(0.141)
T x Y	0.121	0.122	0.229	0.178	0.258	-0.085
	(0.080)	(0.094)	(0.168)	(0.132)	(0.179)	(0.219)
P x Y	-0.046	-0.048	-0.081	-0.017	0.076	-0.127
	(0.072)	(0.078)	(0.120)	(0.086)	(0.115)	(0.138)
Observations	14081	12347	6494	8911	5513	2527
Municipality FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Additional Controls	No	Yes	Yes	Yes	Yes	Yes
Year x Department FE	No	No	Yes	No	Yes	Yes

Note: *** p < 0.01, ** p < 0.05, * p < 0.1. Standard errors in parenthesis are clustered at municipality level. The dependent variable is the average yield at farm-level, measured in kg/ha and reported in logarithm. Additional controls include gender and education of the household head, household size. The time period is restricted to 2008 and 2015, when data is available.

To understand why PIRWA has a positive effect on yields, we focus on agricultural inputs, measured by the total expenditure on agricultural inputs (reported in logs). Table 12 shows the estimates of the impact of years of eligibility in PIRWA. We can observe that across different samples, PIRWA increases the inputs in agriculture, but again it is not statistically significant when we take as comparison group only small-holder farmers.

Table 12: The Effect of Years in PIRWA on Inputs

	Dependent Variable: total log expenditure on agricultural inputs					
Sub-sample:	< 10 ha.	< 10 ha.	< 10 ha.	< 5 ha.	< 3 ha.	Farming PIRWA crops
	(1)	(2)	(3)	(4)	(5)	(6)
PIRWA Effect	0.255*	0.092	0.081	0.125	0.157	0.049
	(0.146)	(0.122)	(0.118)	(0.140)	(0.221)	(0.118)
T x P	-0.162	-0.043	-0.039	-0.086	-0.044	0.065
	(0.123)	(0.100)	(0.097)	(0.125)	(0.205)	(0.097)
T x Y	-0.733***	-0.231	-0.265	-0.376**	-0.668***	-0.486***
	(0.219)	(0.165)	(0.164)	(0.181)	(0.209)	(0.170)
P x Y	-0.283*	-0.041	-0.035	-0.094	-0.105	0.012
	(0.154)	(0.138)	(0.128)	(0.148)	(0.230)	(0.127)
Observations	9370	9330	9330	8373	7856	7993
Municipality FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Additional Controls	No	Yes	Yes	Yes	Yes	Yes
Year x Department FE	No	No	Yes	No	Yes	Yes

Note: *** p < 0.01, ** p < 0.05, * p < 0.1. Standard errors in parenthesis are clustered at municipality level. The dependent variable is the total farm expenditure on agricultural inputs, reported in logarithm. Additional controls include gender and education of the household head, household size. The time period is restricted to 2008 and 2015, when data is available.

8.3 The Effect on Household Expenditure

In this section, we estimate the effects of being exposed to the PIRWA program on individual level consumption and food expenditure of individuals living in the treated municipalities.

Information about farmers' welfare can be obtained using the yearly household survey provided by INE. Using information about purchases, we build a measure of total household expenditure and we restrict the sample only to households where at least one member is declaring to be working as a small-holder agricultural farmer. Since we only observe information on whether a household is a farming household, but not the exact crops they grow, we cannot measure the impact of PIRWA on eligible households. However, we can measure the effect of varying the share of the agricultural land in a municipality that is insured under PIRWA (measured as eligible land rather than insured land).

Table 13 measures the effect of PIRWA on total household expenditure. In columns (4)-(6), we also control for the share of agricultural land that is farmed with crops covered by PIRWA, independently on whether a municipality at time *t* is enrolled in PIRWA. Increasing the share of land that is insured has an average positive effect on household expenditure. However, in our most conservative specification, where we control for Department-specific fixed effects, the coefficient becomes very small and not statistically significant. These results suggest that there are not significant effects on total household expenditure of farmers by increasing the share of land insured. However, we need to be cautious with these results since we cannot identify eligible farmers, and we cannot discriminate between small-holder farmers and larger farmers.

Table 13: The Effect of PIRWA on Household Expenditures

	Dependent Variable: Total Household Expenditure (log)					
	(1)	(2)	(3)	(4)	(5)	(6)
Sh. of eligible land	0.090*	0.076*	0.024	0.079	0.047	0.019
	(0.049)	(0.043)	(0.045)	(0.053)	(0.045)	(0.046)
Sh. of agr. land farmed with PIRWA crops				0.037	0.108**	0.031
				(0.060)	(0.053)	(0.049)
Observations	14503	14445	14445	14503	14445	14445
Municipality FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Additional Controls	No	Yes	Yes	No	Yes	Yes
Year x Department FE	No	No	Yes	No	No	Yes

Note: *** p < 0.01, ** p < 0.05, * p < 0.1. Standard errors in parenthesis are clustered at municipality level. The dependent variable is the total household expenditure, reported in logarithm. Additional controls include gender and education of the household head, household size. The time period is restricted to 2008 and 2015, when data is available.

We then turn our attention to food expenditure. Table 14 shows the results for the effect of increasing insured land when the dependent variable is expenditure of food (reported in logs). Similar to total household expenditure, in our most conservative specification, we cannot identify significant effects on food expenditure. However, when not controlling for the share of agricultural land farmed with PIRWA-eligible crops and not controlling for Department-specific fixed effects, we can observe an increase in food expenditure of

11%. This result suggests that there might be sample selection in the selection of municipalities participating in PIRWA that might be picked up by the Department-specific fixed effects. In fact, when controlling for the share of agricultural land farmed with PIRWA eligible crops and not controlling for Department-specific fixed effects, our estimate decrease to 5% and is not significant.

Table 14: The Effect of PIRWA on Food Expenditure

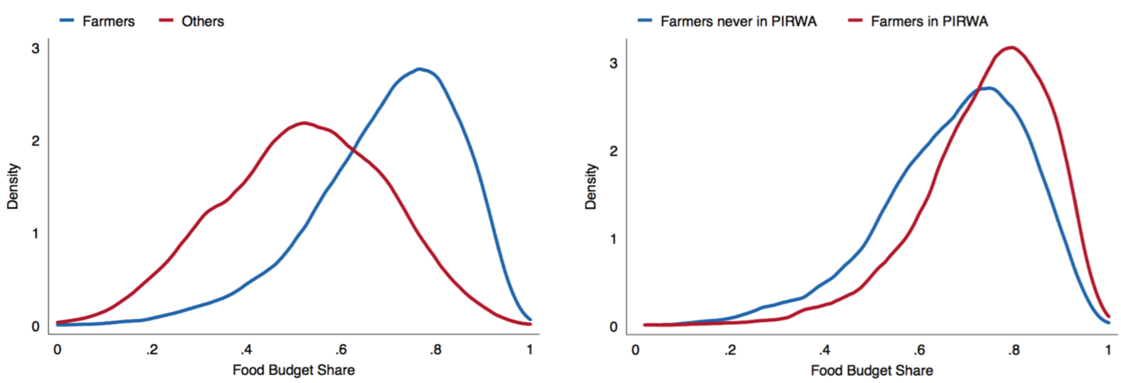
	Dependent Variable: Household Expenditure on Food (log)					
	(1)	(2)	(3)	(4)	(5)	(6)
Sh. of eligible land	0.114**	0.119***	0.054	0.084	0.065	0.039
	(0.046)	(0.041)	(0.043)	(0.051)	(0.045)	(0.046)
Sh. of agr. land farmed with PIRWA crops				0.098	0.194***	0.083*
				(0.060)	(0.054)	(0.049)
Observations	15515	15448	15448	15515	15448	15448
Municipality FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Additional Controls	No	Yes	Yes	No	Yes	Yes
Year x Department FE	No	No	Yes	No	No	Yes

