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Building weather-index-based insurance with agricultural loans

An evaluation of impact on insurance uptake and farmers' wellbeing (2018–2022)

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Building weather-index-based insurance with agricultural loans: An evaluation of impact on insurance uptake and farmers' wellbeing (2018–2022)

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Study funding and acknowledgements

Study funding and background

This study, titled *"Bundling weather index-based insurance with agricultural loans: an evaluation of impact on insurance uptake and farmers' well-being (2018–2022)"*, was conducted as part of the Thematic Window on Agricultural Insurance of the **International Initiative for Impact Evaluation (3ie)**. It was funded under study code **TW13II.1026** and implemented by the **Université Gaston Berger (UGB)** in collaboration with key stakeholders in Senegal's research and agricultural insurance sectors.

The research was designed to assess the effects of bundling index insurance with agricultural credit on insurance adoption, investment behavior, and the overall resilience of farmers in the **groundnut basin of Senegal**. It particularly focused on two farmers' organizations—**COOPEC/RESOPP and CCPA**—which implemented **voluntary and mandatory insurance bundling**, respectively. The study provides empirical insights into the effectiveness of different insurance distribution models and contributes to ongoing policy discussions on expanding financial protection for smallholder farmers.

The research team expresses its **deep appreciation to 3ie** for funding this evaluation and providing continuous guidance in designing a robust impact assessment methodology.

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This evaluation has benefited from the collective efforts of many stakeholders who have contributed their time, knowledge, and resources. We hope that the findings will serve as a foundation for improving agricultural insurance models and enhancing financial resilience for farmers across Senegal.

The views and interpretations expressed in this report are those of the authors and do not necessarily reflect the official positions of UGB, 3ie, or any other affiliated institutions.

Executive summary

This endline evaluation report presents the findings of the study *Bundling weather index-based insurance with agricultural loans: an evaluation of impact on insurance uptake and farmers' well-being (2018-2022).* Conducted under the Thematic Window on Agricultural Insurance of the International Initiative for Impact Evaluation (3ie), the study was implemented by Université Gaston Berger (UGB) in collaboration with key stakeholders in Senegal's agricultural insurance sector. The research focused on two farmer organizations, COOPEC/RESOPP and CCPA, which implemented voluntary and mandatory bundling of agricultural insurance with credit, respectively.

The evaluation assessed whether bundling weather index-based insurance (WII) with agricultural loans influences farmers' insurance uptake, agricultural investment behavior, access to credit, resilience to climate shocks, and overall well-being. A quasi-experimental design compared insured and non-insured farmers over a four-year period, emphasizing the effects of different bundling modalities.

Key positive findings:

- **Enhanced access to larger agricultural loans:** Microfinance institutions and farmers' organizations perceived farmers who were aware of their insurance coverage as lower-risk borrowers, which facilitated their access to larger agricultural loans. This highlights the role of insurance in improving creditworthiness, even though it did not fully translate into broader financial inclusion.
- **Higher production volumes and sale prices:** Farmers who were aware of their insurance coverage increased both their production volumes and the prices at which they sold their crops. This translated into higher income and a larger share of their production destined for household consumption, strengthening food security.
- **Income and livelihood improvements:** Among farmers who were aware of their insurance, there was an improvement in income levels, suggesting that when properly understood, index insurance can meaningfully contribute to smallholders' economic development.
- **Financial protection potential:** Although insurance payouts were limited, farmers who understood their coverage demonstrated a stronger ability to cope with financial shocks, showing early signs of enhanced resilience mechanisms.
- **Growing landscape for agricultural insurance:** Despite challenges, the insurance landscape in Senegal is evolving, supported by international initiatives, national strategies, and partnerships between the insurers: the Senegalese National Agricultural Insurance Company *(Compagnie Nationale d'Assurance Agricole du Sénégal* [CNAAS] and the private insurers), the Agricultural Bank (*La Banque Agricole* [LBA]), the microfinance institutions, and farmers' organizations. These developments create an opportunity for better design of insurance products and expanded access in the future.

These findings confirm that WII, when bundled with credit and accompanied by adequate farmers' awareness, holds significant promise as a tool for improving rural livelihoods and fostering agricultural development.

Areas with no observed impact:

- **No effect of the bundling method on uptake:** Voluntary bundling did not significantly improve informed uptake of insurance compared to mandatory bundling. Awareness of insurance coverage remained low across all groups. Many farmers did not realize they had been insured, even when paying premiums, which undermined informed financial decision-making.
- **No significant effect on agricultural investment:** Insurance coverage, regardless of bundling modality, did not significantly stimulate investment in improved agricultural technologies, inputs, or riskier but potentially higher return production practices.
- **No measurable changes in cultivation practices:** Farmers' adoption of new farming techniques or diversification strategies remained largely unchanged despite access to insurance and credit.
- **Persistence of unawareness:** A significant percentage of farmers, particularly under mandatory bundling, remained unaware that they held insurance coverage, undermining the intended behavioral effects of risk protection.
- **Limited perceived reliability of insurance:** Due to lack of direct payouts to farmers and poor transparency of compensation processes, trust in the insurance mechanism remained low, especially among those who were unaware of their coverage and did not receive regular information on the insurance products. Focus group discussions revealed growing dissatisfaction among farmers regarding the perceived utility of insurance.

These findings indicate that while WII can enhance financial access and improve income among informed farmers, it does not automatically lead to broader changes in agricultural investment or resilience without significant complementary interventions focused on awareness and trust-building.

Contextual factors

The study took place amid the COVID-19 pandemic, which disrupted agricultural financing systems and reduced availability of insurance for certain farmer groups during key seasons. These disruptions influenced both perceptions and adoption of the bundled insurance–credit product.

Policy implications and recommendations:

- **Strengthen farmers' awareness and education:** The level of farmers' understanding of insurance is key. Stronger communication strategies, using mobile technology and local farmer networks, must be developed to ensure that farmers are fully aware of their coverage, conditions, and benefits.
- **Enhance product transparency and trust:** Clear, timely communication about payouts and insurance conditions can improve the perceived reliability of insurance products. Transparency during the payout process must be secured to maintain farmers' trust.
- **Expand insurance coverage to additional risks:** To increase the relevance and attractiveness of WII products, coverage should be broadened to include additional risks such as flooding, which is increasingly affecting agricultural production.

- **Leverage new technologies:** Digital solutions, including mobile-based insurance applications, should be explored to facilitate insurance subscription, information dissemination, and payout processes.
- **Promote hybrid financial products:** Insurance should be complemented with favorable credit terms, input financing mechanisms, and market access support to maximize its developmental impacts.

Conclusion

The evaluation demonstrates that bundling WII with agricultural loans can yield significant benefits for smallholder farmers, particularly when farmers are well informed about their coverage. Awareness and understanding are critical levers for maximizing WII's developmental potential. However, insurance alone, without a concerted focus on education, transparency, and integrated financial support systems, is not sufficient to drive transformational changes in agricultural investment and resilience. Strengthening institutional partnerships, improving product design, and integrating innovative communication and financial strategies will be essential to enhance the role of agricultural insurance in building resilience and promoting sustainable rural development in Senegal.

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1. Introduction

Weather index-based insurance (WII) was introduced in Senegal in 2012, but has faced challenges in reaching a sustainable scale. Over five years of pilots (between 2012 and 2016), the only currently operating agricultural insurance company—*Compagnie Nationale d'Assurance Agricole du Senegal* (CNAAS)—recorded low uptake and renewal. This was confirmed in experiences of some of the main stakeholders: Global Index Insurance Facility (GIIF), World Food Programme (WFP), and Inclusive Guarantee (IG). Because of the configuration of agricultural value chains in the country, WII provision in Senegal has required working with farmers' organizations (FOs) and microfinance institutions (MFIs) as aggregators and intermediaries. Thus, insurance contracts are usually linked to a lead product such as credit or agricultural inputs, including seeds and fertilizers, which may also be advanced as a form of credit.

So far, no evidence exists on the potential effect of bundling insurance and credit on agricultural production, investment, technology adoption, or resilience and by implication, on living standards of farmers in Senegal. Consequently, CNAAS, FOs, and other stakeholders seek proof of impacts. Further, there is still an open debate on whether to adopt mandatory or voluntary bundling as a dominant provision strategy. Because of lower operational costs, CNAAS advocate for mandatory insurance on the national scale, but some aggregators and intermediary organizations have expressed doubts regarding the benefits and costs compared to voluntary bundling, which would leave more choice for the client and require more educational and awareness-raising efforts.

This report presents findings from the midline survey of a four-year impact evaluation aiming to address these gaps in evidence. It also investigates changes recently observed in the crop insurance landscape in Senegal. The report strives to describe the bigger picture and shifts in the WII sector in the country, while paying closer attention to future implications for the different stakeholders involved. One ongoing debate pertains to the sustainability of premium subsidies from the Government of Senegal, which has been subsidizing WII premiums at 50 percent. As the number of farmers taking out insurance increases, there is burgeoning discussion about the insurance subsidy burden in the national budget, as well as questions about what potential reform of the insurance subsidy policy could support sustainable agricultural development. This analysis is also related to how WII can grow autonomously, given that it is still "overprotected" by the state and international partners through different interventions (i.e., subsidies, projects, technical assistance). In addition, new distribution and contract models, with meso-insurance as part of the scale-up strategy, raise questions about information channels and access for farmers. These shifts bear important implications for the future of WII in Senegal and necessitate a thorough analysis.

In this evaluation study, we target the knowledge gap concerning the capacity of aggregators (FOs and MFIs) to increase uptake of agricultural index insurance in Senegal, the effects of insurance payouts, as well as potential benefits from insurance in the absence of a shock, including the possibility for bundling to enhance farmers' investment potential through abandonment of low-risk low-return behavior. While there is discussion among partners of the agricultural insurance company CNAAS to sell WII through the rural financial systems, to date, no studies have been conducted to assess whether and by how much this approach would increase uptake, influence the inclusiveness of insurance, and contribute to resilience, income, and broader well-being in Senegal.

This evaluation, therefore, aims to contribute to an evidence-informed strategy at the national level and inform the provision of WII insurance bundled with agricultural loans in Senegal as part of the national agricultural insurance company's activities.

In the run-up to each year's rainy season, crop insurance (almost exclusively WII) is offered to farmers as a voluntary or mandatory add-on to credit, depending on the governance of their affiliated FOs and/or MFI. To address the knowledge gap presented above, two FOs—*Coopérative d'Épargne et de Crédit du Réseau des Organisations Paysannes et Pastorales du Sénégal* (COOPEC/RESOPP) and *Cadre de Concertation des Producteurs d'Arachide* (CCPA)—offer to their members who apply for an agricultural credit in the Senegalese groundnut basin voluntary and mandatory insurance, respectively. These FOs are considered to assess the following evaluation questions:
What sales protocol (voluntary or mandatory bundling) is more likely to sustain uptake of insurance and credit?
Does uptake (through voluntary or mandatory bundling) help achieve the objectives of increased well-being and reduced poverty and vulnerability among small-scale farmers?
How does the bundled product (WII + credit) influence Senegalese farmers' adoption of higher return investment strategies and affect their productivity?
What is the net impact of the bundled product (WII + credit) on farmers' well-being?

a. How reliable are the suggested schemes?
b. How does the bundled product (WII + credit) influence recovery after a rainfall-related shock?
c. What are the co-benefits of WII for farmers, even in the absence of a shock?
d. What are the adverse effects, if any, of insurance uptake on farmers' well-being and adaptive capacity?

For each of the sales protocols, how does awareness affect the estimated impact on the different indicators considered (uptake, adoption of higher return investment strategies, income, and well-being)?
Key outcomes and impacts considered in the evaluation are uptake, investment, productivity, and multidimensional well-being, which entails income and consumption and considers a broader range of assets and capacities based on the sustainable livelihoods approach.

This endline report analyzes the progression of the different indicators captured during baseline and midline evaluations across farmers' groups. The COVID-19 pandemic has put the country in an unprecedented situation, and the Senegalese agricultural sector has not been spared. Given that context, we included specific sections in the midline and endline survey questionnaires and qualitative data collection tools to assess the effects that both the pandemic and the government's measures to curb the spread of COVID-19 have had on farmers in our sample.

The following section presents relevant literature on the effects of bundling insurance and credit on insurance uptake, productivity, and well-being. Section 2 discusses the progression of the crop insurance sector in Senegal. Section 3 provides an overview of the intervention and its design. Section 4 presents the intervention theory of change and the underlying assumptions. Section 5 details the evaluation method and design. The sampling strategy and data are described in Section 6. Section 7 provides the endline evaluation results. Lessons learned are developed and discussed in Section 8.

2. Relevant Literature

Pilot projects for index-based crop insurance, where payouts are triggered if a pre-defined threshold in a rainfall, vegetation, soil moisture, or yield index is reached within a specific time and geographic area, have rapidly spread across the globe over the past decade (Hess and Hazell 2016). **So far, many agricultural WII schemes in low- and middle-income countries (L&MICs) have reported low levels of insurance uptake and renewal rates, especially in the absence of substantial subsidies** (Hazell et al. 2021; Stein 2018; Marr et al. 2016; Cole et al. 2013; Giné and Yang 2009; Giné and Yang 2008). In 2020, less than 10 percent of farms in L&MICs (excluding China and India) had any sort of formal agricultural insurance coverage (Hazell et al. 2021).

The main factors that have been identified to contribute to low uptake include: (1) basis risk and the fact that payouts are partial and probabilistic; (2) the risk structure; (3) high cost of the insurance product; (4) liquidity constraints, especially at the beginning of agricultural season; (5) lack of trust in the insurance provider; (6) unfamiliarity with insurance concepts and difficulties involved in learning about them; and (7) behavioral aspects such as aversion to ambiguity and compound risk (for a more detailed review of the literature on these constraints to insurance uptake, see Carter et al. 2017).

Over the past two decades, several studies have explored linking WII with credit as a driver for insurance uptake and a contributor to credit supply (for further overview of this literature, see Carter et al. 2017 and Meyer et al. 2017).

Theoretical argument suggests that an effective insurance component in such a bundle reduces the risk of farmers failing to pay back loans when they experience a shock the insurance product covers (Farrin and Miranda 2013; Giné and Yang 2009; Mahul and Skees 2007). Through this lower risk of default for both the lender and the borrower, WII is expected to unlock agricultural credit (Meyer, Hazell, and Varangis 2017), so that farmers can increase their productive investments and engage in riskier activities (such as the adoption of new technologies), especially in contexts where lenders are able to seize collateral in case of default (Carter et al. 2011a). Table 1 summarizes these theoretical relationships between insurance, credit, and technology adoption.

Table 1: Modelled impact of insurance and credit on technology uptake

	Environment with low levels of collateral	**Environment with high levels of collateral**
Self-insurance only	Low technology uptake (credit expensive; induces risk rationing)	Very low technology uptake (risk rationing)
Insurance as a separate contract	No demand for insurance and technology adoption does not improve	Increases technology uptake by reducing farmers' risks (demand effect; supply limits)
Interlinked insurance and credit	Increases technology uptake by lowering interest rates (supply effect)	Relaxes supply constraints

Legend: The table, from Carter et al. (2011b), summarizes the theoretical relationships between insurance, credit, and technology adoption under different risk environments and levels of collateral availability.

In turn, credit as part of a bundle can reduce the liquidity constraints many farmers face in paying insurance premiums at the start of the agricultural season, when they need to purchase inputs (e.g., seeds and fertilizer). This is done by pre-financing or deferring payments through the lending arrangement, thus increasing access to insurance (Liu and Myers 2012; Giné, Townsend, and Vickery 2008). Linking insurance and credit is also expected to enable the development of both markets (Carter et al. 2011a).

Previous literature has discussed and studied the potential benefits and costs of bundling in relation to insurance uptake. Regarding benefits, Matul et al. (2013) present evidence from a bank in Ghana that experienced increases in demand through a bundled savings-linked insurance product. Zimmerman et al. (2016) in a study in Columbia found that, with responsible bundling, overall uptake of crop insurance can reach 23 percent, a relatively high level compared to uptake of similar products in other countries. Considering the findings of Tobacman et al. (2017) that suggest no significant influence of unsubsidized stand-alone insurance products on the adoption of promising investment and the increasing consideration of bundling as alternative mechanism, the next step entails research on evaluating the impact of bundling WII, especially with credit.

To date, few studies have empirically assessed the resilience outcomes or welfare impacts of bundled index-based crop insurance and credit. Among those that assess this relationship, some but not all found that insured farmers had increased agricultural investments or made riskier production choices (Karlan et al. 2014; Wong et al. 2020; Dougherty et al. 2021). Overall, however, literature does not confirm an increase in resilience or welfare as a result of the bundle.

Analyzing crop index insurance mandatorily linked to credit in Mali, Duchoslav and van Asseldonk (2018) found no measurable impact of the bundle on farmers' adoption of a range of different agricultural practices and investment strategies. The authors suggest that this is due to farmers' low levels of awareness about their insurance coverage, which seems to stem from the insurance being delivered through aggregators rather that at an individual farmer level, which is similar to the WII delivery channels in Senegal. A more cautious explanation is offered in an experimental study on risk preferences and poverty traps in relation to credit–insurance bundles in South Africa. The study concludes that for the contract offered through this effort, "insurance is not sufficient to counter the behavioral factors linked to asset constraints and risk preferences that suppress modern farm technology uptake" (Visser et al. 2020). This suggests that even if farmers have information about the insurance product, their risk preferences (risk aversion and loss aversion) and asset constraints may limit the bundle's impact on agricultural investment decisions.

Findings from a more recent field experiment, where insurance was offered to beneficiaries of the Ethiopian Productive Safety Net Programme in northern Ethiopia, confirm some of these results, although in this case, the bundle consists of subsidized insurance and input vouchers (rather than credit). In this study, the bundle is generally ineffective in increasing the purchase or use of agricultural inputs in the context of cash and credit constraints. Instead of alleviating ex ante risk constraints through a subsidized insurance product, subsidizing a higher amount of input vouchers at similar cost delivered more immediate effects. The insurance and input voucher bundle led to a slight increase in the scale of farming activities (i.e., surface area cultivated) in the first year, but not in the second. The group of farmers receiving this bundle marginally reduced their time spent farming, while not

increasing casual labor hire, indicating a minor reduction in farming efforts. Overall, the bundled intervention did not increase farm output value (Wong et al. 2020).

This last finding is largely consistent with the conclusion of other recent studies that relaxed credit and risk constraints in (1) Ghana—combining insurance with cash grants in field experiments (Karlan et al. 2014) and (2) Ethiopia—considering commercial independent insurance in the experiment and conducting a case study of insurance bundled with credit (Ahmed et al. 2020), which also did not find significant and consistent impacts on output value or income (Wong et al. 2020). However, these studies did not assess what happens in case of a payout; that is, they do not account for the financial protection function of insurance in the bundle. Duchoslav and van Asseldonk (2018) analyze the impact of drought on insured farmers (in addition to their behavior change impact pathway discussed earlier). Insurance appears to lower the likelihood of food and money shortages affecting farmers during drought, although this effect is small and becomes minimal for food security impacts with increasing drought intensity.

Empirical evidence presented in recent years suggests that WII coverage supports the accessibility and use of credit primarily through an increase in supply. An example of this is a recent study on Ethiopia's drought-prone Rift Valley zone, which finds that index insurance, in the context where close to 40 percent of households are credit constrained, significantly lowers supply-side rationing of credit for insurance adopters (Belissa et al. 2020).[1] A randomized field experiment in Northern Ghana comes to similar conclusions, finding that the likelihood of farmers receiving credit grows by 15 to 21 percentage points when loans are insured. This is because the insurance increases the likelihood a loan would be approved (Mishra et al. 2021). In a 2017 review of practical experiences with bundling schemes, insurance made lending easier in three out of four cases considered (e.g., using softer lending conditions for insured farmers [Mukherjee et al. 2017]).

On the flipside, adding insurance coverage to a microcredit product has been shown to have zero impact on, or even negatively affect, demand for credit. Banerjee, Duflo, and Hornbeck (2014) pointed out the willingness of borrowers in India to give up a microfinance loan to avoid mandatory health insurance that was attached to the loan, losing at the same time the lead and the additional product. Similarly, through a field experiment in Malawi, Giné and Yang (2009) demonstrate low demand for a relatively more expensive credit linked to insurance (compared to credit without the addition of insurance) because the limited liability clause included in loan contracts already provided people with an implicit form of insurance. While a randomized control trial (RCT) in Kenya found uptake of credit bundled with insurance to be higher than that of an independent traditional credit option, the difference in uptake was small—32 compared to 30 percent (Ndegwa et al. 2020). Overall, the findings discussed here indicate that even if bundling could support demand for credit in some cases, mandatory bundling could also result in adverse outcomes on financial inclusion more broadly when clients are unwilling or unable to pay for insurance coverage and, therefore, forego access to the lead product. In Senegal and other countries, different bundling modalities have been tested and implementers, investors, and intermediary organizations seek to better understand these modalities' comparative effects on product uptake and development impacts.

[1] In this case, WII is offered as a stand-alone product, not as an insurance–credit bundle, but the studied effect describes WII's function in unlocking agricultural credit that would also be expected in a bundle.

Given the anchoring of WII in agricultural and climate adaptation policies in Senegal—and the continued subsidy support toward insurance premiums that the Senegalese Government provides—there is increasing interest in understanding the cost-effectiveness of WII (as well as of associated subsidies). Studying whether WII subsidies are a good use of public funds in Senegal, Ricome et al. (2017) simulate three different scenarios of insurance availability without subsidies: no insurance, WII, and hypothetical crop-yield insurance without basis risk. In addition, the authors develop scenarios where the same amount of public funding goes toward four different interventions: (1) WII premium subsidy; (2) loan subsidy; (3) fertilizer subsidy; and (4) cash transfer program. They find that insurance (subsidized or not) has a high level of utility to farmers in the drier parts of the Senegalese groundnut basin and relatively low utility in the wetter parts of the basin. While an insurance subsidy (at 60% in the model) incentivizes farmers in the scenario to also take up insurance in the wetter regions, WII premium subsidy does not have the highest expected utility to farmers, compared with the three alternatives introduced for using public funds. Based on these findings, the authors confirm that WII may be an appropriate public intervention in the driest areas of the Senegalese groundnut basin but also conclude that permanent premium subsidies are not the best use of public funds compared to the alternative options. Instead, in areas where yield risk is high, benefits were the greatest where government's subsidy of loans, fertilizer, or cash transfers was bundled with unsubsidized insurance, though the study did not go into more detail on bundling modalities.

Generally, there is still little empirical evidence around the impact of mandatorily versus voluntarily bundling WII with credit on insurance uptake. While not empirically establishing impacts of the bundle, there are some indications from case studies regarding the relative advantages and disadvantages of voluntary and mandatory bundling. These are summarized in Table 2.