Note: *** p < 0.01, ** p < 0.05, * p < 0.1. Standard errors in parenthesis are clustered at municipality level. The dependent variable is the household expenditure on food, reported in logarithm. Additional controls include gender and education of the household head, household size. The time period is restricted to 2008 and 2015, when data is available.

In terms of welfare analysis, we are also interested on whether farmers tend to allocate expenditure differently when the share of agricultural land that is insured in a municipality increases. To this purpose, we look at the food budget share. This is defined as total food expenditure divided by total household expenditure. Figure 19 shows a comparison between the distributions of food budget shares. In the left panel, we compare farmers versus other households. We can observe that farmers are allocating a much larger share of their budget to food compared to non-farmers, with an average share of around 70%. This suggests, as expected, that farmers are the poorest share of the Bolivian population.

Figure 19: Food budget share comparison

Farmers versus non-farmers **PIRWA versus non-PIRWA**



Note: own elaboration using INE's Household Survey in the pre-PIRWA period (2005-2012).

In the right panel, we compare instead the distribution of food share in the pre-PIRWA years for farmers living in municipalities that will enrol in PIRWA and municipalities that never enrolled in PIRWA. We can see that farmers in PIRWA municipalities tend to allocate slightly higher shares to food, meaning that PIRWA was indeed targeting municipalities where poorer farmers are living.

We are then interested in understanding whether access to PIRWA had an effect in the way households allocated their expenditure to food items. Table 15 shows the estimates of the effect of increasing insured land on the food budget share of farmers. We observe that increasing insured land does not affect the way farmers allocate expenditure to food. At the same time, not surprisingly, we observe that municipalities where the share of agricultural land farmed with PIRWA-covered crops presents a larger budget share for food. In fact, being this an indicator of poverty, we would expect PIRWA municipalities to present this pattern. However, this is a small coefficient, with an increase of 3 to 4% in the food budget share when the share of agricultural land farmed with PIRWA crops goes from zero to one.

Table 15: The Effect of PIRWA on Food Budget Share

	Dependent Variable: Food Budget Share					
	(1)	(2)	(3)	(4)	(5)	(6)
Sh. of eligible land	0.009	0.019*	0.004	-0.001	0.006	-0.001
	(0.011)	(0.011)	(0.011)	(0.012)	(0.011)	(0.011)
Sh. of agr. land farmed with PIRWA crops				0.033**	0.048***	0.029
				(0.015)	(0.014)	(0.018)
Observations	15008	14950	14950	15008	14950	14950
Municipality FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Additional Controls	No	Yes	Yes	No	Yes	Yes
Year x Department FE	No	No	Yes	No	No	Yes

Note: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. Standard errors in parenthesis are clustered at municipality level. The dependent variable is the household's food budget share, defined by food expenditure divided by total household expenditure. Additional controls include gender and education of the household head, household size. The time period is restricted to 2008 and 2015, when data is available.

We complete our analysis by focusing on poverty. We make use of two indicator variables, one for whether the household is living below the poverty line and one for whether the household is living below the extreme poverty line. Poverty lines are the official INE poverty lines computed at Department level and taking into account rural and urban areas.

Table 16 shows estimates of the impact of an increase in the share of agricultural land insured on poverty and extreme poverty. We observe that, while PIRWA has a small and insignificant effect on poverty, it has a positive effect on extreme poverty. Insuring all the agricultural land in the municipality leads to a reduction of 7% in the extreme poverty incidence.

Table 16: The Effect of PIRWA on Poverty

Dependent Variable:	Household is poor			Household is extreme poor		
	(1)	(2)	(3)	(4)	(5)	(6)
Sh. of eligible land	-0.005	-0.026	-0.026	-0.075**	-0.071**	-0.067**
	(0.028)	(0.032)	(0.033)	(0.029)	(0.031)	(0.032)
Sh. of agr. land farmed with PIRWA crops			-0.004			-0.019
			(0.036)			(0.032)
Observations	16627	16627	16627	16627	16627	16627
Municipality FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Additional Controls	No	Yes	Yes	No	Yes	Yes
Year x Department FE	No	No	Yes	No	No	Yes

Note: *** p < 0.01, ** p < 0.05, * p < 0.1. Standard errors in parenthesis are clustered at municipality level. The dependent variable is the household's food budget share, defined by food expenditure divided by total household expenditure. Additional controls include gender and education of the household head, household size. The time period is restricted to 2008 and 2015, when data is available.

8.4 Results from the FGDs

Here we discuss the main results of the FGDs. In the Appendix "Structure of FGDs and summary of results", we present a summary of these findings.

8.4.1 Main threats to crops

To collect this information, a flipchart was used to answer two questions: what are the main climate threats to the crops, and how are crops protected against them? How do these threats affect your daily life activities?

The main threats recorded in all municipalities were drought, hail and frost. However, other incidents such as floods and winds were also identified by the producers. Also, pests and diseases in animals are also considered significant threats in their agricultural and livestock activity. An important aspect to note is that within the municipality of Padcaya there are different ecological layers, so that each of these threats can become more important than others depending on the circumstance.

Another salient element in this question, which emerged in the discussion of producers in the Padcaya focus group, was the need to have a monitoring system to better prevent the arrival of extreme climatic events that can cause significant disasters in crops.

Producers also mentioned a citrus processing plant that still hasn't opened. They relied on it as a way to sell excess production, which would otherwise end up rotten and thrown away.

The main results by climatic events are described below.

Drought was perceived as one of the most important threats in all the municipalities. In recent years, due to a significant decrease in rain spells, droughts have occurred more intensely. While a few years back, the rainy season was expected to last from late November to early March, but last year this period changed to late February to early March, with some isolated rainfall in April and May.The farmers emphasized that there were many circumstances in which they could do nothing to protect their crops. Given that droughts are increasingly common and cause significant damage, a dam cannot usually supply all producers at the time of greatest crisis. Irrigation systems are not very advanced except for some cases, such as Uriondo, Arbieto, Calamarca and Mecapaca.