Table 2: Advantages and disadvantages of voluntary and mandatory bundling

	Voluntary bundling	**Mandatory bundling**
Positives	• Technically more market-led because it is demanded by and paid for by the farmer (could be subsidized or not) • Calls for more involvement of the implementing agency in terms of offering—better client education for better product appreciation, looking to add more incentives for the farmer to take the product, improving the value proposition of the client • When the value proposition is clear, the uptake is robust	• Easy to scale up, especially with desirable services like agricultural loans • Lowers distribution costs • Avoids the challenge of adverse selection
Negatives	• Calls for more investments from the implementer and hence, a sustainable business case may take time to emerge for all stakeholders involved • At times, implementing a model like this may hijack the value proposition idea and so the focus shifts to creating a value chain for the product, rather than looking at ways	• Less investment in client education and awareness efforts so true appreciation for insurance and its value may not take root • Forces farmers to pay for services • May have higher cost

	Voluntary bundling	Mandatory bundling
	we can positively integrate the insurance in the already proven value chain	component for the farmer and need sustained subsidy support

Legend: This table from Mukherjee et al. (2017) contrasts the benefits and drawbacks of voluntary and mandatory bundling of WII with agricultural credit. It highlights the trade-offs in terms of farmers' autonomy, operational costs, scalability, and the level of awareness and understanding required to drive uptake and sustained participation.

To our knowledge, as of yet, no study has provided a direct empirical comparison of the two bundling methods—voluntary or mandatory—of WII and credit to analyze impacts on insurance uptake rates and farmers' well-being. In this context, our findings aim to guide policy and strategy around WII provision and integration with credit, informing agricultural development, resilience, and adaptation and financial inclusion agendas.

3. Growth of the crop insurance sector in Senegal

Weather index-based crop insurance is available in Senegal through different schemes, including micro-level retail insurance targeted at smallholder farmers, macro-level sovereign insurance with policies held by the government, and meso-level with policies held by risk aggregators such as FOs, MFIs, and banks.

Micro-level crop insurance has emerged in Senegal since 2008, with the creation of the public–private national agricultural insurance company, CNAAS. This company started issuing its first indemnity-based crop insurance policies in 2009. CNAAS has several different agricultural insurance programs the government publicly subsidizes that are implemented in collaboration with several partners, including FOs, MFIs, banks, development partners, and technical partners such as agro-meteorological services. In 2012, CNAAS started offering index-based insurance products to smallholder farmers with membership in FOs, which serve as aggregators. Since then, the products and indices used have evolved through several stages:

- Ground measurements were primarily used for index-based insurance products during the early years, in 2012 and 2013. These are based on automatic rain gauges capturing actual rainfall, and each covers a radius of about 5 to 7 kilometers. Currently, CNAAS has access to 302 rain gauges.
- In 2014, satellite indices for index-based insurance were first introduced in Senegal through the R4 project, in addition to continued use of ground measurement in some geographic areas. This index estimates the rainfall based on ARC2 satellite data.
- In 2015, the Relative Evapotranspiration Index was introduced as a second satellite index using Environmental Analysis and Remote Sensing (EARS) data. It combines measures of water losses resulting from soil evaporation and crop transpiration.
- A recent CNAAS-supported study on basis risk for the three abovementioned indices found that the risk was overall the lowest for the ground measurement-based index and the highest for the satellite index that estimates rainfall (CNAAS 2022). As a result, CNAAS is considering shifting away from this index in the near future, because the basis risk associated with this product seems structurally high.
- In 2021, area yield indices were first tried and they triggered some payouts in the Tambacounda region. In post-season reviews, farmers preferred area yield or a combination of area yield and ground measurement-based rainfall indices over satellite indices.

At the macro level, the Government of Senegal has been a member of the drought risk pool of the African Risk Capacity (ARC) since its creation, in 2014. Development partners that are members of the Start Network, such as Catholic Relief Services, Oxfam, *Action contre la Faim*, Plan International, World Vision, and Save the Children, participate in the ARC Replica program and work alongside the government to deliver assistance during severe drought shocks. So far, the Government of Senegal has received a USD 16.5 million payout during the 2014/2015 season (ARC 2017) and USD 12.5 during the 2019/2020 season. As part of the ARC Replica program, Start Network members in Senegal received a payout of USD 10.7 million triggered by the 2019 drought and replicating the payout the Senegalese government received that year (ARC 2019; Start Network 2020). Hence, the country has received in total USD 39.7 million in payouts as part of the ARC program. The payouts have supported cash disbursements, food distributions, and the subsidized sale of livestock fodder predefined through a contingency planning process (Start Network 2020; ARC 2017).

Meso-level (or portfolio) index-based insurance has been introduced recently, as a progression of some micro-insurance products CNAAS proposed to farmers through their affiliated FOs or banks. Initially, individual farmers held the contracts those organizations distributed on behalf of CNAAS. However, since 2017, and more significantly in 2018, CNAAS has negotiated portfolio contracts with different organizations, accounting for a large part of the number and amount of premiums issued. Through portfolio insurance of partners, including the largest Senegalese agricultural bank, LBA, meso-level WII insurance and average yield index-based insurance (AYII) have strongly contributed to CNAAS' business growth. The two products represented 61 percent of CNAAS' portfolio in 2021. Traditional products, such as indemnity-based insurance, represented 39 percent of the portfolio.

According to a ranking issued by the Senegalese National Department for Insurance, CNAAS was 18th in the Senegalese non-life insurance market in 2019, with a CFA 1.875 billion (~USD 3.25M) turnover. This is equivalent to a 1.4 percent share of the overall market, compared to 1.07 percent in 2017 (prior to signing the main portfolio contracts with LBA and a large FO in the country, ASPRODEB (*L'association sénégalaise pour la promotion du développement à la base*) (Government of Senegal 2019).

3.1 Partnership and distribution

CNAAS is a public–private partnership created in the form of a public limited company with a starting social capital of CFA 1.5 billion. The capital was divided between the government of Senegal (36%), local private insurance and reinsurance companies (56%), and FOs (7%). In 2016, the regional regulatory body for the insurance market, CIMA (*Conférence Inter-africain des Marches d'Assurance*) introduced a reform that raised the minimum share capital for public limited companies from CFA 1.5 to 3 billion (USD2.5M to 5M). In response, CNAAS launched a capital increase process that at the end of 2019, yielded a social capital of CFA 3.155 billion (~USD 5.46M) (CNAAS 2020). By entering the CNAAS capital through the Deposits and Consignment Fund *(Caisse de Dépôt et Consignation [CDC])*, the government remained the majority shareholder, owning 45 percent of shares. Private insurers hold 38 percent of shares, followed by the LBA with 12 and FOs with 5 percent, respectively.

CNAAS' primary partner in terms of institutional, technical, and financial support is the Senegalese government, which has given the company a key role in its national social protection strategy. Producers insured through CNAAS benefit from a 50-percent subsidy to

each policy issued. In addition to the ministry of finance, which provides financial and institutional support, government's public agencies such as the National Meteorological and Civil Aviation Agency (*Agence Nationale de l'Aviation Civile et de la Météorologie [ANACIM]*), the Senegalese Institute of Agricultural Research (*Institut Sénégalais de Recherche Agricole [ISRA]*), and the Department of Agricultural Statistics of the Ministry of Agriculture *(Direction de l'Analyse, de la Prévision et des Statistiques Agricoles [DAPSA]*) provide technical support. Additional support comes from international development partners through various projects, including the World Bank's Global Index Insurance Facility (GIIF), the WFP's R4 project, the West African Development Bank-funded project for cotton and maize producers affiliated with the National Federation of Cotton Producers *(Fédération National des Producteurs de Coton [FNPC]*), or more recently, the Canadian Cooperation.

Partnerships play a key role in the distribution of insurance products in Senegal, especially index-based products. At the launch of the ARS (*Assurance Récolte Sahel*) drought index-based product, the distribution was insured by the broker Inclusive Guarantee (IG, formerly Planet Guarantee). This product was the first crop index-based insurance in the country, as part of the GIIF program. A partnership between CNAAS and IG made the latter the leading distributor for index-based insurance products throughout GIIF projects in the country. Hence, IG was responsible for ensuring the validation for the index product, its marketing (including training of the aggregators' sales agents and representatives), premiums collection, follow-up of the crop-growing seasons, and processing of claims and payouts. While aggregators were present in that distribution channel, they did not have a direct relation with CNAAS, but with IG, which marketed the product on behalf of CNAAS.

Depending on the relationship between CNAAS and its distribution partners, we can classify them according to their role in the sector—whether they connect farmers directly to the insurer or not. Therefore, "direct distribution partners" refers to the situation where aggregators are only intermediaries (not policy holders), making the insurance product available to farmers as part of an individual contract with CNAAS. In the case of "indirect distribution partners," parameters are still set at the individual farmer level, but the aggregator, who signs the unique contract with the insurer, holds the policy. Thus, no contractual relationship exists between the insurer and individual farmers. Direct distribution partnerships correspond to micro-level insurance schemes, while indirect distribution partnerships are aligned with meso-level distribution schemes.

During the years following the end of GIIF Phase I, in 2015, at the demand of some aggregators—including FNPC/Société de Développement des Fibres Textiles (SODEFITEX), ASPRODEB, and LBA—CNAAS began to manage parts of its portfolio that IG had previously controlled. Therefore, while the portfolio distribution strategy was essentially based on CNAAS' collaboration with the broker IG during the early years of crop index-based insurance, since 2017, such partner aggregators have been CNAAS' main distributors and clients. Types of aggregators include banks, MFIs, FOs, or donors' projects and programs. Banks and MFIs—primarily LBA and Crédit Mutuel du Sénégal (CMS)—are the largest contributors to CNAAS' portfolio through an indirect distribution scheme, where contracts are signed between the banks and CNAAS, rather than between CNAAS and individual farmers. The total premium CNAAS collected in 2021 through these financial institutions accounted for up to 48 percent of its portfolio. The R4 project, that the World Food Programme (WFP) implements, is the largest contributor as part of the direct distribution scheme, with premiums collected accounting for 22 percent of CNAAS' index-

based insurance portfolio in 2021. Contributors in CNAAS's portfolio that operated an indirect distribution scheme include also FNPC, which works with the SODEFITEX processor (16% of the collected premiums in 2021).

Table 3: Distribution partners and their contribution in the total amount of premium collected in 2021

Name of the distribution partner	Type of actor	Type of partnership with the insurer	Contribution to the total premium collected (2019)
FNPC/SODEFITEX	Processor	Indirect (meso level)	16%
AGROPOLE SUD	Development project	Direct (micro level)	0%
SONACOS	Processor	Indirect (meso level)	3%
PADAER II	Development project	Direct (micro level)	10%
PAM/RA	Development project	Direct (micro level)	18%
LBA	Bank	Indirect (meso level)	28%
CMS	Bank	Indirect (meso level)	20%
MY AGRO	Digital platform Service	Direct (micro level)	4%

Source: Authors, based on CNAAS' documents
Legend: This table provides an overview of CNAAS' key distribution partners in 2021, detailing the type of partnership, type of actor, and percentage contribution to the total premium collected. The table distinguishes between micro- and meso-level schemes, which influence how farmers access and engage with insurance products.

The meso-level distribution schemes in Senegal are particular because the insurer and the aggregators (FOs, MFIs, or banks) agree that the premium needs to be set at the farmer level and supported by the farmer. Therefore, even though the aggregator is the client signing the contract, the scheme must provide information about the number of farmers insured, their location, the area of land covered, and the type of index triggering the payouts to the insurer. Aggregators are also committed to informing their clients or member farmers that the lead product they provide (mostly agricultural credit) is bundled with an insurance product. During the first years of the portfolio contracts that CNAAS negotiated with its main aggregators, farmers could willingly subscribe (voluntary bundling) or purchase the insurance mandatorily (mandatory bundling). However, mandatory bundling has gradually replaced voluntary bundling for most contracts with aggregators (LBA, CMS, FNPC/SODEFITEX, SONACOS, etc.).

The growing collaboration between CNAAS and LBA.
LBA was founded in 1984, under the initial name of Senegal National Agricultural Credit Funds (*Caisse Nationale de Crédit Agricole du Senegal [CNCAS]*). LBA has the guarantee of the state, which owns the highest share of its social capital (through the contribution of the ministry of finance and other public institutions). CNCAS and CNAAS share the status of private financial institutions, with most of their social capital owned by public funds. They are both committed to the achievement of the government's main objective regarding the funding of the agricultural value chains. Since the last capital increase, LBA has a 12-percent stake in CNAAS and regards the insurance company as an opportunity to reduce the risk in its portfolio while increasing the funding provided to its partner clients. These clients include FOs and some MFIs in rural areas whose members or clients are exposed to drought risk. LBA is one of the larger banks in Senegal, with a total balance between CFA 200 and 300 billion. It is represented in all regions of the country, with one of the highest levels of coverage, especially in rural areas. This explains the rapid growth in collaboration between the two institutions in the past three years with four decisive moves:

1. LBA's decision to support CNAAS capital at 12 percent of the shares
2. LBA's decision to make WII products mandatory for all agricultural credit products it offers, in areas where WII is available
3. CNAAS' decision to close some of its offices in areas where LBA is present, and in exchange, set up an office in LBA's agencies
4. CNAAS' decision to make the WII product available almost everywhere in the country where drought risk is present and where LBA operates

To commercialize the product and inform farmers about it (in the case of meso-level schemes), CNAAS and LBA initiated the recruitment of sales agents in local LBA agencies where insurance products are available. Besides, all aggregators, separately from their partnership with CNAAS, receive training on the functioning of the products to be able to provide appropriate information to their members or clients. However, although CNAAS and its partners seem to keep the producers informed, in the case of the meso-insurance schemes, there is no legal regulation that mandates informing the farmer about the insurance product. In both types of distribution schemes (micro and meso), the insurer's and aggregators' capacity to provide all their members/clients with the correct information about the bundle they offer will affect that particular farmers' level of awareness about insurance.

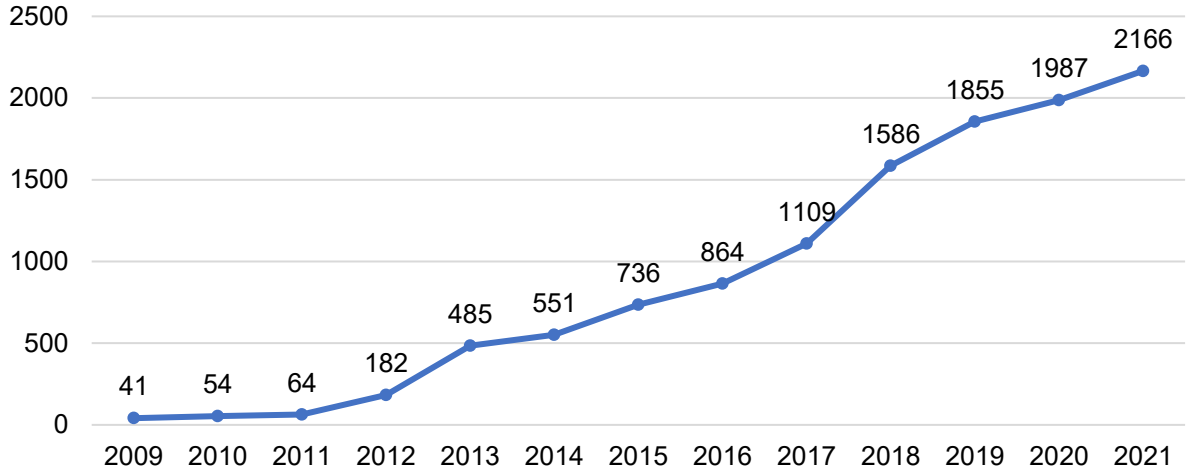
3.2 CNAAS' financial performance

The volume of CNAAS' activities has significantly evolved since its creation, in 2009. In 10 years, the company has multiplied its turnover by 45—from approximately CFA 41 million to almost 2.166 billion (USD 79,000 - 3.9M) between 2009 and 2021, with the average growth rate around 48 percent. The years with the highest growth in turnover coincide with the introduction of the agricultural index insurance product, particularly in 2012 and 2013, with growth of 184 and 166 percent, respectively. In the period of CNAAS' significant growth of portfolio (Figure 1 and Figure 2), two major dates require particular attention:

1. 2012 coincides with the first introduction of the WII products and has the highest growth rate in terms of turnover. The amount of premiums collected tripled compared to 2011, when only traditional insurance was proposed.

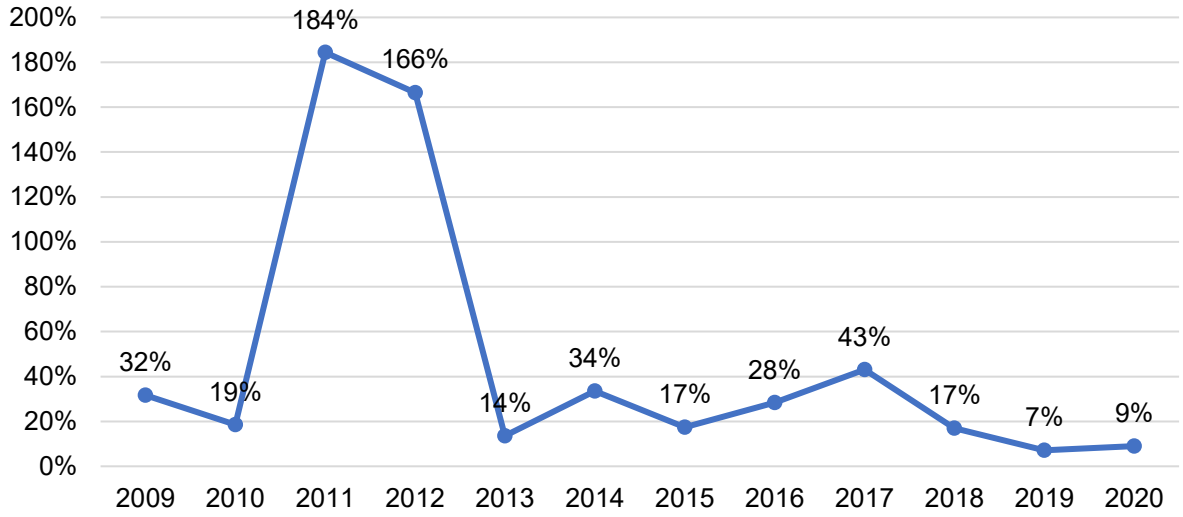
2. 2018 had the highest growth rate after the introduction of index-based products. This coincides with the generalization of satellite indexes and, thus, its introduction in areas where aggregators have members or clients, but CNAAS had not yet installed rain gauges. Besides, in 2018, LBA and ASPRODEB started insuring their portfolio of agricultural credit after the FNPC in 2017.

Figure 1: CNAAS' growth in CFA since its creation



Source: Authors, based on CNAAS' internal data and documents

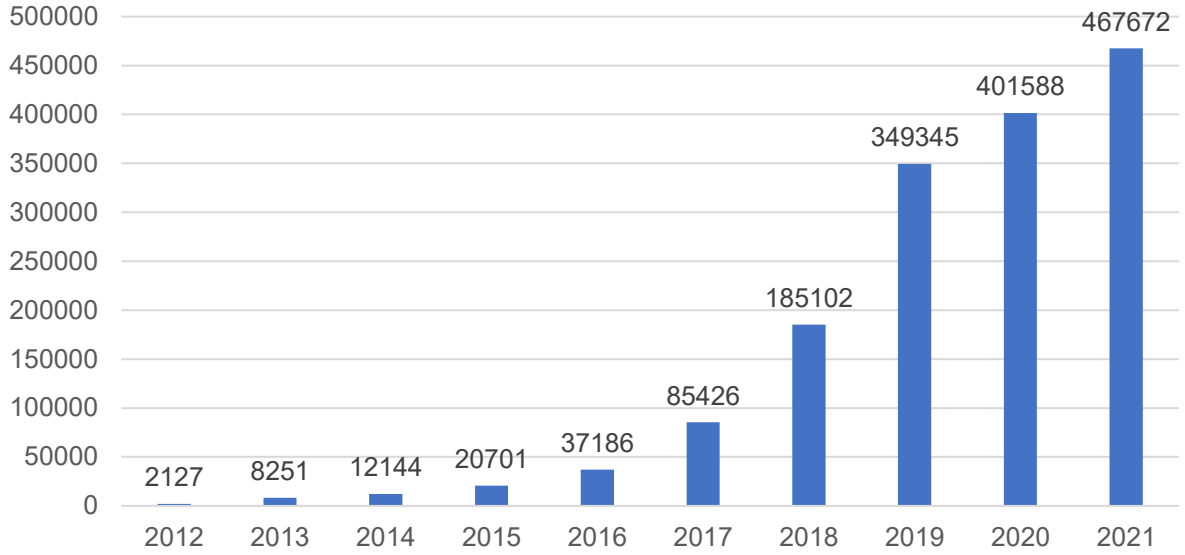
Figure 2: CNAAS' yearly growth rate



Source: Authors, based on CNAAS' internal data and documents

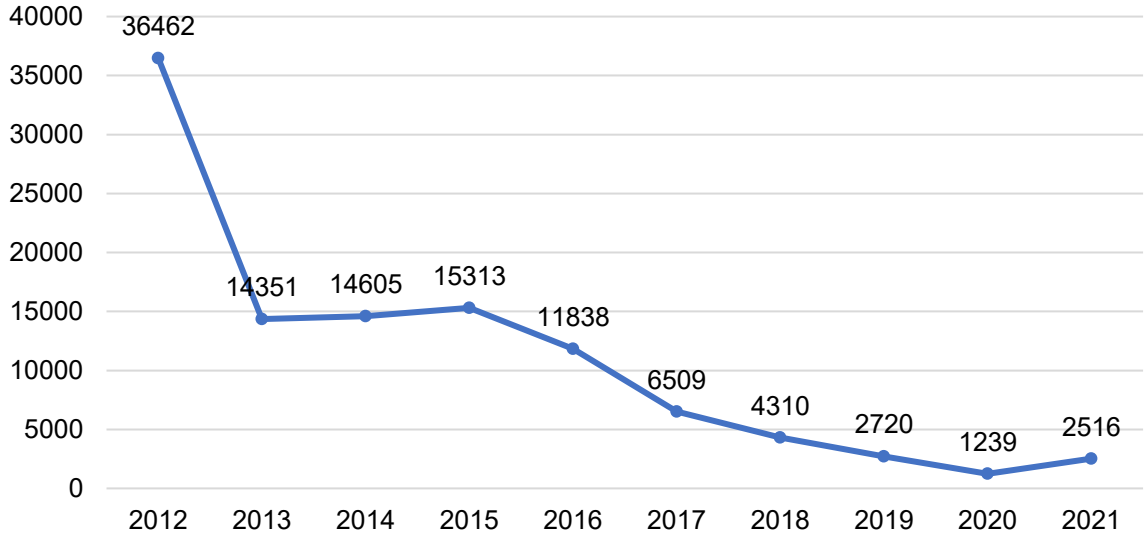
The number of producers CNAAS insures has also grown fast since the introduction of the index-based insurance policies. It is interesting to note that insurance premiums have, on average, continued to decrease significantly since index insurance was introduced, with simultaneous increase in insured producers. This is explained by the importance of index-based products in CNAAS' sales compared to the sales of the traditional indemnity-based products, which enable more farmers to insure smaller plots with lower level of investment and hence, lower premiums to pay. Besides, because satellite-based products allow for lower premiums than those based on rainfall measurement on the ground, their expansion has contributed to a decrease in premiums.