Likewise, usually water harvesting is undertaken. Producers also resort to digging some trenches and building ponds to store water. However, due to the evident reduction of the rainy season during the last year, the opportunity to store water has been very difficult. In the case of the municipality of Arbieto, the problem of water is very serious, and they have not been able to improve their irrigation strategies enough to be able to counter this threat. In fact, half of the municipalities, which include Calamarca, Arbieto, Mecapaca, Uriondo and Cotagaita, highlighted the need to improve water management strategies.

Some societies resort to traditional rituals in the hope of countering droughts. One such traditional belief that stands out, occurs within the Aymaran tradition, particularly in the municipalities of Calamarca and Mecapaca, is carrying out "fasts" or rituals to Mother Earth to ask for rain, that are guided by priests known as the "Kamanes".

Finally, the case of the municipality of Mecapaca should be highlighted for being one of the few that has irrigation systems and can harvest more than once a year. This municipality has a river that goes through its lowest altitude area. However, the river is part of La Paz city’s wastewater disposal, and thus, it is contaminated. Consumers in La Paz city are wary of products coming from this area, which directly affects the income in this area. Local producers remark that this is an unfair prejudice as there have not been any cholera outbreaks or intoxication cases resulting from their products. As a result, producers often sell their products falsely claiming they were grown elsewhere.

Hail is one of the other most constant threats in all selected municipalities. As many of the producers said, the consequences of this phenomenon are practically irreparable, although sometimes everything depends on the crop, since there are crops that are more resistant, such as maize or potatoes, while fruit trees are destroyed.

As for the protection methods used to face hail damages, results vary across municipalities, since small farmers usually use a tradition inherited from their parents. For example, they detonate firecrackers and dynamite to "remove or redirect the clouds". This practice is carried out in the municipalities of Poroma, Tupiza, Cotagaita, Arbieto, Calamarca and Mecapaca. Conversely, in the municipalities of Camargo, Padcaya, Uriondo and, Arbieto, producers are more used to “anti-hail” meshes, that are flexible iron networks with which they cover the crops. However, the cost is undoubtedly high. Hence, many producers fail to implement this strategy to protect their crops.

Frost is the third most frequent and devastating threat in all selected municipalities. Among the most used protection strategies are bonfires, which warm the crops though the release of its smoke. In other municipalities, there is a tendency to cover crops with plastic sheeting to preserve heat, as is the case of Calamarca, but others resort to more sophisticated systems, such as in Uriondo, where thermal meshes are used, and, as such, the cost is also high and very few have access to it. In the municipality of Padcaya, the use of greenhouses to protect the most delicate crops is emphasized, but these usually belong to producers who have financial means. The only municipality that said that nothing could be done against this phenomenon was Mizque which, despite making bonfires, considers this practice to not be enough to face this type of threat.

The threat of **floods** was present in some municipalities such as Poroma, Camargo, Tupiza, Cotagaita, Padcaya, Uriondo and Mecapaca. The protection strategies that are usually carried out in most of the affected municipalities are the construction of walls of protection of diverse materials like branches, stones or cement. The former is called rustic shortcuts; the latter are named gabions and retaining walls, respectively. However, these walls are surpassed by the flow of the river many times, and hence losses are possible even when precautions are taken.

One noticeable fact is the large number of producers who have their crops on the verges of the river. It is understood that this facilitates the possibility of irrigating their crops. However, considering the latent risk of floods, it does not seem suitable to continue growing plantations so close to the river.

Alternatively, producers with crops on riverbanks cannot transfer their crops to other lands, because the ones they have were assigned by inheritance. In addition, in the municipality of Camargo, they indicated that floods are not a very common or a persistent threat. However, in the case of the municipalities of Uriondo and Mecapaca, they do constitute a frequent menace, but any farmer can change or choose other lands.

Wind was the only climatic threat considered with fewer significant consequences for crops. In fact, only four municipalities, Poroma, Mizque, Calamarca and Mecapaca, pointed out that winds sometimes cause certain damages such as burying crops by the blowing of dust and other objects. Likewise, it was pointed out that a strategy is to put certain "backrests" to plants, like wooden boards, so that they do not break in case of very strong winds.

Another element that stands out in the discussion of threats to crops was **plagues**. Municipalities such as Padcaya and Uriondo pointed out that the type of pest depends on the type of phenomenon that can occur at a given time of year. For example, in the case of increased humidity produced by rainfall, there is a huge proliferation of flies and other insects that are harmful to different crops. In the case of droughts, usually worms and other flies can significantly destroy crops. Nevertheless, most producers recognized that such threats are easier to control because they generally have access to pesticides to fight them. The need for organic pesticides was also emphasized in the municipality of Calamarca, since the chemicals usually affect crop quality and, in some cases, do not completely fight all pests.

8.4.2 Consequences of adverse climatic events

After describing the main threats faced by producers across different municipalities, producers identified the direct consequences of these threats for their daily lives, and the strategies they use to deal with the damage caused by climatic adversities.

Since agriculture is the main or even sole source of income for many of the producers, the most direct consequence of adverse climatic events is a substantial loss of income. This dynamic reduces their quality of life since they do not have enough money for daily sustenance. Furthermore, as noted in the municipality of Mecapaca, food security within a household is also affected. This is because all these municipalities organize their agricultural activity under a family subsistence system, where domestic food necessities are covered first and then surplus production is sold or exchanged for other products to diversify and complement their nutritional needs. Under these circumstances, there is a need to seek other sources of income or invest in other activities, such as livestock in some areas of Padcaya, Poroma and Mecapaca. In the case of Calamarca, it was pointed out that construction and trade are the most favoured activities to compensate for losses in agriculture.

In the case of other municipalities, migration is also an important consequence. In fact, three of the aforementioned municipalities, except for Mecapaca, also resort on this alternative. The most common destinations for migrants are the largest cities of the department, but also other major cities in Bolivia, such as Santa Cruz, Cochabamba or Potosí. After migrating, men and women are often employed in agriculture or in low-skilled jobs, such as construction or household chores. Nonetheless, in some regions that are closer to the border, such as the municipalities of Tarija, Potosí and La Paz, producers usually cross the border to work in the aforementioned activities, along with sewerage maintenance, in Argentina, Chile or Brazil.

Undoubtedly, municipalities that have managed to diversify agricultural production, as well as their income sources, are better prepared to face losses. This is the case of Camargo, Padcaya, Calamarca and Mecapaca.

8.4.3 Producer's perceptions of risk and crop insurance

An open debate was held to understand the producer's perceptions about insurance access, as well as how they conceive agricultural risk. One of the most important conclusions that should be highlighted in terms of access to insurance is a prevalent lack of financial education among most producers in all municipalities. Their understanding of risk is also basic. Generally, they merely define risk as the possibility of losing their crops, without considering factors generating risk or the availability of effective strategies which could help reducing it. Within this context, an effective strategy is to promote prevention or resilience beyond the methods described in the previous subsection. In fact, some of the town technicians, who joined the FGDs, said that agricultural programs with a focus on risk are just beginning to be implemented.