Figure 3: Number of producers insured under CNAAS



Source: Authors, based on CNAAS' internal data and documents

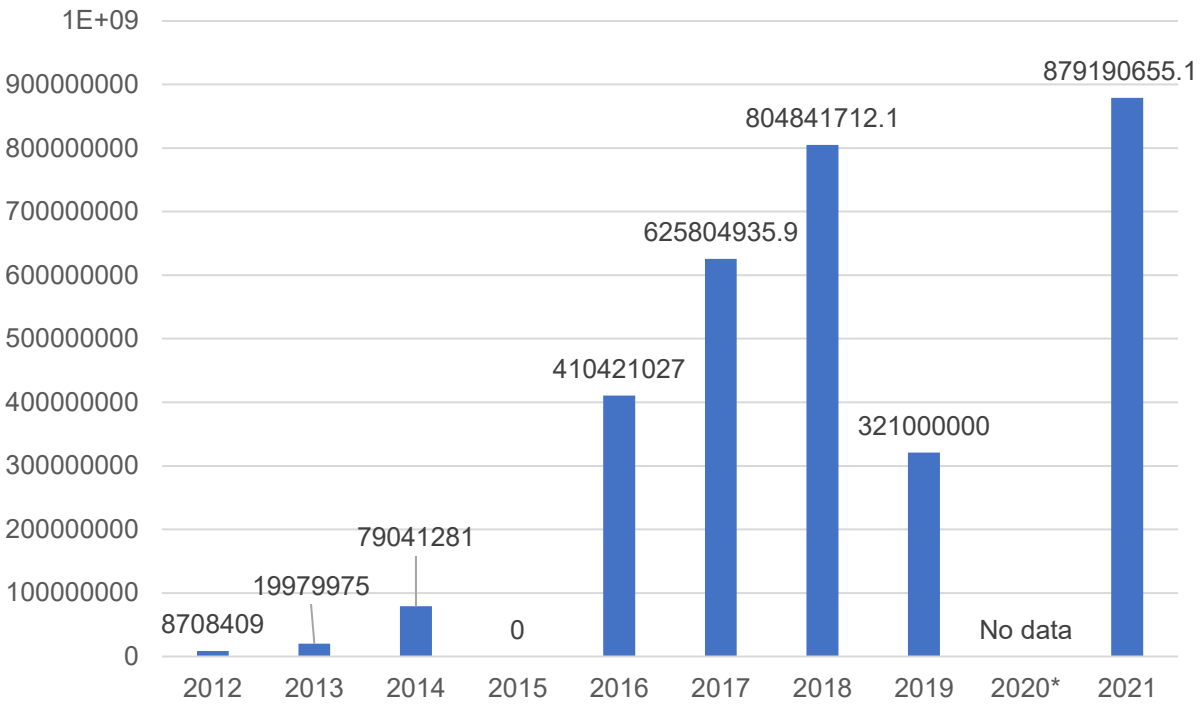
Figure 4: CNAAS average premiums collected per year (in CFA per hectare)



Source: Authors, based on CNAAS' internal data and documents

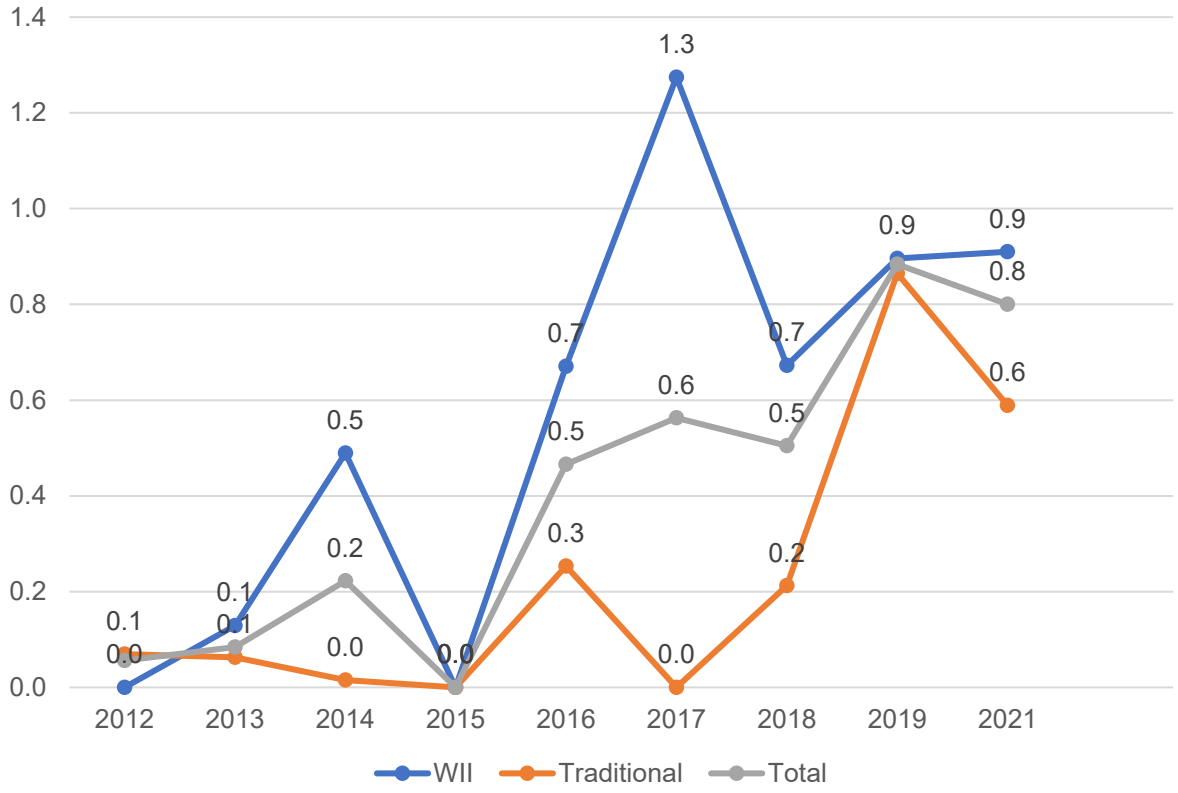
Figure 5 and Figure 6 present the progression of CNAAS' payouts and its loss ratio since the introduction of WII products, disaggregated by type of product (index insurance or traditional insurance). With the increase in the number of policies sold and the growth of the CNAAS portfolio, claims have also multiplied. Since 2012 and apart from 2015, CNAAS paid out each year with an average loss ratio (proportion of claims to premium earned) of 40 percent when considering both traditional and index-based products. Disaggregating per type of product shows an average loss ratio of 56 percent for index-based products and 23 percent for traditional crop insurance during the same period, according to our calculation based on CNAAS business data. The highest loss rates took place in 2017 and 2019, with 60 and 90 percent, respectively. It is worth noting that the loss ratios of the last business years are the highest and the rate seems to increase the most for the index-based products, designed mostly to target relatively small-scale farmers.

Figure 5: Payouts administered since the introduction of WII products (in CFA)



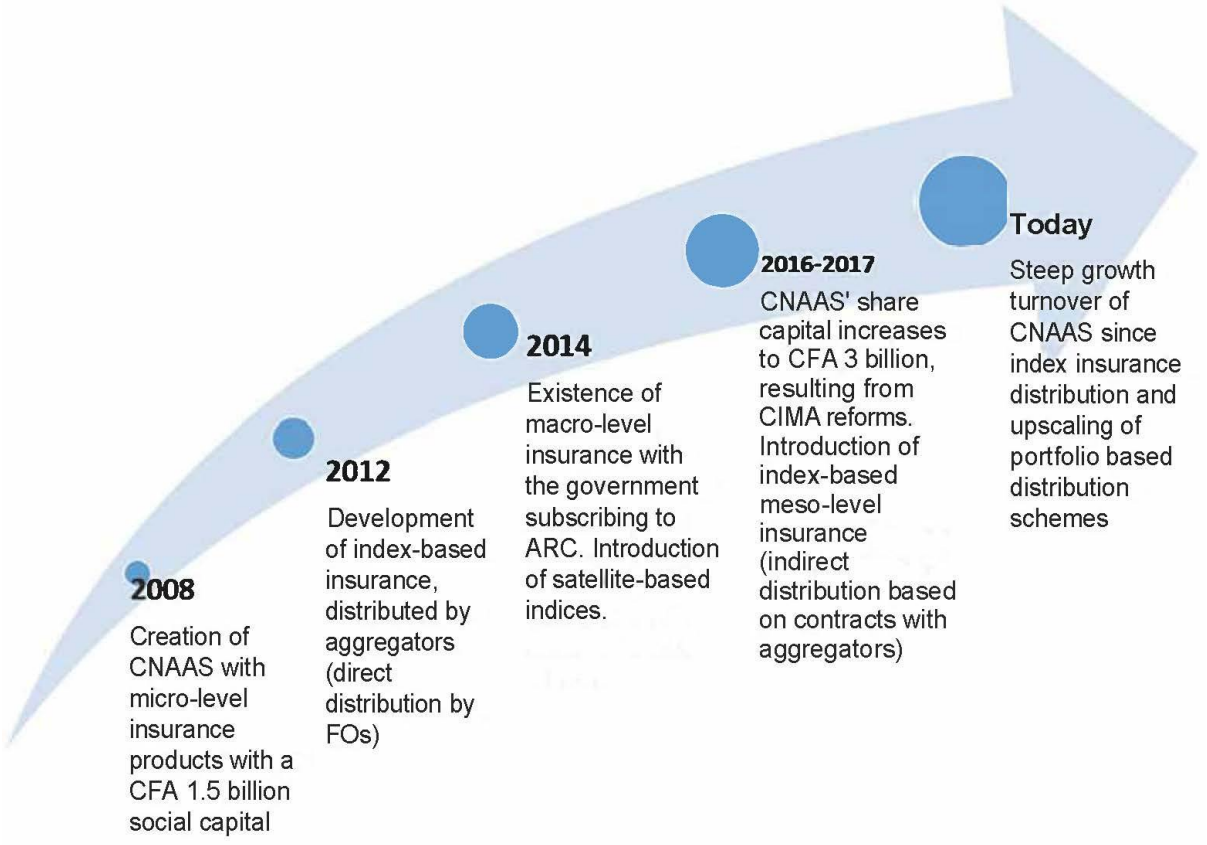
Source: Authors, based on CNAAS' internal data and documents

Figure 6: CNAAS loss ratios since the introduction of WII products



Source: Authors, based on CNAAS' internal data and documents

Figure 7: Summary of the main dates in the crop insurance sector's progression in Senegal



Source: Authors

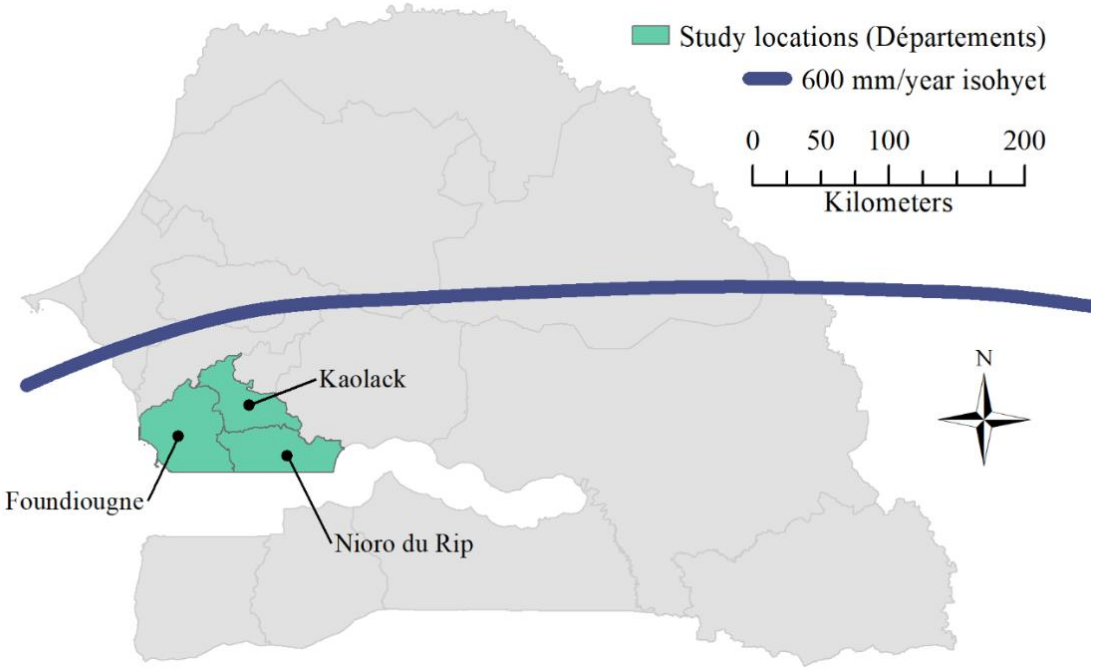
4. Intervention overview

This section provides more information about the intervention—the insurance product proposed, its characteristics, and how it is bundled with credit. It also offers a comparison between the two FOs involved in this study, COOPEC/RESOPP and CCPA, and based on their institutional procedures and their members' characteristics, which FO the farmers in our sample belong to.

4.1 Areas of intervention

The regions in the center of Senegal are the main contributors to Senegalese agricultural production (Jalloh et al. 2013). The position of these regions vis-à-vis the 600-millimeter isohyet, which divides the country in a mainly rain-fed agricultural area in the south and an irrigated agricultural area in the north, makes their population vulnerable to rainfall variability. According to Sall (2015), rural households in the Senegalese groundnut basin face structural constraints, including exposure to rainfall deficits, and have struggled to develop adequate adaptation strategies. The intervention, as part of this study, considers applicants for CCPA and COOPEC/RESOPP's agricultural loans in the central regions of Kaolack (*Départements* Kaolack and Nioro du Rip) and Fatick (*Département* Foundiougne) (see Figure 8).

Figure 8: Study location



Source: Authors

4.2 Description of the intervention

This study evaluates the impact of providing WII insurance bundled with agricultural loans in Senegal. In the run-up to each rainy season, the national agricultural insurance company offers insurance to farmers who apply for agricultural credit. Between 2012 and 2020, the governance and strategy of the cooperative through which member farmers accessed credit and in some cases, the MFI the cooperative was affiliated with, determined whether insurance was a voluntary or mandatory add-on to credit. This study considers two cooperatives that initially offered different provision models: CCPA provided mandatory insurance to loan-taking members, while COOPEC/RESOPP offered insurance as a voluntary add-on for credit candidates.

4.2.1 The WII products

From the first pilot in 2012 until the 2017 rainy season, farmers in the groundnut basin received only one type of agricultural insurance product: a drought index-based insurance designed on the basis of ground measurements of rainfall through rain gauges covering approximately a 5-kilometer radius. This product was developed through the ARS project led by PlaNet Guarantee. In recent years, the number of rain gauges installed grew to meet the demand of the FOs who wanted to increase the share of their members with access to the insurance product by expanding geographic coverage. However, a significant portion of farmers remained uncovered due to a rise in the number of institutions that decided to include WII as part of the services they provide to their members, as well as growing membership. Given this situation and the fact that automatic rain gauges and their installation are costly, to resolve the problem of geographic access to insurance,[2] during the

[2] Satellite-based drought-index insurance has existed in Senegal since 2014, in the regions of intervention of the R4 project implemented by WFP and Oxfam. However, before the 2018 rainy season, this product was not available for the regions of Fatick and Kaolack in the groundnut basin.

2018 rainy season, a satellite-based drought-index insurance, which had been previously only available in the south and east of the country, was introduced in the groundnut basin. However, as mentioned above, due to high basis risks associated with the satellite-based indices, in particular the one that estimates rainfall, CNAAS has reconsidered supplying index-based products.

Figure 9: Number of farmers insured by type of product

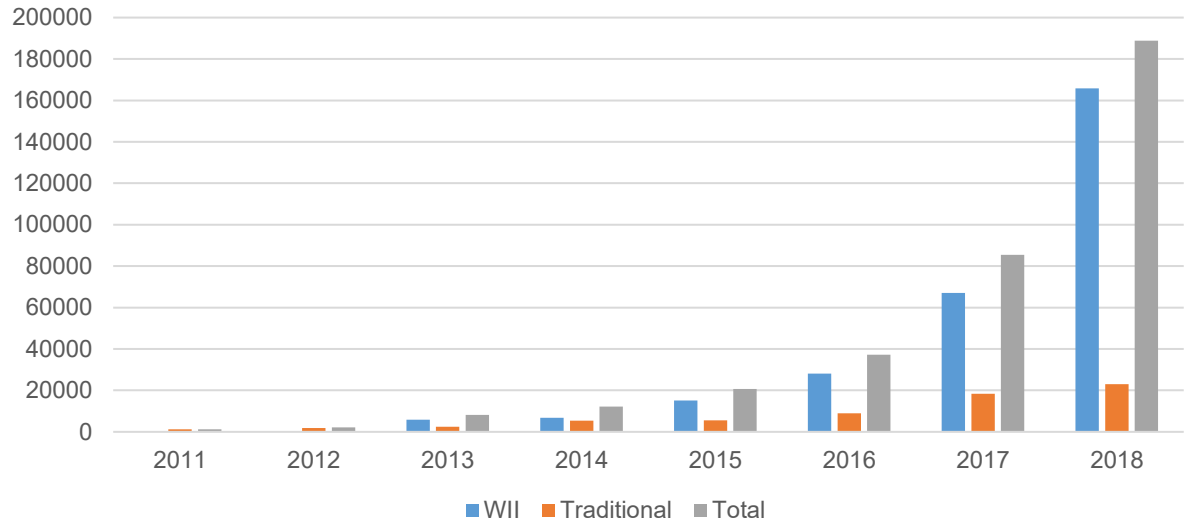
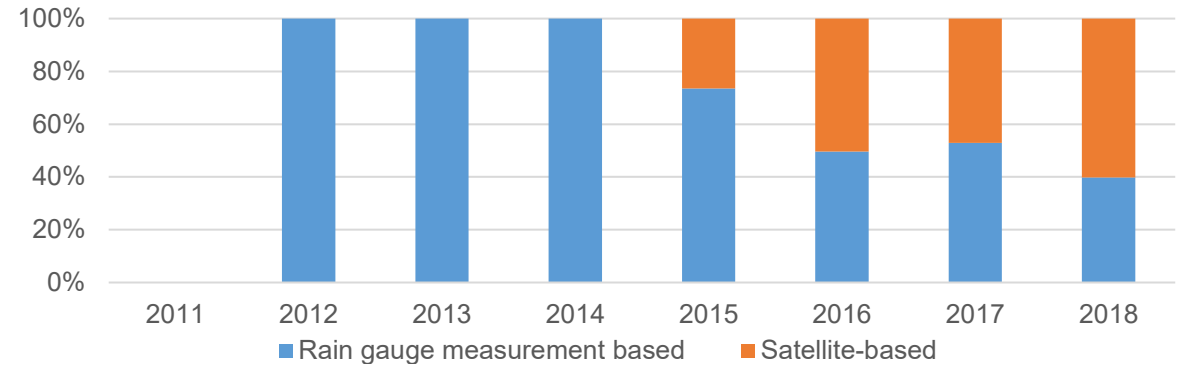


Figure 10: Distribution of weather index insurance sales by type of index



Both the satellite and the rain gauge-based products are designed to cover groundnut. However, the satellite index cover also includes crops such as maize, millet, and rice. For the ARS drought product, a separate index needs to be developed for every type of crop. The consequence in terms of premium rates is that only one range of premiums that varies depending on the location and its level of exposure to rainfall variability is set for the satellite index, while for the ARS index, every crop covered has its own range of premium rates. The satellite index can cover an area of land where multiple crops are grown; for the ARS index, the insured land must have only one crop. In the intervention this evaluation looked into, two ranges of premium rates were considered during the first two years of implementation.

1. Satellite index-based drought insurance: between 4 and 14 percent of the insured capital, depending on the location.
2. Rain gauge measurement-based drought insurance: between 7.61 and 13.35 percent of the insured capital, depending on the location.

Under the ARS product, the insurer can pay up to 80 percent of the insured capital, while for the satellite product, payouts can reach up to 95 percent. The satellite index-based product separately covers three stages of plant development through the index: the vegetative period, the flowering period, and the maturation period of the crop. Under rain gauge-based products (ARS), the index covers an additional, fourth stage—sowing failure.[3]

Regarding the level of basis risk[4] and products performance, CNAAS does not have recorded yields in every 5-kilometer radius; instead, they regroup villages that share a unique rain gauge or per cluster (as part of the satellite index-based product). This means that there is no currently available assessment of correlation between yields and payout levels.[5] Instead, CNAAS calculates a statistical basis risk using the following formula:

> Statistical basis risk=(number of instances recorded where positive[6] basis risk results in overpayment, on the basis of post-season follow-up[7] + number of instances recorded where negative[8] basis risk resulted in underpayment, calculated on the same basis as for positive basis risk) / (total number of rain gauges or areas where rain gauges are installed) * the number of years).

According to CNAAS, the current statistical basis risk rate is between 5 and 8 percent for the index that uses rainfall measurements on the ground. For the satellite-based index, no official numbers are available at the national level. Anecdotal evidence from pilot projects in other areas of Senegal that use a satellite-based index indicates frequent mismatches between the index triggers and actual losses on the field during the first years (2014 and 2015) before a net improvement during the last two years (2016 and 2017). The recent risk assessment (discussed in more detail in Section 2), confirmed these indications.

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[3] Product descriptions are based on oral accounts the insurer CNAAS and its broker Planet Guarantee provided, as well as technical documents they shared as part of the training workshops the study team organized for the COOPEC and CCPA sales representatives and sales agents.

[4] "Basis risk in index insurance arises when the index measurements do not match an individual insured's actual losses. There are two major sources of basis risk in index insurance. One source of basis risk stems from poorly designed products and the other from geographical elements. Product design basis risk is minimized through robust product design and backed by testing of contract parameters. Geographical basis risk is a factor of the distance between the index measurement location and the production field. The greater the distance between the measurement instrument and the field, the greater the basis risk. (…) This basis risk is reduced when the area covered by the index is homogeneous both in terms of weather and in terms of farming techniques. Therefore, as the density of weather stations and satellite pixels is increased, basis risk is minimized." (https://indexinsuranceforum.org/faq/what-basis-risk).

[5] CNAAS' weather index insurance specialist confirmed this information.

[6] When the index triggered while there was no actual loss.

[7] The agricultural season follow-up is conducted using the information local representative of the insurance company collects in each region and the information collected from official agricultural official technicians working for the government. This is also triangulated with the information received from framers' representatives and other key informants.

[8] When the index did not trigger although there was an actual damage due to "bad" rainfalls, as specified in the insurance contract.

4.2.2 Implementing partners in the field: FOs

As discussed earlier, CNAAS has increasingly turned to integrating insurance and credit into an inseparable bundle (referred to in this study as mandatory bundling) and negotiated arrangements with agricultural loan providers and aggregators (FOs, banks, and MFIs). In its early stage, this study considered two cooperatives with different provision models: (1) CCPA that provided mandatory insurance to loan-taking members, and (2) COOPEC/RESOPP that offered insurance as a voluntary add-on for credit candidates. However, with the start of the 2021 agricultural season, the COOPEC/RESOPP FO, following its general assembly, decided to also make the insurance a mandatory add-on for its member credit candidates.

4.2.3 Comparison between COOPEC/RESOPP and CCPA institutional procedures

The COOPEC/RESOPP FO and MFI system

COOPEC/RESOPP works as an umbrella organization for cooperatives. Through its nine rural cooperatives that constitute a network of 40,000 members distributed across eight regions of the country, the cooperative network RESOPP and its financial branch, an institution for saving and credit named COOPEC, offer to their members/clients services such as input procurement, microfinance, commercialization of agricultural surplus, and technical support. Through the OSIRIS (*Organisation pour la Sécurité et la Résilience des Initiatives Rurales*) project, COOPEC has offered voluntary WII bundled with agricultural loans to its members since 2017. The OSIRIS project, which started in January 2015 and ended in March 2018, worked to improve the social and economic protection of rural vulnerable populations in the eight regions where RESOPP presently operates. COOPEC/RESOPP have guaranteed the continuity of WII provision beyond OSIRIS through a memorandum of understanding with CNAAS, continuing access to agricultural insurance for the farmers affiliated with the organization.

CCPA FO

CCPA also works as an umbrella organization consisting of 8,000 members distributed across four regions of the country: Fatick, Kaffrine, Kaolack, and Tambacounda. Like RESOPP and most of the FOs in the central parts of Senegal, CCPA supplies members with agricultural inputs like seeds and fertilizers in the form of loans and other agricultural services. They are different from RESOPP in that CCPA, similarly to most other FOs, does not have their own financial branch; rather, they fund the members' activities through collaboration with independent MFIs. Additionally, CCPA operates only in rain-fed agricultural areas of the country, while COOPEC/RESOPP works in both rain-fed and irrigated agricultural areas. CCPA members were among the first farmers to be introduced to index-based crop insurance pilots in Senegal through the GIIF ARS project that ended in 2015. Since then, CCPA members have had access to insurance through the organization, the insurer, and its broker. Initially, they were free to choose whether to take out insurance or not. Then, in 2018, for the first time, CCPA made insurance a mandatory add-on to loans their members take out.

As an umbrella organization, CCPA is made up of a set of groundnut producers' associations at the level of the different villages and communes in the regions where CCPA operates, known as GIPAs (*groupement intervillageaoise de producteur d'arachide)*. Although CCPA is a legal entity that represents their members' interests in front of partners (such as banks, insurers, oil producers, and the government), membership, management of credit applications/approvals, and subscription to insurance are decentralized. It is at the

level of the GIPAs that the applications for credit are received and approved, the amount of individual contributions is defined, the insurance premiums are collected, and the reimbursement are redistributed. Memberships are also made at the level of GIPAs and each GIPA has its own rules of operation. Thus, the governance system of CCPA has two levels: (1) at the central level, where the executive board of CCPA manages major funding decisions such as negotiations of loans for the entire organization and negotiations with clients, and (2) at the local level, where GIPAs are responsible for their development by signing up new members or distributing loan allocations they receive from the central board.

Table 4 describes the principal characteristics of the procedures the two institutions use in the different services they provide to their members.

Table 4: Comparison between COOPEC and CCPA standard procedures as of the baseline crop season in 2018

	COOPEC/RESOPP	**CCPA**
Governance	Central level with all decisions to be approved by the local head of COOPEC/RESOPP booking office	Two levels: 1. Major decision at the central level (CCPA executive board) 2. Decisions regarding the management of the members at the GIPA level
Area of intervention in the groundnut basin	Groundnut basin in the regions of Fatick, Kaffrine, and Kaolack, sometimes in same departments, but mostly in different rural communes and villages	
Condition of membership	Yearly contribution of CFA 10,000 (CFA 5,000 [USD 9] each for RESOPP and COOPEC)	Yearly contribution that varies between CFA 0 and 5,000 (USD 9) depending on the GIPA
Source of funding for agricultural activities	COOPEC MFI as the financial branch of the RESOPP; As a microfinance institution, COOPEC is refunded by banks such as LBA	Independent banks (mainly LBA), MFIs, oil manufactures channeled through CCPA, and more recently, government's rapid funds for entrepreneurship (2020) (DER)
Micro insurance product	The product: WII provided by the national agricultural insurer CNAAS with a unique premium rate set per area of homogenous rainfall variability and independently with each FO operating in the area.	
	Premium Rate: 3–7% for the satellite based-index and 7.61 and 13.35% for the rain gauge-based index, depending on the areas[9]	
	Voluntary insurance proposed to applicants for credit.	Mandatory insurance for all credit applicants.
Average value of the insurance premium paid (2018)	CFA 6,711.78 (USD 12)	CFA 6,171 (USD 11)
Average value of credit in 2018	CFA 56,165 (USD 100)	CFA 114,669 (USD 204.76)
Mode of acquisition of	RESOPP independently acquires	CCPA uses the funding from the

[9] For each type of index (rain gauge measurement on the ground or satellite-based), the premium rate farmers pay depends on their location, regardless of their affiliated organization. To date, most locations have had only one type of index and one type of insurance product available. For the areas where rain gauges are available and the satellite index is developed, the farmers can select the type of product they purchase.

	COOPEC/RESOPP	CCPA
agricultural inputs	agricultural inputs (seeds, fertilizers, and agricultural materials) from wholesalers	independent banks, MFIs, and oil manufacturers to acquire seeds, fertilizers, and other agricultural inputs from wholesalers
Mode of distribution of agricultural inputs to farmers	COOPEC assesses famers' credit application for inputs and provides loans in the form of vouchers for agricultural inputs to accepted applicants. Farmers with vouchers then exchange them for the corresponding quantity of inputs (listed on the voucher) at RESOPP's local depot.	Farmers receive loans in the form of agricultural input acquired by CCPA from its financial partners. To repay their loans, farmers are required to sell back their production to CCPA, which collects them for its partners (oil manufactures mostly).
Complimentary services to members	Technical advice on better production practices and assistance in commercialization (possibility to sell back the production to the cooperative at the official groundnut price the government declares).	

Source: Authors

Legend: This table compares the operational and governance procedures of COOPEC and CCPA. It details their different approaches to bundling insurance with credit, with COOPEC employing voluntary and CCPA mandatory treatment, which affect the farmers' choices and behaviors.

4.3 Implementation status and challenges as of endline

4.3.1 Implementation results

The results of the 2019–2020 agricultural season (which is the second year of impact observed) were very good for the COOPEC FO implementing partner, and most of the members/clients who received a loan through the cooperative were able to pay it back. This increased the institution's confidence and financial stability, positively affecting activities for the following season. In 2019, COOPEC was able to provide credit and facultative WII product to the most trusted members who had a longstanding relationship with the cooperatives and who had paid back their previous loan. No WII payout was triggered for insured COOPEC member farmers in 2019–2020. Those accessing credit through COOPEC at the start of the 2020–2021 agricultural season (the midline season) did not have access to the insurance product that year due to administrative delays in the negotiations between the broker of the insurance company (IG) and the FO COOPEC. This was partly related to impacts of the COVID-19 pandemic (see Section 3.3.c. for more details).

In turn, the CCPA FO implementing partner, after good results during the 2019–2020 season, experienced issues of members' side-selling produce to Chinese traders able to offer higher prices, which a new government policy enabled. Consequently, several farmers decided not to respect their contracts with the industrials they typically use to procure inputs, facilitated via CCPA, and that they had agreed to reimburse in kind at the end of the season. This created issues between CCPA and the industrials that financed CCPA's input procurement to collect the production from its members (in kind). The situation negatively influenced CCPA's ability to mobilize finance for their membership in the 2020–2021 season. At the last moment, they received the government's acceptance to include the organization in a public funding entrepreneurship program named Rapid Entrepreneurship Delegation *(Délégation à l'entrepreuriat rapide [DER]).* In addition, no WII payout was triggered for insured CCPA member farmers in the 2019–2020 season, like in the case of COOPEC, but the CCPA Board

contested the insurer's decision not to indemnify, requesting that the insurer (CNAAS) revise its decision. As a result, CCPA decided not to purchase the insurance for the 2020–2021 season. In addition, late access to finance due to the COVID-19 pandemic meant that credit was only available to CCPA member farmers after the insurance window had already closed (further discussed in Section 3.3.c. below).

At the end of 2020, for both COOPEC and CCPA proposing the mandatory and the voluntary bundling products, respectively, only two concrete years of delivery were implemented—2018 and 2019, when the insurance product was effectively offered to the farmers. However, because of awareness-related issues observed in the field during the baseline and midline surveys, some farmers, even in the voluntary group, thought they had been insured for the third year of study (2020). Assuming that in terms of behavioral changes WII might cause, farmers who only thought they had been insured would behave similarly to those who actually had been insured and aware of that fact, in estimating the midline impact, we also take into account the third year because a high percentage of farmers were not aware that the insurance had not been not available to them and reported that they had been insured, although this was not the case (see Table 5).

After a year without insurance, in 2021, following the general assembly's directive, the management of COOPEC/RESOPP decided to make insurance contributions mandatory to secure access to credit. Thus, during the fourth year of the study's observations, insurance became mandatory for all COOPEC producers who took out a loan through the organization. This was a decision COOPEC made independently; the study team had no influence on it. Hence, at the time of the final follow-up survey, both treatment groups received insurance as a mandatory add-on to credit. Consequently, the team updated the research questions and study design, because we could not answer questions related to voluntary bundling using endline data. We decided to consider midline results to answer questions related to type of bundling and selling protocols and we used endline data to pool the treated farmers in one group that received the bundle and compare them with the control group.

4.3.2 Limited awareness among farmers about whether they are insured

During the first year of the study, the results of the baseline revealed that only 48 out of 156 farmers in the mandatory group (mandatory insurance bundled with credit) and 63 out of 159 farmers in the voluntary group (voluntary insurance add-on to credit) reported they were aware of the fact the WII product covered them. The remaining farmers in these treatment groups were insured but did not know it.

During the second year of the study, the study team collaborated with the broker IG to conduct a follow-up spot-check survey via phone to assess how awareness about insurance coverage among farmers may have evolved. These are the results:

- The follow-up survey reached 37 out of 71 farmers in the voluntary treatment group. Among the 37 surveyed, only 20 declared they knew they had been insured and 17 declared they did not know. The broking agents conducting these spot checks took the opportunity to inform the clients who were unaware about their insurance status and ongoing coverage.
- The follow-up survey among 156 farmers in the mandatory treatment group revealed that 51 knew they had been insured, 56 did not know, and the rest (49 farmers) were unreachable. Again, for those who did not know that they had been insured, information was provided about the insurance product and their ongoing coverage.

For the third year, which coincides with the midline survey, we noticed that despite the implementation issues that prevented effective delivery of the WII product to farmers in both COOPEC and CCPA organizations, some producers thought they had been insured. Table 5 summarizes the results of uptake awareness among all study groups across the three years.

Table 5: Uptake awareness among the group across the three years

	Mandatory group		Voluntary group		Effective delivery of insurance
	Declare they are insured	% of total	Declare they are insured	% of total	
Year 1 (baseline data)	48	31%	63	40%	Yes
Year 2 (monitoring data)	51	33%	37	23%	Yes
Year 3 (midline data)	73	47%	62	39%	No
Year 4 (endline data)	172	33%	N/A	N/A	Yes

Note: This table tracks farmers' awareness of their insurance status across three years (baseline, midline, and endline). Source: Authors

4.3.3 Effects of the COVID-19 pandemic on agricultural financing

In 2020, the two cooperative partners involved in the study (COOPEC and CCPA) experienced substantial difficulties accessing sufficient funds to make available to their members in the form of agricultural input credit at the start of the season. Due to the health, social, and economic impacts of the COVID-19 pandemic, some traditional funds usually provided to the microfinance sector were not available this year. This affected the entire microfinance sector, especially the financial institutions working in rural areas.

In our study regions, COOPEC declared that it had been able to maintain around 80 percent of its activities using its own resources, even though at the national level, the institution was only able to maintain about 25 percent of its activities due to the microfinance crisis the pandemic caused. However, COOPEC's board focused primarily on identifying additional funds for its clients and dedicated less attention to providing the insurance product to farmers that year. Therefore, due to delays from COOPEC in responding to the insurer's solicitations through its broker IG, the insurance subscription window was exceeded and there was no add-on of insurance to the credit the farmers received.

CCPA faced similar constraints in access to rural finance due to the COVID-19 pandemic. However, it bears noting that the organization had already faced difficulties as a result of new market entrants members side-sold to during the 2019–2020 season (as noted above).

Thanks to their vast organizational and political network, CCPA was able to ultimately access some government financial support provided during the pandemic to enable at least some of their activities to go ahead. However, CCPA members received their inputs financed through this support in the first two weeks of August 2020, after the window of WII policy subscriptions had already closed for the season (in early July 2020). Because WII is only provided in the form of a mandatory bundle with input credit through CCPA, none of the members were able to obtain coverage for the 2020–2021 agricultural season.

5. Theory of change and underlying assumptions

Before presenting the assumptions updated as of midline, we reintroduce the outputs, outcomes, and impacts of the theory of change (also updated as of midline). Inputs, as discussed earlier, include designing, supplying (CNAAS/IG), and selling (COOPEC-RESOPP and CCPA) WII to producers who apply for credit through the networks in selected locations. This requires the purchase and installation of rain gauges, purchase of satellite data, training of financial service officers, and the setup of product provision mechanisms. There are also operational costs linked to aggregators' distribution of the insurance products because the insurance company allocates to them 5 percent of the premium the clients pay.

Outputs:

- **Direct outputs related to WII uptake:** With the intervention, farmers have access to WII through COOPEC-RESOPP and CCPA. The two FOs offer mandatory insurance linked to credit to their members.
- **Indirect outputs related to access to agricultural credit:** Because insurance secures the loan portfolio of the aggregator (FO, bank, or MFI), the number of farmers receiving credit is higher, as is the amount of credit they receive.

Outcomes:

In the short term, there will be a high effective uptake of WII. For poorer farmers, insurance offers the option to reduce collateral requirements and enhance access to credit by using it as a partial subsidy to collateral. In the longer term, insurance will (1) compensate policyholders for rainfall-related harvest losses the insurance contract covers and (2) stimulate agricultural and off-farm investments, resulting in increased productivity and higher levels of resilience, even in the absence of a shock.

Impacts:

The expected impact of the intervention is an increase in overall well-being of farmers and their households WII contributes to:

- **Directly** by preventing debt from rainfall deficit-related credit default and increasing income on-farm via the outlined productivity channels and off-farm by investing in additional income-generating activities. Impacts will depend on reliable and sustainable insurance mechanisms, farmers' use of payouts in a way that increases their income, and the realization of economic co-benefits from insurance coverage even in the absence of a shock. Finally, building capacity to adapt to larger processes of climatic change—for instance, by integrating insurance with other services—will be crucial in ensuring impacts in the long run.
- **Indirectly** through the availability of more funding in the agricultural value chains where WII exists (i.e., groundnut), increasing access to credit, especially for liquidity constrained farmers. Even in the case of non-achievement of the abovementioned direct benefits (e.g., when farmers do not trust the insurance product or do not understand the risks covered), farmers could benefit from more facilities in accessing credit and thus, increase their level of investment, production, income, and well-being in the long run.

5.1 Effects of insurance regardless of a shock occurrence

Hypothesis 1:
Voluntary incentivized bundling of insurance and credit increases its informed uptake (midline).
If the applicants to the agricultural credit the two FOs proposed are well informed of the benefit of agricultural insurance, they will decide to buy the index insurance product specifically because of the protection it provides against payment default. Because most of the farmers the insurance is proposed to live in areas where indemnification has already been paid, the level of uptake by producers who have free choice over product use is expected to be high.

Hypothesis 2:
Informed and desired uptake of WII (i.e., when it is voluntary) stimulates adoption of a higher level of investments, technology adoption, and improvements in agricultural practice in the long term through applications for higher amount of credit (endline).
The purchase of WII is expected to incentivize high-risk high-return crop cultivation, because it secures compensation when a shock occurs (International Fund for Agricultural Development and World Food Programme 2010). However, this will be the most relevant for farmers who make a well-informed decision to purchase insurance because they will perceive a reduction of their exposure to rainfall-related risks. The perceived uncertainty will also decrease, resulting in a higher level of credit amount they apply for and overall investment across years.

Hypothesis 3:
Mandatory bundling of index-insurance and credit leads to an increase in uninformed and undesired uptake (endline).
When insurance is mandatorily bundled with credit, the education and advertising efforts that are typically necessary to explain to farmers how the product works and its usefulness can decrease drastically. When they are in a dire need for funding for their activity, most clients affiliated with banks and other types of aggregators that provide agricultural loans are likely to automatically accept the insurance product if it is a precondition to access the credit.

Hypothesis 4:
Uninformed and undesired uptake as a result of mandatory bundling of insurance with credit does not increase the level of agricultural investment, stimulate technology adoption, or improve agricultural practices (endline).
Farmers will not adopt high-risk high-return investment behaviors if they have not freely chosen to adhere to the insurance or do not know they are insured. If they feel they do not need insurance or do not understand how it works, the product will not produce any effect (beyond potential payout) or affect agricultural practices and, subsequently, living standards.

Hypothesis 5:
Mandatory bundling of index-insurance and credit can be perceived as positive and have positive effects on producers' agricultural activities if it is accompanied by a clear understanding of the risk transfer's role in the insurance product (endline).
Even in the context of mandatory bundling, farmers can have a positive perception of the insurance product, understand well its role as a risk transfer tool, and thus, make riskier but more profitable investment choices.

Hypothesis 6:
High-risk, high-return investment options, if adopted by the farmers who have declared to be insured, will lead to an increase in their income and improved living conditions (endline).
Informed subscription to insurance enables an increase in producers' revenue in the absence of shocks by providing them with confidence and increase in agricultural credit they apply for that the supply side is more willing to answer positively because of the reduced default risk. In the long term, as the income of the household increases, the producer is expected to also experience improved well-being.

5.2 Effects of insurance when a shock occurs

Hypothesis 7:
Indemnifications received after a harvest loss enable farmers to avoid debt, payment default, and indirect losses in the long run (endline).
The FOs and MFIs operating in Senegalese rural areas have quite strict repayment policies. Most of them do not allow a new loan to be issued to a producer until the previous one has been completely paid back. In these circumstances, farmers used to contract new debt to resolve older ones with the risk of falling into a spiral of payment default or selling their assets to reimburse loans. The compensation farmers will receive is expected to reduce payment defaults after a shock and associated indirect losses.

Hypothesis 8:
Compensation received when a shock occurs contributes to reducing farmers' vulnerability and decreases their chances to fall into chronic poverty in the long run (endline).
Chronic poverty can be a result of either consumption or asset smoothing as adaptation strategies after a shock. Because the WII, when tied to credit, covers the producer's loan against rainfall variability at up to 80 percent of the amount of funding received, it considerably reduces the shocks' negative effects on consumption and investment.

Hypothesis 9:
Provision of crop insurance as an add-on to credit results in more farmers benefiting from higher amount of loans (endline).
Because the insurance product derisks the portfolio of financial institutions and the FO that provides agricultural loans to their clients or members, it could increase their willingness to fund more farmers with higher amount of loans. Farmers could, therefore, benefit indirectly from the presence of the insurance product on the offer side of the market even if they do not directly change their decisions because of the insurance.

Hypothesis 10:
The COVID-19 pandemic resulted in negative effects on production activities and farmers' well-being and had the same effect on all treatment and control groups (endline).
We expect the direct effects from the COVID-19 pandemic and the impacts from measures the government put in place to reduce the spread of the virus to have an effect on farmers' access to market between March and May 2020, just before the start of the rainy season and the related preparation of the agricultural activities. That period also coincides with the beginning of the lean period in rural areas, depending on how good last year's harvests were. We assume all farmers in different groups will be affected negatively at similar levels.

6. Ethical approval and compliance

In 2017, the Senegalese National Committee of Ethics for Research in Health *(Comité National d'Éthique pour la Recherche en Santé [CNERS])* granted ethical approval for the formative evaluation (TW13 1073) preceding this impact evaluation under protocol number SEN17/35. This approval follows the guidelines outlined in *the Law 2009-17 on March 2009*, which governs research ethics and delivers Institutional Review Board approval (including in social sciences) in Senegal. The initial phase of the study employed an RCT design, completed within 10 months, and focused on understanding the dynamics of bundling agricultural insurance with credit.

In 2018, following successful completion of a first phase formative evaluation, the study transitioned into a full impact evaluation (TW13 1026). This transition included an amendment to the original protocol. The revised approach extended the observation period to five years and replaced the RCT with a matching methodology. This approach also addressed concerns related to ethical implications of randomization and ensured greater inclusivity. This amendment was submitted to and approved by the CNERS, reflecting the study's commitment to ethical integrity and methodological rigor.

Additional adjustments were made to the protocol in response to evolving circumstances, including the COVID-19 pandemic, which disrupted field activities between 2019 and 2021. During this period, the study team suspended fieldwork but maintained compliance with ethical standards. In April 2022, a comprehensive amendment to the protocol was submitted to the CNERS to renew ethical approval and accommodate updated tools and methodologies for the final phase of data collection.