While, as noted above, there is no clear understanding of agricultural risks among farmers, they do have some scattered ideas about it. One group of producers understood risk as something that was bound to happen and that they needed to be prepared for. Others perceived it as a huge uncertainty in front of which they are completely defenceless.

They also had a very basic understanding of insurance. Some responded by saying that insurance is the possibility of recovering the losses suffered due to some natural phenomenon. They expressed a substantial need to be oriented about it, since their perception of insurance was accompanied by more aversion than affinity. In fact, many producers pointed out that insurance access involves many requirements. Few producers can cope with the payment of high interest rates or quotas. In the case of private institutions which require monthly premium payments, there is little flexibility in the time given to meet their obligations. Quite possibly their understanding of insurance is influenced/confused by their understanding of credit, which they perceive as more important than insurance.

In the case of the PIRWA insurance, while producers considered that the help provided by this type of subsidy was evident, but the amount paid for compensations was not high enough to deal with damages caused by natural phenomena.

Finally, the idea of creating insurance to cover damage caused by certain pests and for animal husbandry emerged. Since a large part of the farmers alternate their agricultural activity with livestock, such risks also generate high costs and can lead to income losses equivalent to those experienced in agriculture.

8.4.4 Constraints in Municipalities with access to PIRWA

The municipalities that had access to the PIRWA Crop Insurance were Poroma, Cotagaita, Padcaya, Mizque and Calamarca (see Figure 20). The municipalities of Tupiza and Mecapaca indicated that this type of insurance was offered to them, but their mayors were still considering its implementation.

Figure 20: FGDs in Municipalities with access to PIRWA

Note. In the upper panel, the left picture shows the FGD in the Municipality of Poroma, while the right picture shows the FGD in the Municipality of Cotagaita. In the lower panel, the left picture shows the FGD in the Municipality of Padcaya, while the right picture shows the FGD in the Municipality of Mizque. Source: Daniela Romero (INESAD).

The debate was carried out based on general ideas and the experience of producers who had benefited from such insurance. One of the most important aspects in all the focus groups with this type of insurance was the high degree of unawareness of its characteristics. A large chunk of the producers did not have a clear idea of what it was and what it offered. While analysing the advantages and disadvantages of the insurance, the groups pointed out that, even if PIRWA represents a support to cover basic needs, it was also generating some dependency. Some producers often demand this type of help rather than generating complementary strategies and becoming more resilient.

As for the disadvantages of insurance, the requirements for registration are frequently very demanding. In addition, as many producers do not reach even half a hectare of production of any of the products admitted by insurance, the amount they receive is usually considered too low. Moreover, the activation requirements of the insurance establish that the payment must be made if the damage is higher than 70% of the total insured surface, which was considered a large loss.

From their part, the technicians that joined the discussion affirmed that the main reason why many producers could not access insurance is because the type of products they cultivated were not covered by the insurance. The producers pointed out this fact as a major disadvantage, particularly in the case of fruit crops. Fruit producers complained that products such as barley, alfalfa and forage crops are insured without being part of the daily diet.

In the case of bean crops, which are also covered by this insurance, it was explained that the relevant number of producers who grow them, especially in the region of Cochabamba, justifies the necessity to be chosen among the products insured.

Compensation following an adverse event was also cited to be problematic. Once damage has been confirmed, individual payments are made to affected farmers. However, compensation can be characterized by problems. For example, a curious situation expressed by the producers occurs when their signature does not match the signature on the identity card. If, after three attempts, the same signature is not achieved as in the identity card, the producer cannot receive the payment. Also, the identity card must be valid in order for the farmer to receive a compensation. This can become a major obstacle, especially for elderly producers or those who live in remote communities, and who rarely have the possibility of moving to the city to fulfil the revalidation of their identification card.

Finally, many producers considered that the amount paid by insurance is too low to cover their needs. Although this insurance is more intended to cover the costs of seeds, as indicated by the town hall's technicians, the producers expressed that this is not the most important cost of production. They report that the insurance should cover the production cost and become a significant aid to the producer.

In these circumstances, producers also pointed out the imperative need to completely understand the characteristics of PIRWA insurance and of other insurances in order to be better able to decide what type of coverage would suit them best. Currently, the understanding remain limited.

8.4.5 Constraints in Municipalities with access to FTR and Vine-Growing Insurance

The municipalities that were part of the pilot test of the FTRs, carried out by PROFIN and FAUTAPO, were Camargo, Arbieto and Uriondo (see Figure 21). Only the last one continued with this type of insurance thanks to the initiative of the Vine-Growing Insurance offered by ALIANZA Seguros.

Figure 21: FGDs in Municipalities with access to FTR and Vine-Growing Insurance

Note. The left picture shows the FGD in the Municipality of Arbieto, while the right picture shows the FGD in the Municipality of Uriondo. Source: Daniela Romero (INESAD).

In the case of the first two municipalities, the FTRs program was considered as a great support for the producers, who would be welcoming to a new initiative of this type. The producers pointed out that, while the insurance is a great support for production, the amount of the insurance premium was too high and limited the access to the insurance. Technicians responsible for monitoring the premium indicated that its magnitude varied depending on the product, the insured area and the type of production costs to be covered, as defined by the producers. In addition, they also assert that the amounts of both the deductible franchise and the premium were constantly modified to better respond to the needs of producers.

Producers reported that the number of hectares used for agricultural production as a requirement to access the insurance was too high. Also, the products covered, mainly grapes and peaches, were insufficient to cover all producers, since they tend to be working on very small number of hectares and that they often plant more than one product per hectare, many of which are not covered by insurance.

This insurance mainly covered damages caused by hail in vine plantations. However, frost and drought were also major threats that were not covered by the insurance. In the municipality of Camargo, agricultural activity is based on a variety of products, mainly fruits, which are generally not accepted by insurers because they involve too much risk or simply because their conditions of production and the limitations of the market make them unprofitable. In the case of the municipality of Arbieto, one of the first impressions left by producers is that this insurance was not very accessible, especially because the amount of the premium was very high and many of them own at most half a hectare of land, which raised the premium cost relative to owned land substantially. Another aspect that the producers of both municipalities pointed out was the delay in payments. They claimed that they had to wait up to one month to access the payment, which is why they consider the support was not effective to cover emergencies.

Once the pilot test of the FTRs concluded, the municipality of Uriondo had the possibility to continue accessing this type of insurance through the insurer ALIANZA Seguros. The producers of this municipality indicated that the premium was high and the size of compensation was not enough to cover the costs of production. For these reasons, many producers were not willing to purchase the insurance. This can be confirmed by the fact that among the 13 producers that participated in the focus group, only 3 had purchased it.

Some producers still had some doubts about the concept of insurance or were confused when consulted about its characteristics. For example, they reported that paying premiums entails "losing income" because this expense is charged irrespective of whether the loss occurs or not, although the amounts are obviously not as significant as those at stake in a disastrous event.

Another problem pointed out by farmers is related to the timing of both the damage verification and the compensation payment. Some participants reported that, after a hailstorm, the insurance company verifies the losses the day or a very few days after the weather shock. Farmers claim that damages to crops are not evident in such a short period of time and there should be multiple visits to verify the damage. Most of the farmers also reported that the compensation payment takes too much time. At the end, compensation payment ends up being mismatched with farmers' needs. Finally, since the insurance only covers one type of loss and product, farmers are unprotected from the occurrence of other types of losses and from damages in other crops.

8.4.6 Constraints in Municipalities without access to any type of crop insurance

Only two municipalities, Tupiza and Mecapaca, had no experience with crop insurance (see Figure 22). In both cases, technicians and producers pointed out the need for having access to this type of service.

Figure 22: FGDs in Municipalities without access to crop insurance

Note. The left picture shows the FGD in the Municipality of Tupiza, while the right picture shows the FGD in the Municipality of Mecapaca. Source: Daniela Romero (INESAD).

In the municipality of Tupiza, technicians from the town council indicated that negotiations were being held to access the PIRWA crop insurance and that it would possibly be implemented in the current campaign. Producers expressed they did not have the opportunity to access insurance before, but that they had experience with credit, which they mistakenly associate with insurance.

Producers acknowledged that insurance is a way of recovering damages, and it is another form of income that can help with household expenses, especially in a case like PIRWA. Producers have a very vague idea of what crop insurance implies, as well as what is the meaning and repercussions of crop risks. Nevertheless, there is a great expectation for accessing crop insurance, because they think it can transform their living conditions in a positive way.

For the municipality of Mecapaca, it was possible to perceive that there was a little more knowledge about insurance, especially about PIRWA. Some producers judged the compensation payment of PIRWA insurance as too low to be considered as a real support for climate disasters. They believe that such a payment would only cover very basic needs, given the high production costs. They think that projects should be created first to promote financial education, which could inform them about the structure of the insurance and the real benefits that are extracted from it. This would allow them to decide under better conditions what type of insurance suits them best. They consider that the government should support them with technical training on how to expand their market and diversify their sources of income. Apart from the partial understanding of public insurance, there is little knowledge about private crop insurance, since this municipality is usually classified as being very risky because of the salient frequency of climatic events they face.

8.4.7 Overall lessons from the FGDs

Natural phenomena such as drought, frost and hail have become the main threats to farmers in most of the municipalities visited. They can cause irreversible damage, often leaving producers completely defenceless.

There is a strong need for financial education in most municipalities, as well as training programs on agricultural risks and resilience. This is the main obstacle for crop insurance to become a priority in agricultural production strategies. Ignorance of the advantages of insurance leads to aversion among farmers. Since understanding is limited, producers think that the insurance cost is too high and that there are not many advantages of purchasing it. Sometimes they even consider insurance as a risk in itself, which involves losing money if no loss occurs.

Since the range of adverse climatic events is large, crop insurance should cover a broader range of risks to become a more effective and preferred alternative for producers. Producers also consider that insurance can become an attractive option if it can protect most of the costs of production, or at least the most significant ones. Another important element of attractiveness would be the incorporation of livestock in the insurance, since this is often a complementary activity to agricultural production.

An insurance that can respond in a comprehensive way to the needs of producers will certainly become a priority for them. The most common request for a crop insurance to be interesting was affordable payments of the premiums through payment in quotas. Premium should be lower and the purchasing methods should be more flexible, i.e., producers should be able to pay it in more than a single quota. It is also important that, in case of loss, the indemnity should not take too long to reach the producers.

Finally, the producers consider they require more training in various topics, such as agricultural technology, water management, irrigation systems, product transformation, opening of new markets, and cattle breeding. They are also fully prepared to participate in meetings that will enable them to gain a better understanding of agricultural risks and strategies to deal with them. They are aware of their limitations when deciding to buy insurance, and hence any financial institution that wants to offer this type of products should start promoting them with training on financial education. Fostering a sound understanding among producers of their responsibilities and benefits would be the first step.

9. Implications of study findings

In order to understand the primary implications of the findings we first highlight some of the main findings from the study. First, as far as the quantitative findings are concerned, we find that unfavourable weather shocks affect individuals negatively reducing yields and inputs but not expenditures. On the other hand, favourable weather shocks and extreme poverty both reduce take-up. Access to the publicly subsidized PIRWA insurance program increases farmer’s yields and inputs but not expenditure. Access to PIRWA also reduces extreme poverty.

From the qualitative study, we find that there is limited knowledge about how insurance works. However, farmers recognize benefits of insurance under disasters. The farmers often confusion insurance products with credit. Farmers are interested in financial education and technical training for management of water, irrigation, seeds, and animals (which they often use as a way to diversify risk). Finally, farmers use PIRWA compensations for subsistence expenditures.

While previous research had identified lack of trust and liquidity constraints as barriers to agricultural insurance take-up, removing them does not ensure 100% take-up of agricultural insurance either. Even after repeated exposure, and insurance being offered at 0-cost, a lack of understanding about insurance hinders take-up.

The implementer INSA relied on a top down approach for spreading information and knowledge about the PIRWA insurance program. They started by sensitizing municipality local authorities first, then moving on to local leaders who then sensitize the local communities. This however, failed to lead to 100% take-up even when cost is 0. Even widespread sensitization campaigns do not improve knowledge and understanding about insurance. Clearly this is something that needs to be taken into account in the future. Similarly, we also need to take into account that people have a huge appetite for receiving technical training and would be keen to participate in training programs should such programs be offered.

10. Major challenges and lessons learnt

The PIRWA program was already under implementation by the Government of Bolivia. Hence, we did not face issues on the implementation front. We obtained data mostly from publicly available sources, so we did not face any issues on that front either.

Appendix A: Weather Shocks and Farmers' Lives in Bolivia

In this section, we focus on analysing how weather shocks affect the productivity and welfare of farmers in Bolivia. We estimate the effect of weather shocks on outcome y of farmer *i* at time *t* living in municipality *j* using the following model:

$$\boldsymbol{y_{ijt} = \beta_0 + SHOCK'_{jt}\gamma + X'_{ijt} + \sum_{t=1}^{T} \mu_t d_t + \alpha_j + u_{ijt}} \qquad \textbf{(4)}$$

where $SHOCK_{jt}$ is a vector of weather shocks measured at time t in municipality j, $\boldsymbol{X}_{ijt}$ is a matrix of time varying individual and municipality characteristics, α_j is a municipality-specific fixed effect, d_t are time-specific fixed effects, and u_{it} are idiosyncratic error terms, which we assume to be correlated over time for each municipality. Additional controls include day-time and night-time temperatures outside of the growing seasons, average precipitation outside of the growing season, gender and age of the household head and the number of household members. Our parameters of interest are the elements of the vector γ, which captures the effect of changes in every selected weather shock on individual outcomes.