This amendment centered on:

- Reinforced ethical safeguards, including anonymization and secure storage of participant data.
- Updated tools for better capturing the impact of the pandemic on agricultural practices and insurance uptake.
- Extended observation timelines to account for the suspension of field activities.

Throughout its duration, the study adhered to stringent ethical guidelines, including:

- **Informed consent:** Participants were provided detailed information about the study in local languages, ensuring their understanding and voluntary participation.
- **Data anonymization:** Collected data were anonymized and securely stored to maintain participants' confidentiality.
- **Compliance with local and international standards:** The study followed Senegal's national ethical guidelines and international standards for social science research.

7. Evaluation method and design

7.1 Identification method

To measure the causal change in the key outcomes, we use a difference-in-difference design with matching. Difference-in-difference methods are appropriate to exploit the time or cohort dimension and they allow accounting for unobservable but fixed characteristics. However, without matching, we would systematically be confronted with imbalances, model dependence, researchers' discretion issues, and eventually, bias in the difference-in-difference design. Matching allows us to eliminate these issues. By matching on control variables, we can estimate the sample average treatment effect. One of the most commonly used matching techniques is propensity score matching (PSM). However, PSM is suboptimal in our case, because it can increase imbalances and is thus, inefficient compared to the more powerful full blocking. Instead of PSM, we suggest using the Mahalanobis distance equation and match each treated unit to the nearest control unit to fully approximate a block randomization experiment.

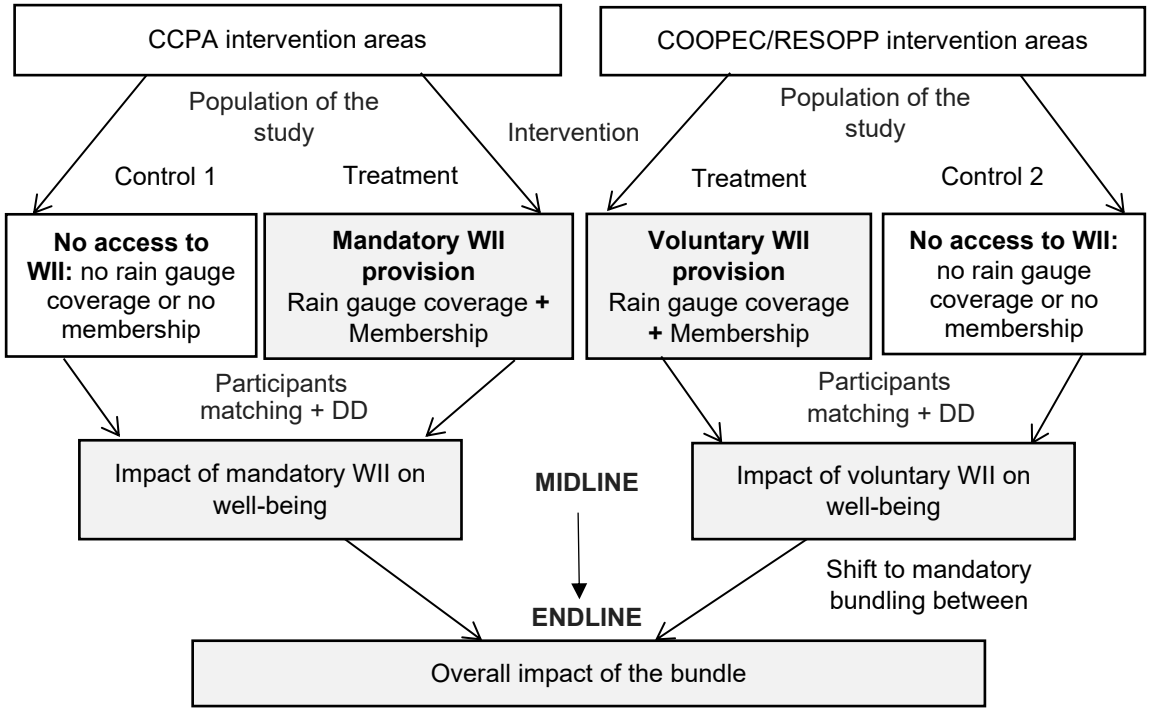
The rationale of the choice of double difference with matching as identification method is partly based on the specific need to avoid ethical issues and unintended negative consequences an experimental design could create. In fact, it would be difficult and ethically questionable for the research project to impose mandatory insurance on people for a chance to access credit or keep people of a control group uninsured for a long period of time, while they are in the same area as the people insured or simply not selected. Furthermore, it would be difficult for the implementing agencies to bear the weight of such a design for five years. Consequently, the farmers' networks and their microfinance branches or partner institutions chose the bundling method (voluntary or mandatory) to serve their members or clients as they normally would, in the absence of the research project.

Unintended consequences may occur—for instance, stemming from basis risk or incentives for maladaptation related to the WII product itself. However, we note that WII would be implemented in the study location regardless of this evaluation. We, therefore, do not expect additional harm to participants as a result of the study. Instead, the evaluation could help to identify some unintended consequences and support stakeholders in addressing them.

7.2 Sampling strategy

Participants for treatment groups were selected among farmers who are members of the two organizations and, therefore, have access to WII in all areas of the Senegalese central region the organization covers. For each location, we considered control groups selected from villages that do not belong to the two cooperatives' intervention area. To increase comparability, we considered control villages in the same commune as each treatment village, as well as all control individuals regardless whether they came from "voluntary group village control villages" or "mandatory group village control villages." Indeed, because the intervention areas for COOPEC and CCPA are similar, this enabled us to increase the chance to have a potential best match for each farmer in each treatment group. Figure 11 summarizes the sampling strategy and identification procedure.

Figure 11: Sampling Strategy and identification procedure



As highlighted in the figure, we will compare the impact of the WII and credit bundle on well-being to a control for each of the two FOs with different sales protocol (i.e., whether bundling WII with credit is mandatory or voluntary). The specific design and sampling strategy we suggest allow us to assess impacts of the bundle on well-being for each context individually. Because we assume that the members of the two institutions are from comparable populations, it also enables us to compare for the effect of voluntary versus mandatory bundling on the level of uptake and well-being by directly controlling for differences in farmers' cooperatives.

7.3 Revised analysis plan and research questions

7.3.1 Farmers' insurance coverage and awareness of status

To best deal with the implementation challenges related to the above discussed issue of awareness around insurance status and to make sure that we work with effective treatment groups—farmers who adhere to the program and not those who were falsely treated—we propose to further break down farmers' profiles for each treatment group in terms of their insurance awareness status:

Farmers who were insured at least once (during the four years of study) and who were always aware of their insurance status (A).

Farmers who were insured at least once (during the four years of study) and who were never aware of their insurance status (B).

Farmers who were insured at least once (during the four years of study) and who knew at least once, but not always, that they were insured (C). This group could include:

a. Farmers whose declared year of insurance coincided with the effective year they received the coverage (C1).
b. Farmers whose declared year of insurance is different from the year they effectively benefited from the coverage (C2).

Depending on which farmers among the four groups are included in the sample, we will estimate the indirect benefit of WII on access to credit from FOs providing index-based insurance (model 1) and the direct benefit of WII related to an informed uptake (model 2).

Model 1:
All profiles A, B, C1, and C2 (described above) will be considered in the treatment sample because they have all received credit at least once (during baseline) from their affiliated organization, COOPEC or CCPA. Knowing that both organizations offered WII for at least three years as a voluntary or mandatory add-on to credit, farmers may benefit from potentially facilitated access to credit WII product creates in the organizations' internal policies of loan distribution. These farmers of the treatment groups considered as part of the assessment of model 1 will, hence, be compared to farmers of the control group who hold membership in other organizations that do not have access to WII.

Model 2:
We assumed that a farmer who has at least once decided to purchase the insurance product and was aware of their uptake decision (A and C1) may have taken actions to improve their revenue as a result. In the same way, farmers who think they are insured while they are not (C2) would behave the same as those who are effectively insured and are aware of it. Therefore, in model 2, we will consider all farmers who reported that they believed they were insured for at least one period during the three years of observation between baseline and midline (i.e., profiles A, C1, and C2) to assess the potential direct benefit of WII coverage.

7.3.2 Revised research questions

Model 1 and model 2 described above enable us to compare two channels through which the insurance product could affect farmers' behaviors and well-being by isolating the impact for only the farmers who believed and reported that they were insured and could, thus, behave accordingly. The two considered direct and indirect channels (through better access to credit and through conscious uptake of WII, respectively) enable us to complete our research questions with question 5:
What sales protocol (voluntary or mandatory bundling) is more likely to sustain uptake of insurance and credit? (to be answered with baseline and midline data)
Does uptake (through voluntary or mandatory bundling) help reach the objectives of improved well-being and reduced poverty and vulnerability among small-scale farmers? (to be answered with baseline midline and endline data)
How does the bundled product (WII + credit) influence the adoption of higher return investment strategies and affect productivity of Senegalese farmers? (to be answered with baseline midline and endline data)
What is the net impact of the bundled product (WII + credit) on farmers' well-being? (to be answered with baseline midline and endline data)

a. How reliable are the suggested schemes?
b. How does the bundled product (WII + credit) influence recovery after a rainfall-related shock?
c. What are the co-benefits of WII for farmers, even in the absence of a shock?
d. What are the adverse effects, if any, of insurance uptake on farmers' well-being and adaptive capacity?

For each of the sales protocols, how does awareness affect the estimated impact on the different indicators considered (uptake, adoption of higher return on investment strategies, income, and well-being)?

7.3.3 Effect of the COVID-19 pandemic

To understand any potential implications of the COVID-19 pandemic on the livelihoods and well-being of our study population and to make sure results are adequately interpreted in the current context, we suggest including an additional research question for the midline, to be reflected in the quantitative survey and qualitative data collection:

What are the impacts of the COVID-19 pandemic on insurance and farmers' well-being?

a. How does the pandemic situation affect farmers' agricultural activities?
b. Which changes does the pandemic create in insurance distribution and uptake?
c. How did farmers respond and what is the effectiveness of their coping strategies?

To respond to these questions, we will first consider the population as a whole (treatment and control combined), assuming that the COVID-19 pandemic health and/or socioeconomic impacts affect all farmers in one way or another. We will then control effects based on groups farmers belong to in order to explore whether being in a specific group or being insured or not played a role in buffering the consequences of the pandemic.

To amend the midline survey questionnaire accordingly, the team drew on efforts to collect data and design tools to understand the COVID-19 pandemic's impacts and inform a response, such as those collected in Innovations for Poverty Action's Research for Effective COVID-19 Responses Research Hub.[10] This provides a repository of ongoing research projects and questionnaires related to the COVID-19 pandemic and its impacts.

7.4 Timeline and study monitoring

In Senegal, the agricultural year, commonly known as agricultural season, begins between May and June with the preparations that precede the arrival of the first rains. By the end of May and early June, farmers start to acquire the necessary input through their affiliated organizations in terms of credit for members. The procedure for supplying the insurance product starts every year with the training of the head of the FO and their sales officers on the functioning of the product—the risk covered, premiums, and thresholds that trigger the payouts. The trained representatives and sales officers are then required to disseminate the information they received from the insurer to their clients and members who apply for agricultural credit that year.

As part of this evaluation, the representatives and sales officers of the two FOs received additional training during baseline to harmonize their understanding of the insurance product's across the two organizations. After obtaining the bundled credit and insurance in June, farmers carry out their agricultural production activities for at least three months, from the end of June/early July to the end of September/early October. After the production period comes the period of harvest and commercialization, which starts automatically after the rainy season, in early October. Farmers who belong to COOPEC/RESOPP, CCPA, and other FOs have the possibility to sell their products directly to their affiliated associations at a predetermined price. That enables them to sell an important share of their products within a period of two months at a reasonable price.

In terms of the field work, because we needed to collect information on the results of the agricultural season in terms of production volume and values, it was necessary to start the data collection after the harvest. Therefore, in early November, we conducted initial

[10] Moe information at: https://www.poverty-action.org/recovr/research-hub.

interviews with the representatives of the two organizations to gather their first impressions regarding the results of the agricultural season. We then conducted the training of surveyors and focus group discussion (FGD) facilitators in early December, with the results gathered during the interviews with representatives of the FOs.

At baseline, the survey started in mid-December and lasted three weeks. The survey team was composed of 10 surveyors divided between two teams of enumerators, each led by a supervisor. A survey firm was engaged to monitor all quantitative data collection and carry out controls in collaboration with the study coordinator. After the survey, three teams of FGD facilitators conducted a total of nine FGDs disaggregated by gender and treatment received.

At midline, the survey started in mid-January and lasted until early March due to the complementary phone calls needed to track farmers who were no longer in the production areas. As in baseline, the survey team was composed of 10 surveyors divided into two teams of enumerators, each led by a supervisor. The same baseline survey firm was engaged to monitor all quantitative data collection and carry out controls in collaboration with the study coordinator. After the survey, three teams of FGD facilitators conducted six FGDs (compared to nine during baseline) disaggregated based on treatment (mandatory vs. voluntary) because baseline did not yield enough participants for female groups.

During endline, the survey started in mid-March and lasted approximatively two weeks. The survey team was also composed of 10 surveyors divided into two teams of enumerators, each led by a supervisor. The same survey firm as in the previous survey rounds was engaged to monitor all quantitative data collection and carry out controls. Six FGDs, as in during midline, were conducted as part of the qualitative data collection arm.

In addition, the team carried out 14 key informant interviews in February and March of 2022, with representatives of CCPA and COOPEC at the village and regional level, as well as with key stakeholders in the Senegalese agricultural insurance sector.

8. Sampling and data

The target population of the study are farmers in the Senegalese groundnut basin who are members of the COOPEC/RESOPP and CCPA FOs. In the departments of Foundiougne, Kaolack, and Nioro du RIP that constitute CCPA and COOPEC areas of intervention in the groundnut basin, we stratified at the department and commune level to include all communes of intervention before clustering at village level to minimize potential contamination and spillover effects between the two treatment groups, but also between the treatment groups and the control group.

8.1 Sample size and power calculation

As is commonly the case for matching methods, we propose to do a sample size calculation like the one used in randomization and by carefully targeting the control sample, make it comparable to the treatment group. The required sample sizes for each of the two outcomes considered as part of this study—the uptake rate across treatment groups and the impact in the level of income generated—were calculated using the Hemming and March (2013) Stata calculation approach. We calculated the required sample for each of the considered outcomes before keeping the largest (See Table 19 and Table 20**Error! Reference source not found.** of Appendix A for the details of the sample size calculation and results).

The assumptions regarding the baseline values are based on existing literature and were adapted to the context of the study. For insurance uptake, 30 percent is the maximum uptake rate (among farmers who have access to the product) documented by the literature when the product is subsidized and offered with incentives. Although we found higher uptake of over 70 percent during the formative evaluation conducted in 2017 as part of this study, we suggest considering the abovementioned 30 percent as a conservative estimate, assuming that potentially lower renewal rates may not sustain the high uptake. The intra-cluster correlation coefficients, the potential attrition rate, and the endline level of outcomes are informed by the results of a baseline evaluation conducted in 2017. The same applies to the average number of individuals per cluster, which is informed by the average number of insured farmers per village in the selected areas according to the official statistics of the insurer and its intermediaries. Regarding the required number of clusters, when the outcome is income generated with the insurance product, the assumptions provide a minimum of between 12 and 21 clusters, depending on the level of significance and power calculated: 5 percent significance and 80 percent power for 12 clusters; and 1 percent significance and 90 percent power for 21 clusters. For the uptake rate, the number of clusters required under the same interval of significance level and power are 8 for 5 percent significance and 80 percent power and 16 for 1 percent significance and 90 percent power. The results of the sample size calculation are summarized in Table 6.

Table 6: Sample size and power calculation

	High significance and power (1% and 90%)		**Standard significance and power (5% and 80%)**	
Outcome variable considered	Quintiles of income from WII	WII uptake rate	Quintiles of income from WII	WII uptake rate
# of farmers in the treatment group (with 30% of attrition)	189	145	109	73
# of farmers in the control group (three times larger than treatment)	567	435	327	219
# total of farmers to survey	945	725	436	292

Note: This table shows the results of sample size and power calculations for the study, using varying levels of significance (1% and 5%) and statistical power (80% and 90%).
Source: Authors.

8.2 Sampling procedure

8.2.1 Sampling procedure for the treatment sample

In line with the results of the sample size calculation and power calculation, we clustered at village level making sure villages selected in a treatment group could not be selected for comparison. Therefore, in the three departments (Fatick, Foundiougne, and Kaolack) where cooperatives operate in the regions of Fatick and Kaolack, 42 villages (21 village clusters for each cooperative) distributed across 14 communes were selected. The treatment participants in the mandatory bundling group and the voluntary bundling group were selected from the dataset of insured farmers that both FOs, in their role of intermediary in WII provision, sent to the insurer CNAAS during the 2018 crop year. Because we seek to compare the outcomes of these two groups in terms of their behaviors toward the insurance product (uptake, understanding, trust, etc.), we conducted a Mahalanobis distance matching to include farmers who are the most similar on the basis of the amount of credit they received (as a proxy of their production capacity) and the insurance premium they paid

(reflecting the share of the production they decided to insure or the weight they provide to insurance in their activity of production). The combination of the matched pairs provided the treatment group composed of farmers who received the same insurance product bundled with credit either mandatorily or voluntarily.

8.2.2 Sampling procedure for the control sample

For the selection of the control sample, because we allow it to be three times larger than the treatment group, we chose to increase the required number of control clusters by selecting five control villages in each commune where at least one treatment village was selected. Because in Senegal, the commune is the second smallest level of administrative division after the village, selecting the control villages in the same commune as the treated villages enables us to increase the chances of having common support between insured and non-insured farmers. The five additional control villages were randomly selected from the list of villages that did not benefit from the insurance product. Finally, in each of the treatment and control villages, nine farmers were selected for the survey through a systematic random sampling procedure. Of the 14 communes where treated farmers were selected, 2 have both farmers who belong to COOPEC/RESOPP organization with access to the insurance voluntarily, and those who have access to insurance mandatorily through the CCPA. Consequently, we selected 10 control villages in those two communes. The principle was to select five control villages for each treatment option (mandatory or voluntary bundling) in each commune. This results in a total of 80 clusters (5 control villages in 12 communes and 10 control villages in 2 clusters).

8.2.3 Selection of the FGD participants

At baseline

FGDs were conducted to complement the survey data collected. The main objectives of the FGDs were to corroborate and enhance our interpretation of the quantitative data, so the FGD composition considered the difference in type of bundling between the participants in the study. Homogeneous groups of farmers were randomly selected, stratified by gender, the treatment received, and the commune they belonged to. Thus, discussions were organized separately for men and women according to their treatment group with a focus on the effects of rainfall variability and the adaptation strategies farmers have developed to deal with these effects. Table 7 presents the list of FGDs carried out.

Table 7: Overview of focus group discussions conducted during baseline

Treatment/Control group	**Insured**		**Uninsured**	
	Men	Women	Men	Women
Voluntary treatment	Yes	Yes	Yes*	Yes*
Mandatory treatment	Yes	Yes	Yes*	No*
Control	Not applicable	Not applicable	Yes	Yes
Total FGD	2	2	3	2

Note: This table summarizes FGDs conducted during the baseline study, detailing participant characteristics and discussion themes. The stars in the two last columns of the table stand for "not being aware that they are insured." This is because, as our baseline results showed, some farmers are officially insured and have paid their premium, but are not aware that they are insured.
Source: Authors.

By default, none of the farmers in the control group are insured, so it was not possible to conduct FGDs. In the voluntary and mandatory treatment groups, all farmers were supposed to be insured. However, we discovered during the baseline survey that some farmers did not know they were insured in both the mandatory and voluntary treatment groups. Thus, they are technically insured, but they are not aware of the coverage. To better understand the reasons behind these cases, we conducted FGDs with farmers in those groups. Finally, another criterion for participation in FGDs was to have groups of participants within the same commune to reduce transportation costs and additional strains on time for potential participants. Because women are in the minority in the sample, we did not find enough "uninsured women (women who did not know they are insured)" who live in the same commune and have taken out insurance as a mandatory add-on to their loan. In total, we conducted nine FGDs during the baseline

At midline and endline

The organization of the midline and the endline FGDs follows the same consideration as at baseline. However, we did not separate farmers of the treatment groups between those who were aware they were insured and those who were not because, as noted earlier,, there was no provision of the insurance product during the 2020 season (which is the midline survey season). Besides, we expected that pooling farmers of different levels of awareness in each of the treatment groups would help compare differences in outcomes to draw lessons that better reflect the reality in the field. In the control group, because the proportion of female farmers participating in the survey was lower than in the other group, it was difficult to reach enough female participants, taking into account the distance separating the potential participants. Therefore, mixed group discussions were convened for control. This resulted in a total of six FGDs being conducted as part of the midline fieldwork.

Table 8: Overview of focus group discussions conducted during midline and endline

	Men	**Women**
Former voluntary treatment (COOPEC farmers)	Yes	Yes
Always mandatory treatment (CCPA farmers)	Yes	Yes
Control	Mixed men & women	Mixed women & men
Total FGD	3	3

Legend: This table outlines FGDs conducted at midline and endline, focusing on evolving perceptions of WII.
Source: Authors

8.3 Survey coverage

8.3.1 Baseline

The objective of the baseline survey was to collect data from 378 treatment farmers (189 among COOPEC/RESOPP members and 189 among CCPA members) and 720 controls distributed across 2 regions, 3 departments, 14 communes, and 122 villages. In the treatment group, the actual number of farmers surveyed for COOPEC/RESOPP (voluntary insurance) was 159; for CCPA (mandatory insurance), it was 156. For the control sample, of the 720 farmers who constituted the initial target, 679 were effectively surveyed. The resulting baseline attrition is, hence, estimated at 16 percent for the voluntary group and 17 percent for the mandatory group. In the control group, the attrition was only 6 percent thanks to the possibility of replacement in the field. However, after matching between treatment and control, the control group narrowed to 533 participants.

8.3.2 Midline

The objective for the midline quantitative data collection was to survey all farmers who had participated in the baseline survey two years earlier. At the end of the midline survey, a total of 695 farmers were surveyed and among them, 138 were in each of the treatment groups and 419 were in the control group. Thus, the attrition at midline was at 11.5 percent for the voluntary group and 11.3 percent for the mandatory group. For the control group, the attrition was estimated at 21.4 percent.[11]

8.3.3 Endline

As in midline, the objective for the endline survey was to survey all farmers who had participated in the baseline survey four years earlier. At the end of the survey, 516 farmers were surveyed and among them, 101 were in the former voluntary treatment group (i.e., among COOPEC FOs' members), 116 were in the CCPA mandatory treatment group, and 300 were in the control group. Table 9 summarizes the survey results in terms of the number of treatment and control villages per commune, department, and region for each of the two rounds of survey.