Weather, productivity and welfare

We look specifically at two types of outcomes. First, we are interested in understanding how weather shocks affect **farmers' productivity**. To this purpose, we make use of information about farmed crops and about production, available in the Agricultural Survey for the years 2008 and 2015, and we build the average yield for each farmer by averaging crop-specific yields weighted by area farmed. Yield is measured as kilograms of production per hectare farmed, and is reported in logs in order to interpret the results as percentage increase in yield. We can observe that over time, the yield distribution shifted slightly to the right, but yields improvements have been very limited in this period of time. Secondly, we are interested in understanding how weather shocks that are happening during the growing seasons affect farmer's welfare in the following season. To this purpose, we use the Household Survey in the year 2006-2015, and we build an indicator of household-level total expenditure on non-durables. Table A1 presents estimates of the effect of weather shocks on farmers' productivity using equation 1.

Table A1: The Effect of Weather Shocks on Farmers' Productivity

	Dependent Variable: Average Yield at Farm-level				
			Municipalities with medium-high risk of…		
	All	*All*	*Flood*	*Drought*	*Frost*
	(1)	(2)	(3)	(4)	(5)
Degree Days	0.264***	0.260***	0.278***	0.362***	0.363***
	(0.076)	(0.078)	(0.084)	(0.088)	(0.083)
Harmful Degree Days	-0.109	-0.202**	-0.182*	-0.215**	-0.196**
	(0.076)	(0.084)	(0.095)	(0.088)	(0.095)
Rainfall		0.323**	0.291**	0.894**	0.156
		(0.130)	(0.142)	(0.375)	(0.333)
Rainfall Squared		-0.016**	-0.014**	-0.065*	-0.006
		(0.007)	(0.007)	(0.035)	(0.027)
Observations	16361	16279	12475	11998	11478
Municipality FE	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes
Municipality x Year FE	Yes	Yes	Yes	Yes	Yes
Additional Controls	No	Yes	Yes	Yes	Yes

Note: *** p < 0.01, ** p < 0.05, * p < 0.1. Standard errors in parenthesis are clustered at municipality level. The dependent variable is the average farm-level yield, reported in logarithm. Additional controls include gender and education of the household head, household size. The time period is restricted to 2008 and 2015.

We can observe that DDs increase dramatically farmer's productivity. An extra DD during the growing season leads to an increase in yields of around 25%, reaching 36% in areas of medium-to-high risk of drought and frost. We can also observe that HDDs have an opposite effect on yields. Extremely high temperatures lead to a reduction in yield of around 20%, but are only significant when we control for other indicators, such as rainfall. These results suggest that weather shocks are a particularly important determinant of farmers' productivity.

Table A2 presents similar estimations, but focuses on the total expenditure on agricultural inputs for the same period. Increases in HDDs lead farmers to reduce their expenditure on agricultural input quite dramatically. An extra HDD per day reduces expenditure on inputs by roughly 60%.

Table A2: The Effect of Weather Shocks on Farmers' Inputs

	Dependent Variable: Inputs in Agriculture (log)				
			Municipalities with medium-high risk of…		
	All	*All*	*Flood*	*Drought*	*Frost*
	(1)	(2)	(3)	(4)	(5)
Degree Days	0.387	0.141	0.173	0.032	0.086
	(0.267)	(0.228)	(0.265)	(0.260)	(0.236)
Harmful Degree Days	-0.605***	-0.548***	-0.607***	-0.446**	-0.565***
	(0.222)	(0.192)	(0.222)	(0.193)	(0.198)
Rainfall		-0.710**	-0.687*	-1.132**	0.177
		(0.347)	(0.401)	(0.558)	(0.904)
Rainfall Squared		0.005	0.005	0.033	-0.021
		(0.014)	(0.017)	(0.036)	(0.080)
Observations	17794	16312	12496	12052	11516
Municipality FE	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes
Municipality x Year FE	Yes	Yes	Yes	Yes	Yes
Additional Controls	No	Yes	Yes	Yes	Yes

Note: *** p < 0.01, ** p < 0.05, * p < 0.1. Standard errors in parenthesis are clustered at municipality level. The dependent variable is the total expenditure on agricultural inputs, reported in logarithm. Additional controls include gender and education of the household head, household size. The time period is restricted to 2008 and 2015.

The second question we ask is whether such large effects of yields have an effect on farmers' welfare. To this purpose, we focus on total household expenditure measured at the beginning of the following growing season, but referring to the previous 12 months. Table A3 presents estimates on the effect of weather shocks on total household expenditure using the yearly household survey from 2005-2015 and focusing on households where at least one household member is reporting being a small-holder farmer as primary activity.

While we observe large effects on yields of adverse weather conditions, both in terms of extreme events and in terms of normal temperature shocks, these effects do not translate into large welfare effects. In fact, one extra DD per day during the growing season translates only to an increase of around 3% in total household expenditure and not always significant. This suggests that, on average, farmers tend to smooth consumption significantly, since increases in yields only translate into 10 times smaller increases in expenditure. We also observe that extreme events such as increases in HDD, do not affect household expenditure.

We then try to replicate our results using SPEI as an alternative measure of weather shocks.[11] We find that increases in SPEI are beneficial for agriculture, but large increases (both positive, as a proxy for floods, and negative, as a proxy for drought) can lead to sharp reductions in yields. We also find that this negative effect is mainly present in municipalities with medium-to-high risk of drought. Similar to what we observed for temperature and precipitation shocks, large effect on yields do not translate into large variation in expenditure.[12]

[11] These results are not presented here and are available upon request from the authors

[12] In results not provided, but available upon request from the authors, we also try to understand whether weather shocks are affecting poorer areas more than richer areas, we compare our estimates for municipalities where the share of poor households (as defined by the INE's 2012 Census) is larger than 75% and where the share of poor households is smaller than this threshold. We find that observe that the main effect of weather shocks on productivity and welfare is concentrated in poorer municipalities.

Table A3: The Effect of Weather Shocks on Farmers' Expenditures

	Dependent Variable: Total Household Expenditure (log)				
			Municipalities with medium-high risk of…		
	All	*All*	*Flood*	*Drought*	*Frost*
	(1)	(2)	(3)	(4)	(5)
Degree Days	0.019	0.031**	0.030*	0.030*	0.025
	(0.018)	(0.016)	(0.018)	(0.017)	(0.018)
Harmful Degree Days	0.001	0.002	0.018	-0.001	-0.013
	(0.017)	(0.014)	(0.015)	(0.016)	(0.016)
Rainfall		0.016	0.000	0.046	-0.061
		(0.047)	(0.048)	(0.054)	(0.084)
Rainfall Squared		-0.003	-0.001	-0.005	0.010
		(0.003)	(0.003)	(0.003)	(0.008)
Observations	15005	14953	11905	11172	11008
Municipality FE	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes
Municipality x Year FE	Yes	Yes	Yes	Yes	Yes
Additional Controls	No	Yes	Yes	Yes	Yes

Note: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. Standard errors in parenthesis are clustered at municipality level. The dependent variable is the total household expenditure, reported in logarithm. Additional controls include gender and education of the household head, household size. The time period is restricted to 2005-2015.