Table 9: Summary of survey result by region, department, and commune

FO	Regions	Departments	Communes	# of villages	# of Farmers		
					Baseline	Midline	Endline
(Voluntary insurance) COOPEC	1. Fatick	1. Foundiougne	1. Niassene	6	45	40	33
			2. Mbam	1	9	8	4
			3. Diossong	4	32	30	23
			4. Diagane Barka	1	7	5	5
			5. Djilor	2	17	16	9
	2. Kaolack	2. Kaolack	6. Thiomby	2	15	13	10
			7. Ndiebel	4	28	22	17
			8. Dya	1	6	4	0
Total COOPEC	**2**	**2**	**8**	**21**	**159**	**138**	**101**
(Mandatory insurance) CCPA Total CCPA	1. Kaolack	1. Kaolack	1. Gandiaye	1	5	5	0
			2. Thiomby	4	29	24	18
		2. Nioro	3. Keur Mandongo	6	45	38	34
			4. Paoskoto	1	8	8	7
			5. Taïba Niassène	1	9	8	8
	2. Fatick	3. Foundiougne	6. Toubacouta	1	7	7	7
			7. Diossong	4	28	26	23
			8. Nioro Alassane Tall	3	25	22	18

[11] This higher attrition rate in the control group compared to the treatment groups is partly explained by the number of farmers in that group who declared to have purchased a crop insurance during the midline season (30 farmers), 5.6 percent of the 533 farmers surveyed in the baseline control group.

FO	Regions	Departments	Communes	# of villages	# of Farmers		
					Baseline	Midline	Endline
Total CCPA	**2**	**3**	8	**21**	**156**	**138**	**115**
Total treated	**2**	**3**	**14**	**42**	**315**	**276**	**217**
Control group or uninsured farmers	1. Kaolack	1. Kaolack	1. Gandiaye	5	43	12	5
			2. Thiomby	10	88	65	47
			3. Dya	5	38	15	0
			4. Ndiebel	5	44	38	25
		2. Nioro	5. Taïba Niassène	5	44	19	13
			6. Keur Mandongo	5	45	30	29
			7. Paoskoto	5	44	14	6
	2. Fatick	3. Foundiougne	8. Toubacouta	5	40	19	14
			9. Diossong	10	81	63	55
			10. Niassene	5	40	34	27
			11. Diaguane Barka	5	43	16	10
			12. Djilor	5	41	36	28
			13. Mbam	5	44	23	16
			14. Nioro Alassane Tall	5	44	35	25
Total control	**2**	**3**	**14**	**80**	**679 (533)[12]**	**419**	**300**
TOTAL	**2**	**3**	**14**	**122**	**994**	**695**	**516**

Note: This table provides a summary of survey results, detailing key socio-demographic and agricultural indicators by region, department, and commune.
Source: Authors.

The reason some participants were not surveyed is explained largely by their unavailability and ineligibility for participation, rather than by their non-consent to participate in the study. Because some farmers undertake different livelihood activities, they leave their villages after the rainy season to take up work elsewhere, making it difficult for the enumerators to find them. In the control group, because the selection was based on a random systematic sampling during baseline, we could replace absentees in villages where there were enough uninsured farmers. In contrast, the baseline treatment sample was determined beforehand via matching between insured farmers of COOPEC/RESOPP and CCPA..

For the midline and endline, only farmers who had already been surveyed during baseline and or midline could participate in the survey, making it more difficult to reach the target numbers because some participants were lost and could not be replaced even in the control group. In addition, some farmers were excluded from the control group sample at midline and endline due to them reporting they were insured during that season.

[12] Among the 679 farmers surveyed in the control group during the baseline, only 533 were matched to a treatment. Thus, the midline targeted only the 533 matched.

Consequently, the attrition from midline to endline was very high (26%). Several reasons account for this, including the fact that some farmers stopped producing groundnut at endline so we decided not to include them in the survey. Another one was our decision to survey only farmers of the control group for whom we found a match in the treatment group.

Regarding eligibility for the study, control questions were introduced to check whether the farmers who received the agricultural credit were the ones who actually used it or whether they passed it to their parents, spouse, or friends. A previous baseline evaluation showed that in some households, some members (mostly wives) are used as nominees for credit by their head of the household to have two memberships with the FO, allowing the household to apply for two loans (one in their name and one in the name of their wives). In such cases, the loan is officially in the name of the wife, but she applied for it for the husband who then makes the decisions on how to use it. Therefore, we asked the selected farmers in the treatment group whether they were responsible for decisions regarding the loan they received and how to spend it. If the answer was no, we excluded them from the sample.

9. Endline survey results

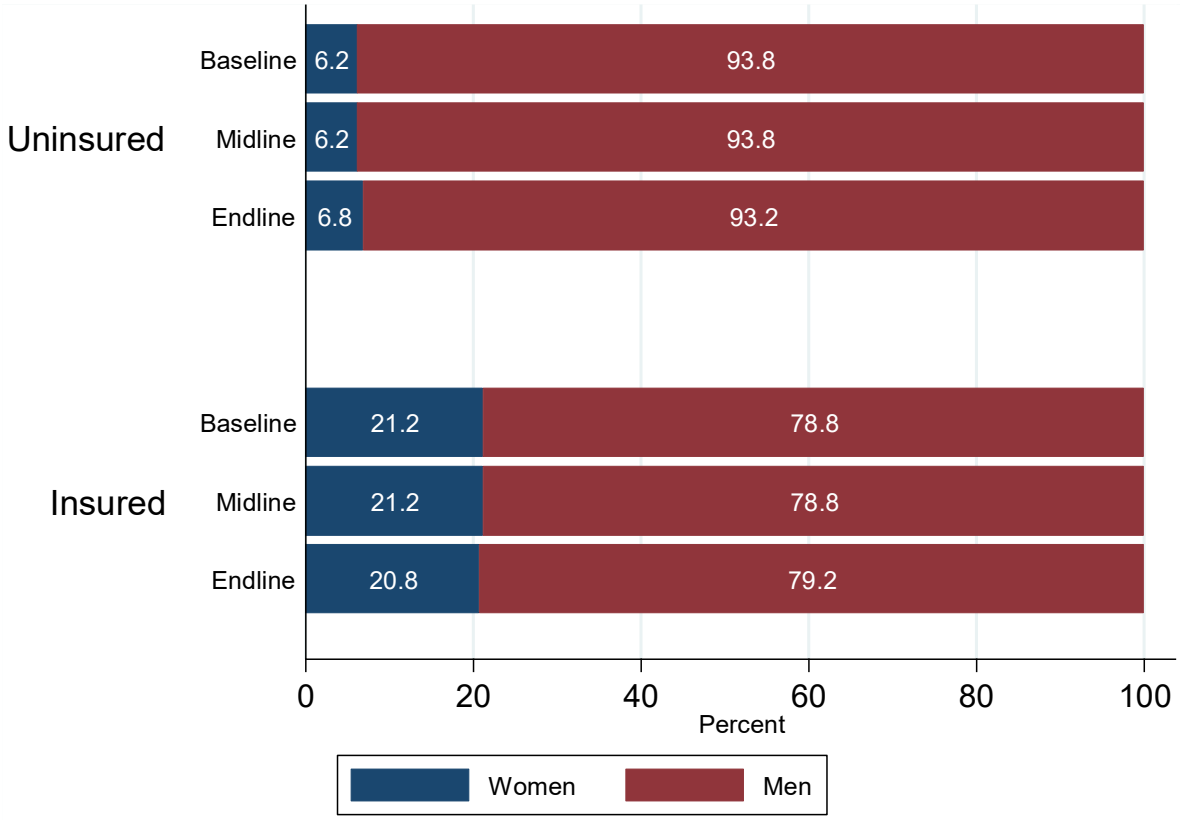
9.1 Socio-demographic statistics

9.1.1 Gender distribution across groups

The graph below (Figure 12) shows gender distribution across survey groups at the endline survey relative to baseline and midline for the participants we were able to access during the three rounds of survey and find a match. Figures are stable over time, and the differences are not significant between baseline and endline when considering gender within each of the two groups. In the treatment group, men represented about 4/5 of the sample and women accounted for about 1/5 of farmers in the sample. when considering proportion of women versus men in the control group, we find that women represent only between 6 and 7 percent of the total number of farmers surveyed during the three rounds and for whom we were able to find a match. This is mostly due to the participation criteria, which required that farmers be responsible for the decisions regarding production activities to be part of our sample. Most women in the control group did not meet that condition.

Due to socio-cultural hindrances, women face challenges accessing/controlling land in Senegal, despite their vital role in agricultural value chains. These findings align with other studies showing large gender inequalities in agriculture (FAO et Commission de la CEDEAO 2018; ANSD 2013). However, membership in FOs provides women the access to agricultural inputs and needed resources to justify their demand for agricultural land. This explains the difference in gender composition between the treatment and control group. Yet, the difference across treatment groups depended on the effort each organization made to be more gender inclusive. In one of the treatment groups, COOPEC/RESOPP, a woman had been the president of the organization for at least 3 years. Besides, women are well represented in most of the COOPEC credit committees that decide which application for an agricultural loan to accept. In CCPA, some of the village associations included in the FO are women’s associations. This helps explain the higher rate of women in the treatment group than in the control group.

Figure 12: Gender distribution across groups

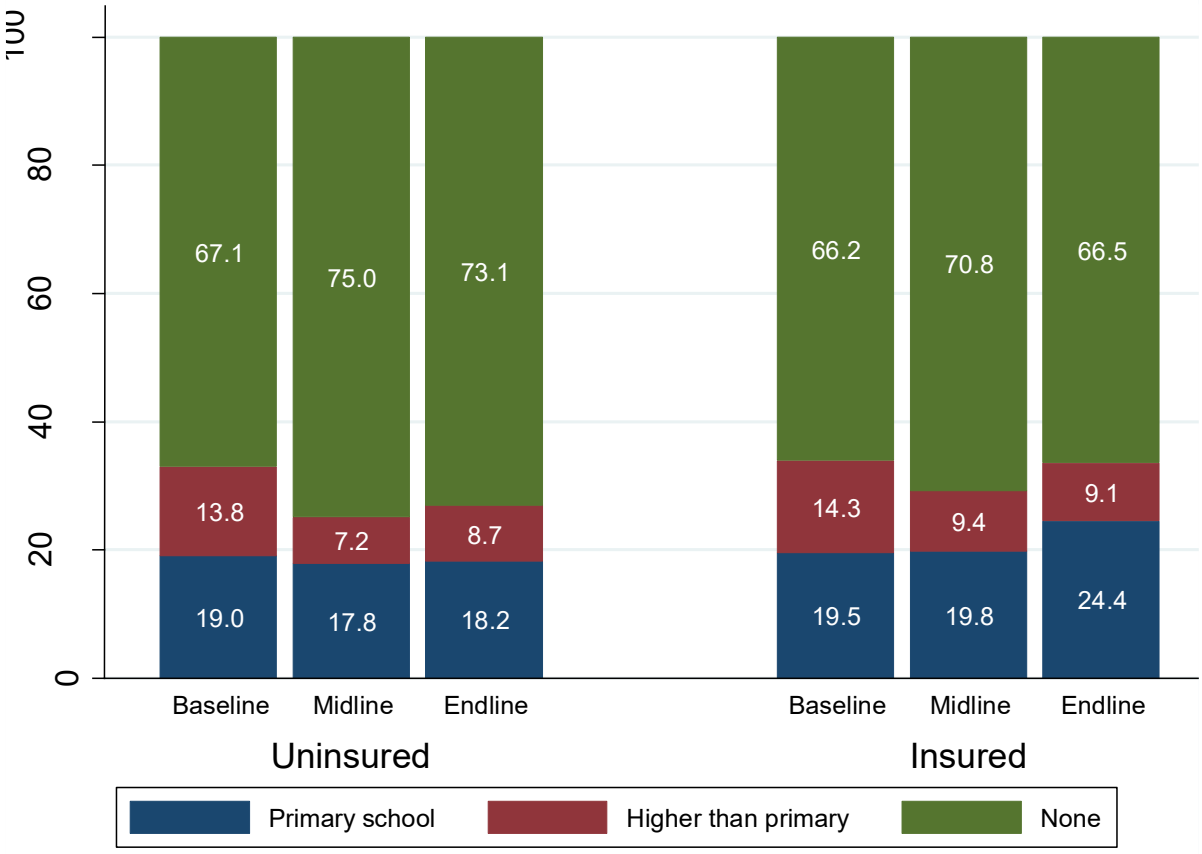


9.1.2 Formal education level

Data show that a large share of farmers never benefitted from formal education. The differences between baseline and endline across groups can likely be attributed to attrition of between 66 and 73 percent (for further discussion of attrition rates, see Section 6.3 above). An additional explanation for this difference could come from the fact that at midline and endline, we drew the enumerators' attention to the difference between enrollment and attendance for at least one year at that level. These people would not be counted as having attained that level of education. For example, if a child was enrolled in school but has not been able to complete a full year of study (maybe they spent only one week or even five months in school), the enumerators would not consider this child as having attained any level of study. This measurement refinement had not been applied during baseline.

The absence of education infrastructure in remote areas can, in part, account for the high rate of farmers with no formal education. In addition, in terms of agricultural revenues, the costs of sending children to school are higher for the most impoverished farmer households. They may decide not to enroll their children in school because they believe the children would be more useful on the farm (Direction générale de la coopération internationale et du développement 2008).

Figure 13: Farmers' formal education level



9.1.3 Housing and living conditions

Table 10 below presents a set of indicators pertaining to households' socioeconomic characteristics (see Annex B for the definition of these indicators and their definitions). We found the average age of the producers to be around 53 and 50 years, with the highest average age observed in the control group while the treatment group had the lowest. The three-year difference between the groups is significant. However, apart from age, we do not note significant differences in other demographic characteristics between the treatment and control groups, such as the total number of children under 5, the total size of the household, and so on.

In terms of housing conditions, we found no important and significant difference in materials used for floor, wall, and roof of dwellings between the groups from baseline to midline to endline. There was a slight difference in the type of cooking fuel used by households (during endline only). Households in the sample are, in general, small-land tenants. The average owned land during baseline for the sample considered and between matched farmers was 1.88 in the treatment group and 1.89 in the control group. Across the two groups, the average land area increased slightly between baseline, midline, and endline. Nevertheless, land area differences between groups were not significant. Regarding the progression of tropical livestock unit (TLU), the score was slightly lower—it was higher in the baseline for each of the two groups. However, the treatment group has the highest score in each period, with 2.64 at baseline compared to 2.52 for the control group. Still, the difference across groups is not significant. From 2.64 and 2.52 for the control and treatment group during baseline, respectively, the TLU score during endline dropped to 2.39 and 2.34.

Table 10: Socioeconomic characteristics

	Obs		Mean		Std.Dev		T-test
	C	T	C	T	C	T	T/C
BASELINE							
Age	292	211	53.50	50.42	12.39	11.26	3.08***
Total children under 5	292	212	3.08	3.26	2.59	2.72	-0.19
Size of the household	292	212	15.86	16.17	7.78	7.89	-0.31
Dwelling floor material	292	212	1.79	1.74	0.59	0.58	0.05
Dwelling roof material	292	212	1.03	1.06	0.30	0.41	-0.03
Dwelling wall material	292	212	1.14	1.11	0.64	0.57	0.03
Cooking energy	282	203	1.32	1.37	0.93	0.99	-0.05
Households' assets	292	212	1.45	1.55	0.74	0.79	-0.11
Owned land	292	212	1.86	1.88	0.99	0.99	-0.02
TLU[13]	292	212	2.64	2.52	1.06	1.05	0.12
MIDLINE							
Total children under 5	292	212	3.16	3.06	2.98	2.65	0.10
Size of the household	292	212	15.48	15.79	7.21	7.17	-0.31
Dwelling floor material	292	212	1.71	1.65	0.76	0.68	0.05
Dwelling roof material	292	212	1.03	1.10	0.30	0.54	-0.07*
Dwelling wall material	292	212	1.39	1.37	1.01	0.99	0.02
Cooking energy	288	205	1.58	1.44	1.19	1.06	0.14
Households' assets	292	212	1.96	2.00	0.89	0.86	-0.05
Owned land	292	212	2.08	2.18	1.00	0.99	-0.10
TLU	292	212	2.47	2.48	1.08	1.08	0.00
ENDLINE							
Total children under 5	292	212	3.57	3.65	3.10	3.06	-0.09
Size of the household	292	212	15.93	16.29	7.96	8.03	-0.36
Dwelling floor material	292	212	1.66	1.69	0.72	0.76	-0.02
Dwelling roof material	292	212	1.04	1.04	0.35	0.36	0.00
Dwelling wall material	292	212	1.21	1.25	0.76	0.84	-0.05
Cooking energy	291	212	1.11	1.23	0.57	0.79	-0.11*
Households' assets	291	211	2.22	2.21	1.18	1.12	0.01
Owned land	290	212	1.89	1.94	1.00	1.00	-0.05
TLU	292	212	2.39	2.34	1.12	1.18	0.05

Note: This table presents the socioeconomic characteristics of surveyed households, such as gender distribution, education levels, and living conditions under indirect benefit of WII related to access to credit from FOs providing index-based insurance (model 1).
Source: Authors

9.2 Agricultural investment, production, and income

9.2.1 Investment

The treatment group made the largest agricultural investments. Investments per hectare increased for both groups between the three rounds of surveys.

Table 11 summarizes the principal groundnut investments farmers made during the previous and current agricultural seasons for the baseline (2017 and 2018), midline (2019 and 2020),

[13] Tropical livestock units (TLUs) allow for comparison of the nutritional requirements across livestock species. Using the International Livestock Research Institute's classification for the Horn of Africa, 1 adult cow weighing on average 250 kilograms is deemed equivalent to 1.0 TLU. In terms of nutritional requirements, a camel is equivalent to 1.4 TLUs and sheep and goats are equivalent to 0.1 TLU.

and endline (2021 and 2022) surveys. Even though the difference was not statistically significant, the treatment group invested more per hectare than the control group in all seasons in the baseline, midline, or endline. The area of land cultivated is also higher in the treatment than control group, although, the differences are, again, not statistically significant. For the endline season, the treatment group invested on average CFA 79,945 (around USD 133), while the control group invested CFA 76,089 (USD 127). This finding is in line with some evidence from the literature showing that index-insurance leads to an increase in agricultural investments (Elabed et al. 2013; Jensen et al. 2014). Some differences observed between the treatment and control group investments per hectare may be attributed to the fact that insured farmers are confident in investing more, because they can expect payouts when facing a bad season due to a rainfall deficit. Additionally, insured farmers are supported with services their FOs provide, facilitating their members' access to credit and inputs, including subsidized ones. During the COVID-19 pandemic, FOs played a pivotal role in mitigating consequences of the pandemic through enhanced market access, support for better access to inputs, and renegotiation of credit payments to financial institutions (Latané, Voisard, and Brower 2021).

Investments per hectare constantly increased over the three rounds of surveys. Between baseline and midline, they grew by 41.8 percent for the control group and 47.4 percent for the treatment group. Between midline and endline, investments per hectare went up by 13.8 percent for the control group and 0.4 percent for the treatment group. This slower increase between the midline and endline coincided with the COVID-19 pandemic, when farmers experienced challenges in accessing input due to mobility restrictions and market closures. As a result, input prices grew, mostly during midline and to a lesser extent, during endline.

When we break down the total cost of input, seeds and fertilizers are the most significant input spending. At endline, seed costs represented around 68 percent of total costs for each group. Fertilizer costs made up 24 percent of total costs. These percentages remained stable through the three rounds of surveys.

Table 11: Investments in groundnut between 2017 and 2022

	Obs		Mean		Std.Dev		T-test
	C	T	C	T	C	T	T/C
BASELINE							
Cost of seeds	291	207	77039.48	90990.29	68915.62	122259.67	-13950.80
Cost of fertilizers	292	209	28722.35	47046.39	45190.66	49949.92	-18324.04***
Cost of other inputs	292	209	7760.02	12098.58	26889.11	29835.62	-4338.56*
Total cost of inputs	292	209	113258.01	149264.53	114021.77	156507.03	-36006.52***
Area of land cultivated	292	210	2.02	2.19	1.47	1.60	-0.16
Investment per ha	292	210	47133.23	54029.66	50075.55	50818.44	-6896.43
MIDLINE							
Cost of seeds	213	150	124827.23	128356	119890.26	134167.17	-3528.77
Cost of fertilizers	215	149	46200.23	50314.70	71477.18	68812.16	-4114.47
Cost of other inputs	215	150	10893.02	15067	31520.46	60660.63	-4173.98
Total cost of inputs	215	150	180759.30	193402.27	166036.87	195998.71	-12642.96
Area of land cultivated	214	150	2.43	2.35	1.70	1.77	0.08
Investment per ha	214	150	66836.40	79637.64	60959.24	69713.39	-12801.25*
ENDLINE							
Cost of seeds	284	202	115499.03	128434.94	106712.45	153129.33	-12935.91

	Obs		Mean		Std.Dev		T-test
	C	T	C	T	C	T	T/C
Cost of fertilizers	283	202	41446.47	49502.30	62036.91	56369.25	-8055.84
Cost of other inputs	284	202	13125.70	7966.83	49619.57	19307.03	5158.87
Total cost of inputs	284	202	170277.38	185904.07	168561.17	194928.44	-15626.70
Area of land cultivated	282	199	2.27	2.37	1.48	1.62	-0.09
Investment per ha	284	202	76089.48	79944.97	48469.77	51692.69	-3855.48

Legend: This table tracks surveyed farmers' investments in groundnut production over a six-year period under model.
Source: Authors.

9.2.2 Production volume and declared income

At endline, the production volume increased slightly but did not lead to higher consumption for the treatment group. Farmers may prefer selling over consuming more to respect their contracts with their affiliated organization.