Farmers and weather shocks

In general, we observe that weather shocks in Bolivia do matter for farmers. Extreme weather, measured using temperature and precipitation, or combined measures such as SPEI, leads to sharp decreases in yields. However, we observe that these shocks do not translate into large differences in farmer's expenditures.

This is potentially due to two mechanisms. Firstly, it is possible that farmers facing high risks of weather shocks might anticipate these by smoothing their consumption. Clearly, in areas where risks are more frequent, farmers will tend to spend less in order to save income and smooth consumption in case of future shocks. This mechanism might explain why, during growing seasons affected by higher HDDs, farmers tend to reduce their expenditure on agricultural inputs. Secondly, it is possible that farmers have already access to informal insurance mechanisms, which support their expenditures after facing weather shocks.

Appendix B: Structure of FGDs and summary of results

To construct the focus groups, we defined three types of municipalities: municipalities exposed to PIRWA; municipalities with access to Vine-Growing Insurance of Alianza Seguros; and municipalities without access to any type of crop insurance. Since each group presents peculiarities in terms of exposure to insurance products, we discuss here in detail the structure of FGDs for each group.

In the FGDs implemented in **municipalities that have been exposed to PIRWA**, we addressed the following questions:

1. What are the main threats your crops face due to climate events and how do you protect against them?
2. How do these threats affect your daily life?
3. Do you know what an agricultural insurance is, and how do you think it works?
4. Are you enrolled in PIRWA (agricultural insurance)? And in your opinion, how do you think PIRWA works at each stage, that is, registration, filing a claim and compensation? What problems do you think exist in any of these stages?
5. When considering whether to join PIRWA, how do you think being insured by PIRWA would impact decisions at work and at home?
6. Following frost, flood, drought, or hail, is a PIRWA compensation enough to recover losses?
7. If PIRWA did not exist, what characteristics should an agricultural insurance have for you to be willing to buy it?
8. Imagine meetings that teach about the possibility of climate-related damages, and how to make better decisions within your household to face the possibility of such damages. Would your community be willing to participate? What topics would you like to discuss in these meetings?
9. Check if something was omitted during the previous discussion. Especially if it is related to the reasons behind their decision either to acquire or not to acquire an agricultural insurance.

In the FGDs implemented in **municipalities with access to the Vine-Growing Insurance**, we addressed the following questions:

1. What are the main threats your crops face due to climate and how do you protect against them?
2. How do these threats affect your daily life?
3. Do you know what an agricultural insurance is, and how do you think it works?
4. When considering whether to enrol in an agricultural insurance, how do you think owning an agricultural insurance would impact your decisions at work and at home?
5. What do you know about the Seguro Vitícola offered by Alianza Seguros? If you do know this product, why would you buy it, or not buy it?
6. What characteristics should an agricultural insurance have for you to be willing to buy it?
7. Following frost, flood, drought, or hail, is an agricultural insurance compensation enough to recover losses?
8. Imagine meetings that teach about the possibility of climate-related damages, and how to make better decisions within your household to face the possibility of

such damages. Would your community be willing to participate? What topics would you like to discuss in these meetings?
9. Check if something was omitted during the previous discussion. Especially if it is related to the reasons behind their decision to acquire or not to acquire an agricultural insurance.

In the FGDs implemented in **municipalities with no access to crop insurance**, we addressed the following questions:

1. What are the main threats your crops face due to climate and how do you protect against them?
2. How do these threats affect your daily life?
3. Do you know what an agricultural insurance is, and how do you think it works?
4. What do you consider when deciding whether to acquire an agricultural insurance?
5. Following frost, flood, drought, or hail, is an agricultural insurance compensation enough to recover losses?
6. How do you think owning an agricultural insurance would impact your decisions at work and home?
7. What characteristics should an agricultural insurance have for you to be willing to buy it?
8. Imagine meetings that teach about the possibility of climate-related damages, and how to make better decisions within your household to face the possibility of such damages. Would your community be willing to participate? What topics would you like to discuss in these meetings?
9. Check if something was omitted during the previous discussion. Especially if it is related to the reasons behind their decision to acquire or not to acquire an agricultural insurance.

The following table summarizes the results from the FGDs.

TOPIC	TYPE OF MUNICIPALITY		
	Municipalities with PIRWA	**Municipalities with Wine-Growing Insurance**	**Municipalities without insurance**
MAIN CLIMATIC THREATS	Main: drought, frost, hail (in lesser proportion: floods, plagues and winds)	Main: hail, drought, Floods, frost (in lesser proportion: plagues)	Main: drought, frost, hail (in lesser proportion: floods, plagues).
METHODS OF PROTECTION AGAINST CLIMATIC THREATS (in order of importance)	*Drought*: water harvest, storage tanks, offerings and fasts are carried out to ask the gods for rain (Calamarca), in some municipalities no methods of protection. *Frost*: implementation of bonfires to heat the ground and heat the crops with smoke. *Hail*: normally nothing carried out against it, except for farmers that have enough resources to buy anti-hail meshes. Firecrackers and dynamite also used to clear the sky. *Floods*: construction of rustic shortcuts, retaining walls and gabions around the crops that are near to the river. *Plagues*: use of chemical pesticides. *Winds*: plastic bags tend to be reused to cover the crops while wooden boards back certain plants.	*Hail*: anti-hail meshes, only when income is high enough. Most producers do nothing. *Drought*: in some cases, water harvest, but the majority report that they are helpless in the face of this phenomenon. *Floods*: construction of rustic shortcuts, retaining walls and gabions. *Frost*: crops are attempted to be covered with thermal meshes (only for producers that can afford it). *Plagues*: use of pesticides.	*Drought*: the majority of farmers do nothing, some use storage tanks. In the case of Mecapaca, producers have a river that always has water, so they have different types of irrigation and can better face this phenomenon. In the municipality of Mecapaca, offerings and fasts are carried out to ask the gods for rain. *Frost*: implementation of bonfires. *Hail*: explosions of firecrackers. *Floods*: construction of rustic shortcuts, retaining walls and gabions. *Plagues*: use of pesticides.