Table 12 show the result of the agricultural season in terms of volume of production; its distribution between sales, consumption, and donation; the price of most sales; and the reported net income. There is no significant difference between the two groups, except for production volume during baseline. The control group produces, on average, 1,688 kilograms compared to the treatment group's 1,378 kilograms. At endline, the production volume was similar for both groups. It increased within the three rounds of survey—by 6 percent between baseline and midline and by 2 percent between midline and endline.
It seems that treatment group farmers sold more (984 kg) than control group farmers (788 kg) in all years, except at endline. Groundnut sales prices increased from CFA 104 (USD 0.17) to CFA 291 (USD 0.48) between baseline and midline. However, these prices decreased by 14 percent between midline and endline. Many factors can contribute to the fluctuation of prices over the years. One important consideration is that the market price for groundnuts has experienced vigorous growth over the past five years, with the Government of Senegal's authorization of groundnut exports and the liberalization of the market that enabled Chinese buyers to enter the it. This gave farmers more marketing possibilities compared to when only the national oilseed producer (SUNEOR, former *Société Nationale de Commercialisation des Oléagineux du Sénégal* [SONACOS]) was in the market (The World Bank Group 2017). Further, the Government of Senegal determines an annual floor price, which is based on a consensus with national groundnuts stakeholders. This price increased between the 2019/2020 and 2020/2021 seasons by 19 percent (from CFA 210 to 250). This can also explain the increase in sales price observed between baseline and midline. However, the floor price did not increase and remained the same between 2020/2021 and 2021/2022 seasons. As production grew over time, consumed production kept expanding, particularly for the treatment group, across all three survey rounds. Between midline and endline, household consumption increased by 35 percent and between baseline and midline by 32 percent. The situation is a bit different for the control group whose consumption increased between baseline and midline (+22%), then decreased between midline and endline (-12%). This decrease is a result of the rise in the share of production sold. Farmers in the control group may prefer selling more and reducing their consumption. However, selling more between midline and endline did not substantially increase farmers' income in the control group due to reduced sales price.

Table 12: Groundnut production results

	Obs		Mean		Std.Dev		T-test
	C	T	C	T	C	T	T/C
BASELINE							
Production volume	291	205	1378.52	1688.88	1519.81	1752.34	-310.37**
Production sold	292	210	476.43	572.37	879.59	934.31	-95.94
Price for most sales	292	209	103.65	109.31	98.65	99.91	-5.65
Consumed production	292	210	148.14	126.50	274.79	258.04	21.64
Donated production	292	210	59.11	72.24	91.04	146.72	-13.13
Income (as declared)	292	210	93458.32	125539.05	180708.48	234701.85	-32080.73*
MIDLINE							
Production volume	214	149	1467.23	1484.90	1362.50	1849.89	-17.67
Production sold	214	149	883.49	918.19	873.31	1068.98	-34.70
Price for most sales	198	135	291.31	287.85	24.28	27.05	3.46
Consumed production	214	149	181.53	167.79	318.70	244.77	13.74
Donated production	214	149	98.55	76.81	165.67	112.26	21.73
Income (as declared)	198	135	294335.35	295310.74	321930.19	322420.76	-975.39
ENDLINE							
Production volume	283	202	1494.63	1497.24	1912.73	3111.85	-2.61
Production sold	283	202	984.17	788.95	1472.78	943.39	195.22*
Price for most sales	249	160	248.97	246.22	33.94	38.20	2.75
Consumed production	283	202	159.05	226.98	319.44	505.44	-67.93*
Donated production	283	202	56.72	61.04	82.78	128.96	-4.32
Income (as declared)	249	160	292824.50	250699.91	392671.92	253147.83	42124.59

Note: This table summarizes groundnut production outcomes, including production volume and declared income (under model 1).
Source: Authors.

9.2.3 Production value and calculated net income

Farmers experienced a decline in their net income between midline and endline, after an increase from baseline to midline. Even though their production value increased between midline and endline, the control group farmers' consumption value decreased between these two periods. We observed the opposite for the treatment group whose production value decreased at endline, while their consumption value increased for the same period.

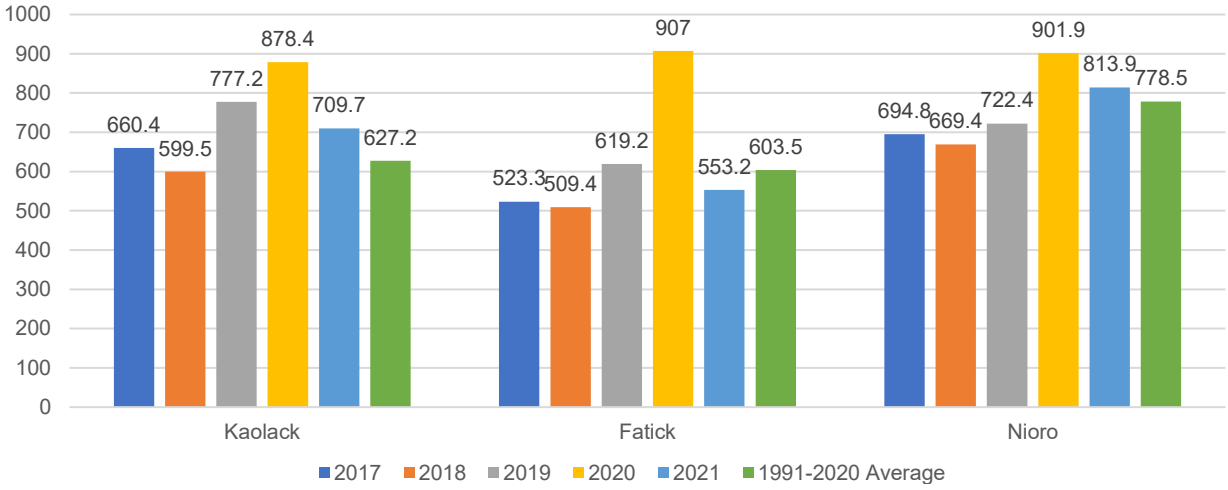
Table 13 presents the valuation for the production volume broken down by sales, consumption, donation, and the associated net income. The treatment group reported a higher net income than the control group during endline – control group net income was CFA 244,597 (USD 408), while the treatment group net income was CFA 256,317 (USD 427). However, the net income differences are not significant across groups. Net income was higher for the control than the treatment group at midline (CFA 278,975 compared to 270,257), but the difference was not statistically significant. Both groups also experienced a decline in their net income between midline and endline—12 percent for the control group and 5 percent for the treatment group. This is due to a combination of production value and price reductions (as shown in Table 12). Indeed, the production value decreased by 9 percent for the control group and 4 percent for the treatment group. Even though the production value reduction seemed to be low, lower prices amplified its effects on net income.

It is also worth noting that the volume of production in the 2018 season appeared to be similar to other seasons, while the volume sold and the achieved sales prices were

particularly low. However, official statistical sources and available rainfall data indicate an overall moderate outcome for the 2018 season, which was comparable to the 2017 season in terms of production and prices farmers obtained during the marketing period (Direction de l'Analyse de la Prévision et des Statistiques Agricoles 2020).

This is consistent with observations from the 2018 rainy season. Figure 14 compares the cumulative rains of the weather stations across the country between 20176, 2017, and 2021 (Groupe de Travail Pluridisciplinaire 2021; Agence Nationale de la Statistique et de la Démographie 2020). Data show that 2018 is the year with the lowest cumulative rainfall between 2017 and 2021 for Fatick, Kaolack, and Nioro. However, the difference observed is not high compared to the previous year, 2017. Indeed, the rainfall decreased by 3, 4, and 9 percent, respectively in Fatick, Kaolack, and Nioro between 2017 and 2018. The highest cumulative rainfall for all three departments during this period was recorded in 2020, coinciding with the midline. That year, Fatick recorded 907 millimeters, while Nioro and Kaolack recorded 902 and 878 millimeters, respectively. However, we note an important decrease of the cumulative rainfall the following year, 2021, for all three departments. Between 2020 and 2021, the cumulative rainfall decreased by up to 63 percent in Fatick.

Figure 14: Cumulative rainfall in Fatick, Kaolack, and Nioro between 2017 and 2021 (in mm)



Annual Reports (2018, 2019, 2020, 2021) of the National Framework of Climate Services in Senegal

The fact that the results for the 2018 agricultural season are not as good as for the other three seasons may be related to timing of the baseline survey, which was just at the end of the harvest period and at the beginning of the marketing period of the season (mid-December 2018–early January 2019). During the 2018 /2019 survey, farmers already knew their level of production for the 2018 growing season and reported it correctly. However, at the time of the survey, they would have only sold a share of the production that the survey then captured. This most likely resulted in a lower volume of sales reported for 2018 than what would have been the total volume sold by the end of the marketing period. In addition, prices are usually relatively low at the beginning of the marketing period, which could explain the low price reported in the 2018 survey. In contrast, the midline survey was conducted at the end of the marketing period (end of January until mid-February 2021), by which point, prices would have increased and farmers would have sold a larger share of their production. The differences in the survey period are a result of delays in data collection activities related to the COVID-19 pandemic in 2020.

Table 13: Calculated production value and net income

	Obs		Mean		Std.Dev		T-test
	C	T	C	T	C	T	T/C
BASELINE							
Sales value	292	209	95458.29	115422.22	179912.15	196791.61	-19963.94
Donations' value	292	209	6898.58	10477.51	15767.19	31895.68	-3578.93*
Consumed value	292	209	19403.34	21162.25	48551.19	54072.07	-1758.91
Total prod value	291	204	170551.34	225604.41	274614.68	349675.34	-55053.07*
Net income	291	204	57046.74	75905.95	235154.53	306422.82	-18859.21
MIDLINE							
Sales value	198	135	280540.28	298758.89	260339.76	323597.07	-18218.61
Donations' value	198	135	31233.33	24542.59	51134.13	34235.46	6690.74
Consumed value	198	135	53346.72	51988.15	87616.85	76693.36	1358.57
Total prod value	198	135	465433.84	474534.81	443100.88	570121.96	-9100.98
Net income	198	135	278975.51	270254.52	367115.07	469643.08	8720.99
ENDLINE							
Sales value	250	161	285147.80	256383.47	385130.33	258844.12	28764.34
Donations' value	250	161	19984.50	24619.73	66141.97	85137.48	-4635.22
Consumed value	250	161	46065.22	66006.22	104522.39	159383.33	-19940.99
Total prod value	250	161	424020.80	457081.22	502916.29	864485.55	-33060.41
Net income	250	161	244597.90	256316.60	440265.88	831864.07	-11718.70

Note: This table presents calculated production value and net income from groundnut farming (under model 1).
Source: Authors.

9.3 Shocks, coping strategies, and changes in agricultural practices

Exposure to shocks seemed to have decreased between baseline and midline but increased between midline and endline. As a result, the length of the lean period for both groups constantly expanded over the three periods. Meanwhile, farmers improved their coping strategies score as a response to experiencing more shocks.
Table 14 summarizes shocks farmers faced and coping mechanisms developed. Between baseline and midline surveys, the scores describing producers' level of exposure to shocks were lower in all groups, while they significantly increased between midline and endline. These scores describe the number of shocks producers had experienced in the 12 months prior to the study period, using quartiles. A higher score means farmers are more exposed to shocks. A comparison across both groups reveals that over time, treatment group farmers were more prone to shocks than control group farmers at midline and endline. However, these differences are not statistically significant. The exposure to shocks decreased, for both groups, between baseline and midline. However, it increased between midline and endline, with an average exposure score for control and treatment group at endline of 3.04 and 3.11, respectively. This high exposure to shocks is driven by a growing number of shocks farmers face, in particular related to climate. Indeed, rainfall season breaks, combined, with late/early starting seasons are pressing challenges for farmers, requiring more effective adaptation options. This played a great role in putting households' production stocks at risk. The length of lean period kept expanding from baseline to endline for treatment and control groups. The lean period between the baseline and endline increased from 2.17 to 2.61 months for the control group and from 2 to 2.55 months for the treatment group.

Throughout the three survey rounds, farmers have increased their coping strategies score (see Annex B for more details on how the scores were built). Between midline and endline, the score went from 2.22 to 2.83 for the control group and from 2.29 to 2.99 for the treatment group. The farmers in the treatment group have, in general, better coping strategies score than the treatment group. The difference between the groups is statistically significant, but only at a 10-percent level. Because they are enrolled in an agricultural insurance contract, farmers in the treatment groups have at least a non-negligeable adaptation option, which people in the control group do not use. The coping strategies score also captures additional and alternative options people use to cope with the consequences of shocks they face. These coping strategies refer mostly to changes in agricultural practices with the provision of better fertilizers during baseline and midline for both groups. However, at endline, farmers were more interested in introducing phytosanitary products to fight crop pests. Uninsured farmers introducing phytosanitary products constituted 5 percent at baseline and 35 percent at endline. Meanwhile, insured farmers introducing phytosanitary products made up 2 percent at baseline and 31 percent at endline.

Table 14: Shocks, coping strategies, and adoption of good agricultural practices

	Obs		Mean		Std.Dev		T-test
	T	C	T	C	T	C	T/C
BASELINE							
2018 cereal cover (months)	291	211	8.43	8.97	3.68	3.73	-0.53
Exposure to shocks	292	212	2.53	2.47	1.17	1.13	0.06
Length lean period (2018)	292	212	2.17	2.00	1.18	1.06	0.17*
General coping strategies	254	195	2.20	2.31	1.05	1.09	-0.11
Changes in existing practices	292	212	1.46	1.82	1.09	1.34	-0.36***
Adoption of new practices	292	212	1.23	1.33	0.79	0.94	-0.10
MIDLINE							
2020 cereal cover (months)	292	212	7.49	7.57	3.63	3.87	-0.08
Exposure to shocks	292	211	1.88	1.98	0.94	0.92	-0.10
Length lean period (2020)	292	212	2.29	2.36	1.24	1.24	-0.07
General coping strategies	248	184	2.22	2.29	1.11	1.07	-0.07
Changes in existing practices	292	212	1.82	1.67	1.34	1.25	0.16
Adoption of new practices	292	212	1.37	1.30	0.99	0.90	0.07
ENDLINE							
2021 cereal cover (months)	292	212	6.84	6.76	3.57	3.65	0.07
Exposure to shocks	292	211	3.04	3.11	0.96	0.94	-0.07
Length lean period (2021)	292	212	2.61	2.55	1.10	1.07	0.05
General coping strategies	290	210	2.83	2.99	1.06	1.06	-0.16*
Changes in existing practices	292	212	1.44	1.47	1.06	1.09	-0.03
Adoption of new practices	292	212	1.21	1.34	0.76	0.95	-0.13*

Note: This table details shocks experienced, coping strategies, and adoption of good agricultural practices by farmers (under model 1).
Source: Authors

Consumption length for the stock of grains (estimated in months) decreased over time for both groups. The insured group has a slightly higher level of consumption coverage of grains stocks.

Figure 15 and Figure 16 present the changes producers reported in their farming practices and any new practices they may have adopted. The main observed change in cultivation practices is the decrease in the use of fertilizers and an increase in the use of phytosanitary

products. This is valid for both the treatment and control group. Regarding the adoption of new agricultural practices, sorting of seeds was the most mentioned at endline. Both groups reported this practice twice as often at endline as they did at baseline and midline. Fencing farms was also noted half as frequently as at midline and baseline. Overall, no significant changes were observed in agricultural practices of all producers considered in our study.

Figure 15: Declared changes in agricultural practices

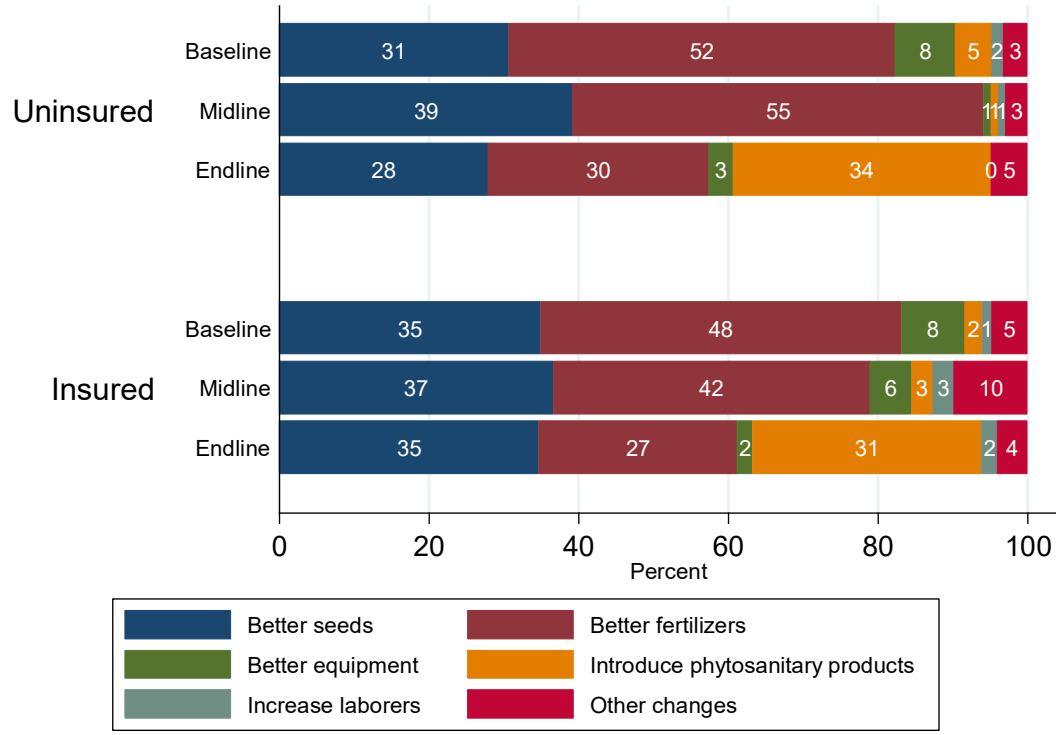
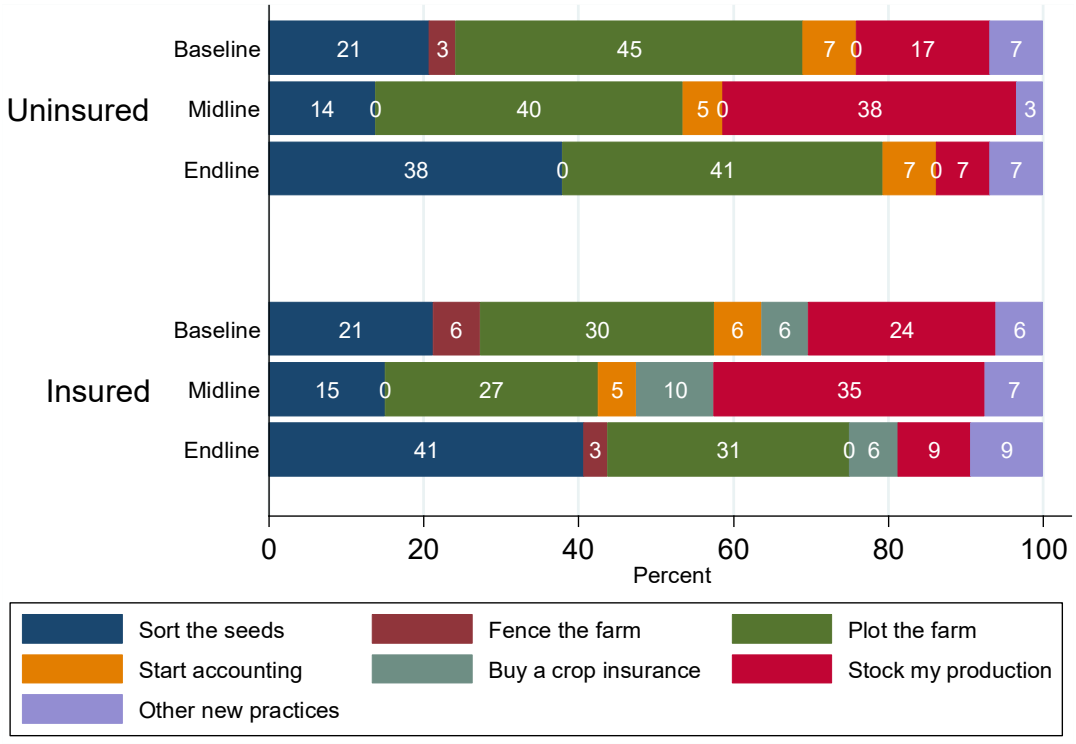


Figure 16: Declared adoption of new agricultural practices



In addition to the information farmers mentioned about shocks experienced and coping strategies used, the outcome of the agricultural season and relatedly, household consumption and the length of the lean period can provide insights about the impacts of shocks and farming households' adaptive capacity. Despite fluctuations over the years and local differences across the sample, the data indicate no major shock to agricultural production throughout the study period (for further discussion of production volume and declared income, see Section 7.2.c.).

Figure 17, Figure 18, and Figure 19 present kernel density plots for the number of months of the households' direct consumption covered by the production of grains in the 2018, 2020, and 2021 growing seasons, respectively.

In 2018, a larger percentage of farmers in the insured group noted a higher number of months their production of grains covered than the percentage of those who reported the same number of months of coverage in the control group. At baseline, there were more farmers reporting fewer months of coverage (less than 12 months) in the control group than in the treatment group. However, in both the treatment and control group, most the farmers reported that their production could cover about 12 months of consumption (until the harvest of the next cropping season).

In 2020, more farmers reported a production that could not cover their need for consumption until the next harvest. Indeed, most reported production that could cover less than 10 months of consumption. These results seemed to be the same for both the treatment and control group even though a slightly higher percentage of farmers in the control group noted fewer months their production could cover. Compared to baseline, the midline results regarding the number of months main grains could cover seemed to have increased because fewer farmers declared a low number of months of consumption.

In 2021, most of the producers were in the left side of the kernel curve, after the 10 months of coverage line. This suggests that they would struggle to cover 12 months of consumption with their harvest. It is also worth noting that slightly more people in the control group reported higher number of months (more than 10 months) their grain production could cover than in the treatment group. This suggests a decreasing trend for the number of months covered (increasing trend for the length of the lean period) compared to the baseline results, where more farmers were on the right side of the curve.