TOPIC	TYPE OF MUNICIPALITY Municipalities with PIRWA	Municipalities with Wine-Growing Insurance	Municipalities without insurance
IMPACT OF ADVERSE WEATHER	Significant losses in income (agriculture is the main source of income). Need for diversification of production and sources of income. Some members of the household need to migrate. Reduction in daily expenses.	Significant losses in income (agriculture is the main source of income). Need for diversification of production and sources of income (livestock is the main complement of agriculture). Some members of the household need to migrate. Reduction in daily expenses.	Significant losses in income (agriculture is the main source of income). Need for diversification of production and sources of income (livestock is the main complement of agriculture). Some members of the household need to migrate. Reduction in daily expenses and food security compromised.
KNOWLEDGE OF CROP INSURANCE	Limited knowledge about the operation of insurance. When talking about insurance, producers cannot distinguish it from credit. Producers express their need for training in financial education.	Limited knowledge about the operation of crop insurance. Producers express their need for training in financial education.	Very basic knowledge about the operation of crop insurance. When talking about insurance, producers cannot distinguish it from credit. Producers express their need for training in financial education.
KNOWLEDGE ABOUT INSURANCE PURCHASE / PIRWA REGISTRATION AND RELATED ISSUES	Producers have a very general notion of how this process work. Not everyone can access this insurance since not all are summoned for registration (e.g. some may not speak Spanish, they do not know the existence of the benefit).	Only few producers have a clear idea of the operation of the insurance. Many requirements to register. The insurance should cover more types of events.	Not applicable.

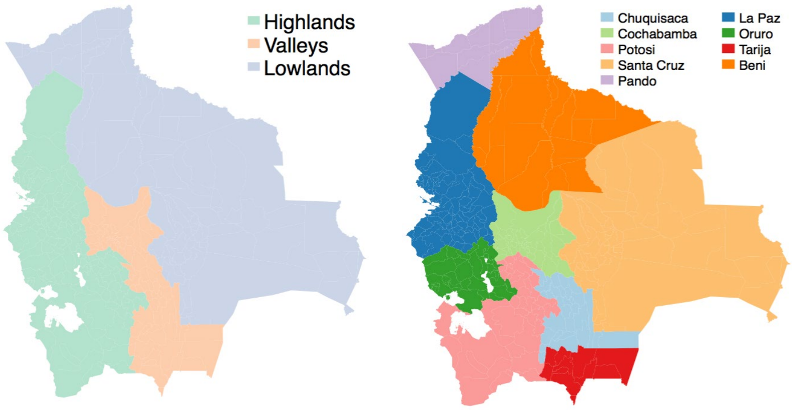
TOPIC	TYPE OF MUNICIPALITY		
	Municipalities with PIRWA	**Municipalities with Wine-Growing Insurance**	**Municipalities without insurance**
	At the time of receiving the compensation, they have problems with some requirements. Some do not have the possibility to renew their identity cards. Other products should also be included in the insurance (e.g. fruit trees). The compensation takes a long time to arrive.	The inspection is performed too soon, when the actual damages are not entirely obvious. The amount of the premium is too high, small producers cannot pay it at once. The compensation takes a long time to arrive.	
EFFECT OF INSURANCE ON DECISIONS	It is a good support to cover the most basic expenses.	It is a good support to cover the most basic expenses.	It is a good support to cover the most basic expenses. Incentive to diversify their sources of income through investment in other activities.
OPINION ABOUT COMPENSATION	They consider that the amount of compensation is very low and that it should cover the higher costs of production. Only helps covering immediate expenses.	It is not enough because it only helps covering immediate expenses.	Does not apply.
DESIRED CHARACTERISTICS OF INSURANCE	Premiums with more accessible payments.	Premiums with more accessible payments.	Premiums with more accessible payments.

TOPIC	TYPE OF MUNICIPALITY		
	Municipalities with PIRWA	**Municipalities with Wine-Growing Insurance**	**Municipalities without insurance**
	A coverage of all types of events and disasters and crops. Compensation of the higher costs of production. Compensation in kind (such as seeds), and not only in money. Insurance for livestock. Personalized insurance could deliver more useful outcomes (against standard products)	A coverage of all types of events and disasters and crops. Compensation of the higher costs of production. Insurance for livestock.	A coverage of all types of events and disasters and crops. Compensation of the higher costs of production. Insurance for livestock. A more aligned insurance with the reality of the farmers in each context.
INTEREST IN TRAINING	Willingness to participate exists. Themes of interest: Financial Education; Water management and irrigation systems; Climate change; Pesticide management; Livestock and cattle raising management; Seed management; Agricultural technology.	Willingness to participate exists. Themes of interest: Financial Education; Water management and irrigation systems; Pesticide management; Livestock and cattle raising management; Seed management; Agricultural technology.	Willingness to participate exists. Themes of interest: Financial Education; Water management and irrigation systems; Pesticide management; Livestock and cattle raising management; Seed management; Agricultural technology.

Appendix C: Additional Figures

Figure C1: Ecological regions and Departments of Bolivia

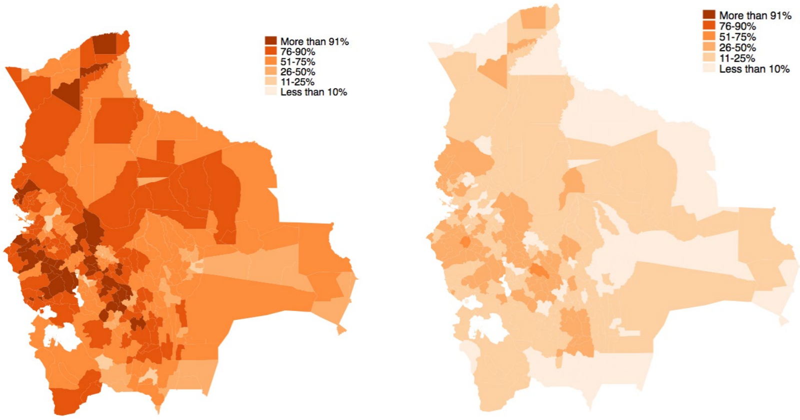
Ecological regions *Departments*



Note: own elaboration.

Figure C2: Share of population in poverty and extreme poverty

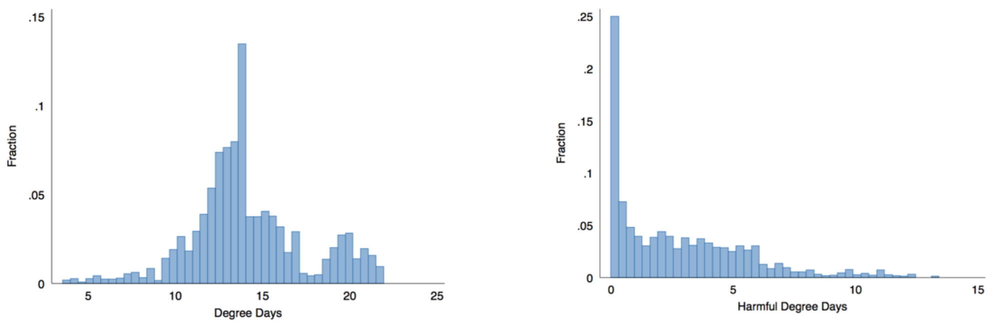
Poverty *Extreme Poverty*



Note: each map presents the geographical distribution of the selected indicators reported at municipality level. Source: own elaboration using INE's 2012 Census.

Figure C3: Degree Days and Harmful Degree Days

Degree Days *Harmful Degree Days*



Note: each map presents the distribution of DDs and HDDs in the Household Survey for the period 2005-2015. Source: own elaboration.

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