Figure 17: Number of months of the household's direct consumption covered by production of grain (2018)

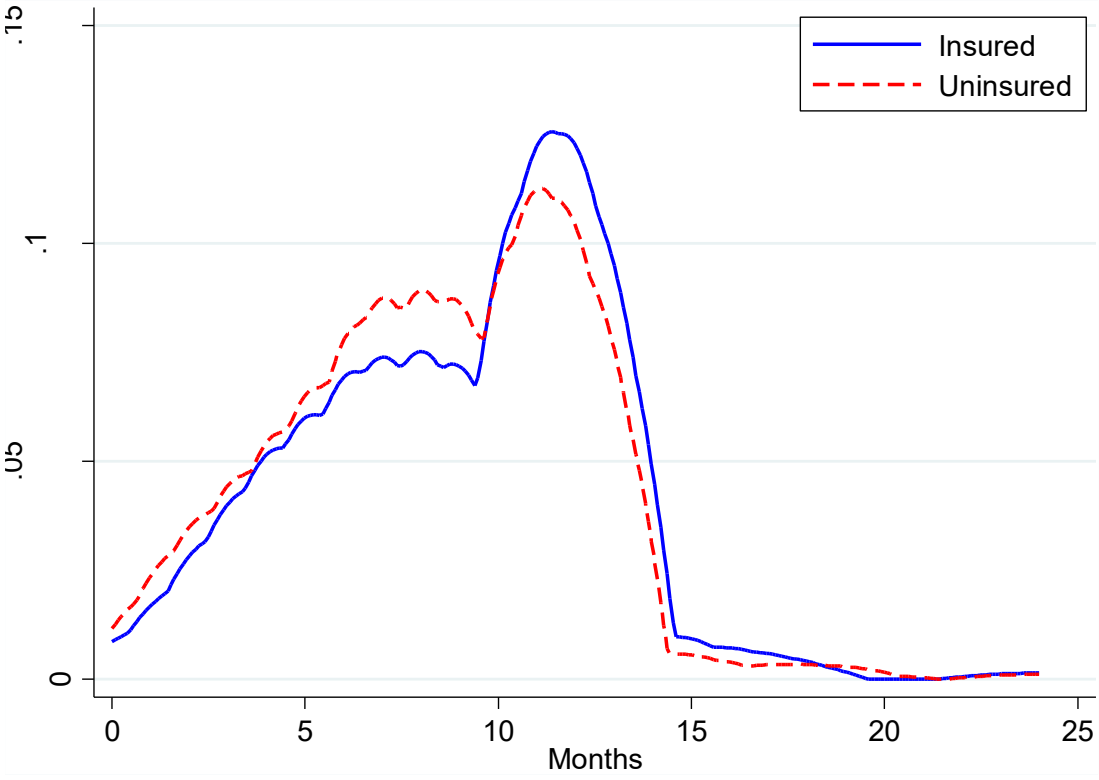


Figure 18: Number of months of the household's direct consumption covered by production of grain (2020)

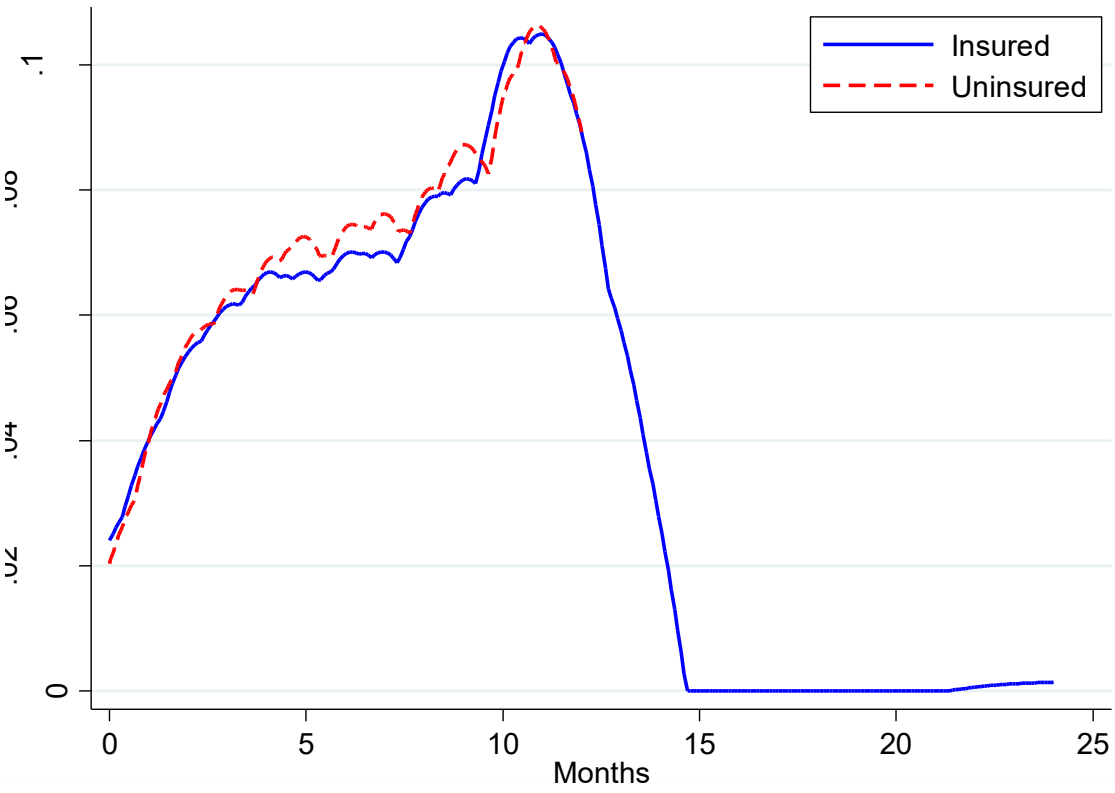
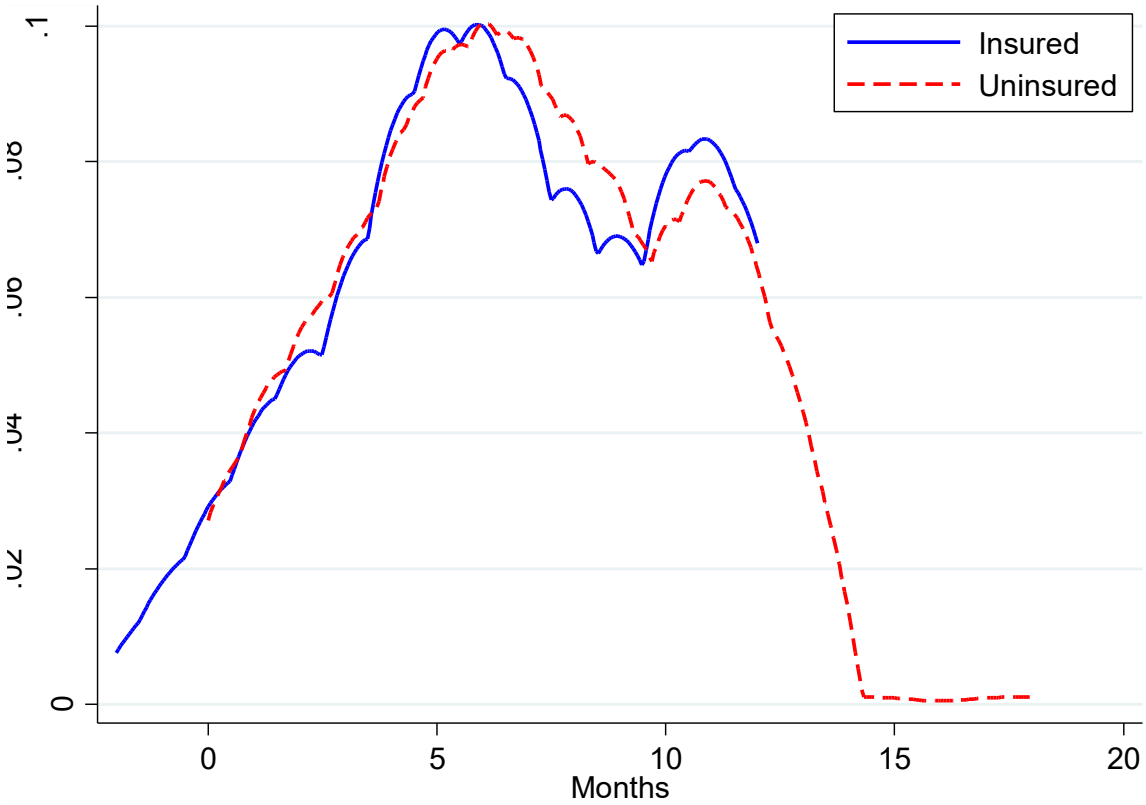


Figure 19: Number of months of the household's direct consumption covered by production of grain (2021)



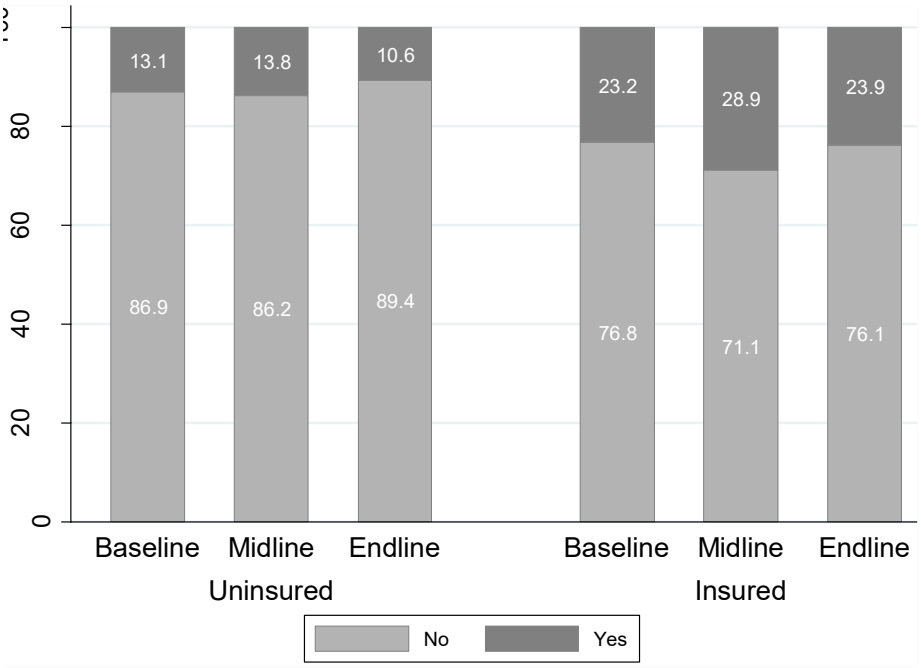
9.4 Credit, membership in FO and agricultural insurance

9.4.1 Access to credit and membership in FOs

Survey participants were interviewed on their experience with loans to assess how their access to credit evolved over time. This includes formal credit obtained from banks and microcredit institutions, as well as informal credit, with a particular focus on credit obtained for the funding of agricultural activities.

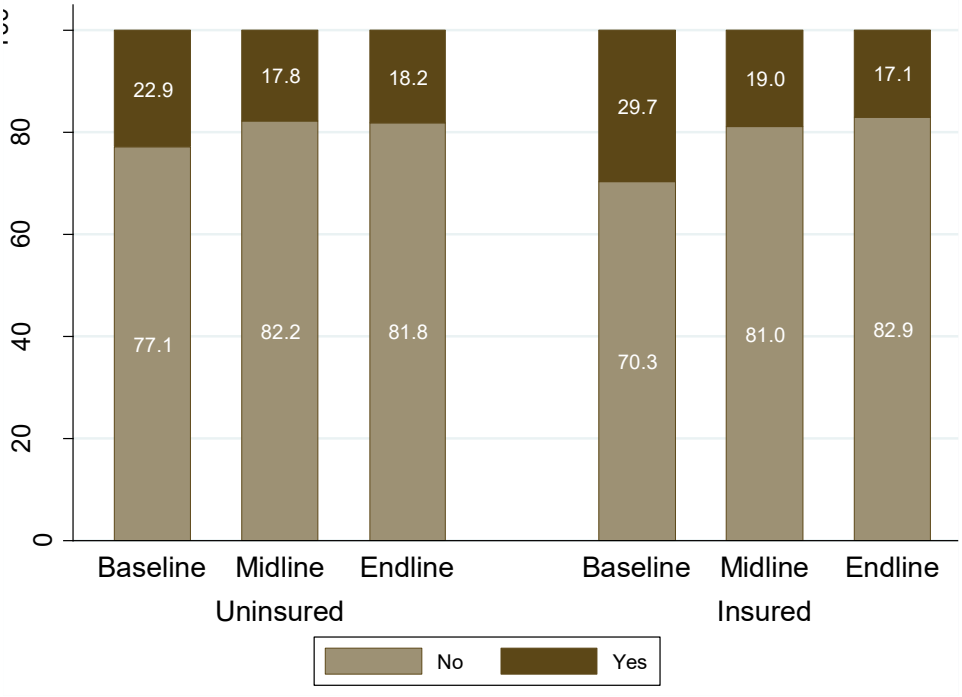
Overall, access to credit remains low for farmers in our survey, at only around 10–29 percent of farmers. Financial inclusion remains a serious issue in the country, and only 3 percent of Senegalese have access to a formal credit (World Bank 2016). A higher percentage of insured farmers received formal credit from banks or MFIs to fund their agricultural activities than uninsured farmers, which was observed in all three survey rounds. This may be attributed to the fact that insurance is bundled with credit and facilitates financial inclusion of farmers. Access to formal credit tends to even decrease for uninsured farmers—13.1 percent had access to formal credit at baseline and only 10.6 percent at endline.

Figure 20: Any formal credit obtained from banks or microcredit institutions for agricultural purposes only



Like in the case of formal credit, informal credit access remains a challenge for farmers in the study. As Figure 21 shows, farmers with no access to informal credit make up between 70 and 83 percent. Insured farmers also have better access to informal credit than uninsured farmers throughout the three surveys rounds. For instance, at endline, 23.9 percent of insured farmers had access to informal loans and only 10.6 percent of uninsured farmers. For insured and uninsured farmers, informal access to credit decreased between midline and endline (13.8% vs. 10.6% for uninsured and 28.9% vs. 23.9% for insured).

Figure 21: Informal credit obtained for agricultural purposes only



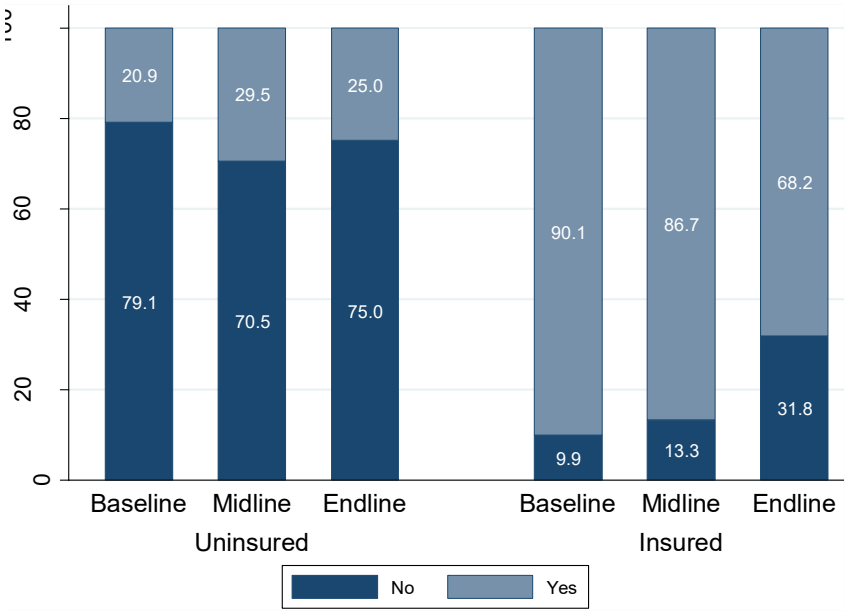
In our selection criteria for study participants, we included producers who are members of FOs in the treatment groups. Farmers in the control group should be only those who did not purchase the insurance product during that year, no matter whether they hold an FO membership or not.

Compared to uninsured farmers, many more insured farmers were affiliated with an FO, especially at baseline and midline. More than 86 percent of insured farmers were affiliated with an FO compared to 29.5 percent of uninsured farmers. While the percentage remained stable for the uninsured farmers over time (between 21 and 29%), we observed a steep decline in the percentage of insured farmers affiliated with an FO—it decreased from 86.7 to 68.2 percent between midline and endline. On the one hand, this may be related to how insured farmers, in particular in CCPA, interpret and view their relationship with the affiliated FO. Some farmers may consider CCPA as a funding institution rather than an FO because they interact with the organization only to receive agricultural inputs on credit that they then pay back at the end of the season. In addition, to access the services FO provides (i.e., access to inputs on credit), some producers are included in the list of members by family or friends as a proxy, without considering themselves as “active” members. On the other hand, farmers are increasingly unsatisfied with services their FO provides, especially insurance. Conditions regarding insurance contract agreements, in particular payouts, remain unclear to them. This situation may decrease the confidence they have in their affiliated institution.

Furthermore, FGD participants described an increasing diversification in livelihoods, with some households moving away from agriculture as a source of income or their main source of income. At the same time, some FO representatives described tightening of rules related to membership admission, along with an increase in annual membership fees. In combination, these factors may have contributed to the decrease in FO membership among the treatment group farmers between baseline and midline.

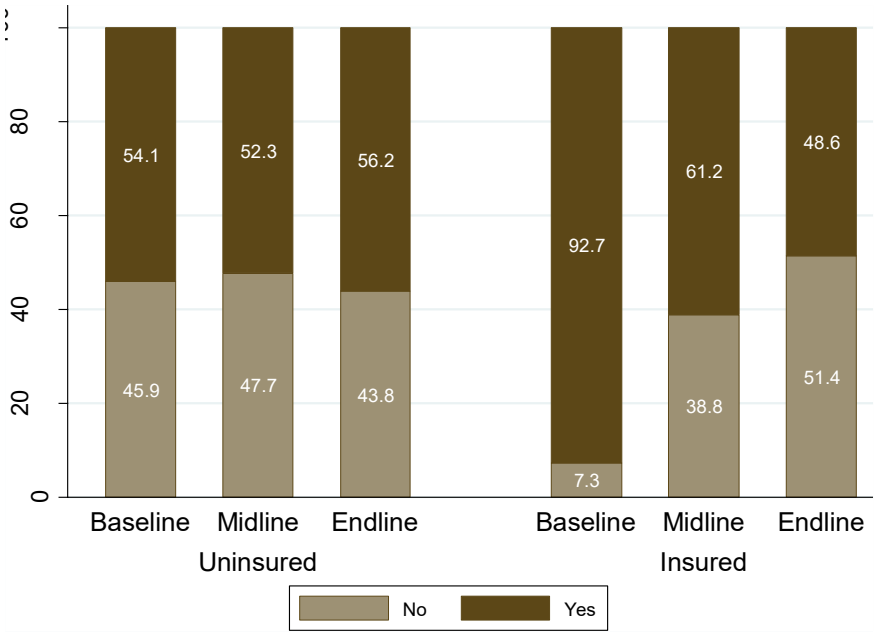
For the control group, the results confirm our assumption that in areas of our study (communes where the treatment villages and control villages are selected), COOPEC and CCPA are almost the only FOs open to groundnut producers. At baseline, 79.1 percent of farmers in the control group reported they had not been a member of an FO. At midline, this percentage decreased to 72.6 percent, while at endline, it finally increased to 75 percent.

Figure 22: Membership in Farmers' Organizations



FO have a competitive advantage to provide different types of services to their members. Among those services, they facilitate access to credit to their members. Percentages of uninsured farmers remained stable over time and only half of them had access to an agricultural credit from an FO. However, the percentage of insured farmers who reported receiving agricultural credit from their FO changed substantially over the survey's three rounds (Figure 23). The decrease was large between baseline and midline (from 92.7 to 61.2%) and still significant between midline and endline (from 61.2 to 48.6%). FOs generally rely on formal credit institutions or Support Fund for the Development of the Rural Sector (FADSR) to access funds. They, in turn, lend to their members. However, during the COVID-19 pandemic, most FOs struggled to access funds from those formal credit institutions, which led to the observed significant decline.

Figure 23: Agricultural credit obtained from a Farmers' Organization



To better capture the level of change of the indicator of access to credit presented above, we used a test to compare the difference between the treatment groups and the control group for each round of survey. Baseline results suggested a small, 10-percent difference between the two groups in the number of farmers who reported receiving a formal loan for any purpose or for agricultural activities only. For membership in FOs, we observed a significant, 69-percent difference (at 1% level) when we compared the control group to the treatment group. Among the producers who were members of an FO, we also found a significant, 39-percent positive difference in the number of farmers who reported they had received a loan from their FOs. However, the amount received was not significantly different between the treatment and control groups.

At midline, compared to baseline, the percentage of farmers receiving formal loans increased just slightly for both the control and treatment groups. We observed significant differences between groups in access to formal credit (in favor of the treatment groups) during each of the three survey rounds. This is because treatment group farmers benefitted more from financial inclusion due to the bundling of insurance with credit. We observed no difference between the groups in terms of the percentage of farmers who reported having received an informal loan, except at baseline with a 10-percent level of significance.

Table 15: Access to credit and membership in FOs

	Obs		Mean		Std.Dev		T-test
	C	T	C	T	C	T	T/C
BASELINE							
Any formal loan	291	211	0.13	0.23	0.34	0.42	-0.10***
Any formal agri loan	292	212	0.13	0.19	0.34	0.39	-0.06*
Any informal agri loan	292	212	0.23	0.30	0.42	0.46	-0.07*
Membership in FOs	292	212	0.21	0.90	0.41	0.30	-0.69***
Any agri loan from FOs	61	191	0.54	0.93	0.50	0.26	-0.39***
Amount of agri loan FOs	32	173	87771	89715	64907	117695	-1944
MIDLINE							
Any formal loan	290	211	0.14	0.29	0.35	0.45	-0.15***
Any formal agri loan	289	211	0.14	0.26	0.35	0.44	-0.12***
Any informal agri loan	292	211	0.18	0.19	0.38	0.39	-0.01
Membership in FOs	292	211	0.29	0.87	0.46	0.34	-0.57***
Any agri loan from FOs	86	183	0.52	0.61	0.50	0.49	-0.09
Amount of agri loan FOs	44	109	100203	90338	100537	69697	9865
ENDLINE							
Any formal loan	291	209	0.10	0.24	0.30	0.43	-0.14**
Any formal agri loan	291	211	0.11	0.21	0.31	0.41	-0.10***
Any informal agri loan	291	211	0.18	0.17	0.39	0.38	0.01
Membership in FOs	291	211	0.25	0.68	0.43	0.47	-0.44***
Any agri loan from FOs	72	144	0.56	0.49	0.50	0.50	0.07
Amount of agri loan FOs	39	69	93603	113236	82192	109112	-19633

Note: This table examines access to credit and membership in FOs (under model 1).
Source: Authors.

9.4.2 Uptake and familiarity with insurance

Knowledge of and familiarity with insurance products kept increasing for both groups. As expected, insured farmers had more knowledge about insurance products than the uninsured.

Figure 24 presents the farmer's level of knowledge about insurance products during the three rounds of survey across insured and uninsured groups. Results show that insured farmers had always had a better level of knowledge of insurance products. For instance, at endline, 85.3 percent of insured farmers have heard about index-based insurance, compared to 63.7 percent of uninsured farmers. The figure also suggests an upward trend of knowledge about index-based insurance among farmers for both groups. The knowledge increased from 12 to 63.7 percent between baseline and endline for uninsured farmers. The percentage of farmers who had heard about index-based insurance rose from 46.7 to 85.3 percent between baseline and endline.

Figure 24: WII product knowledge (heard about it)

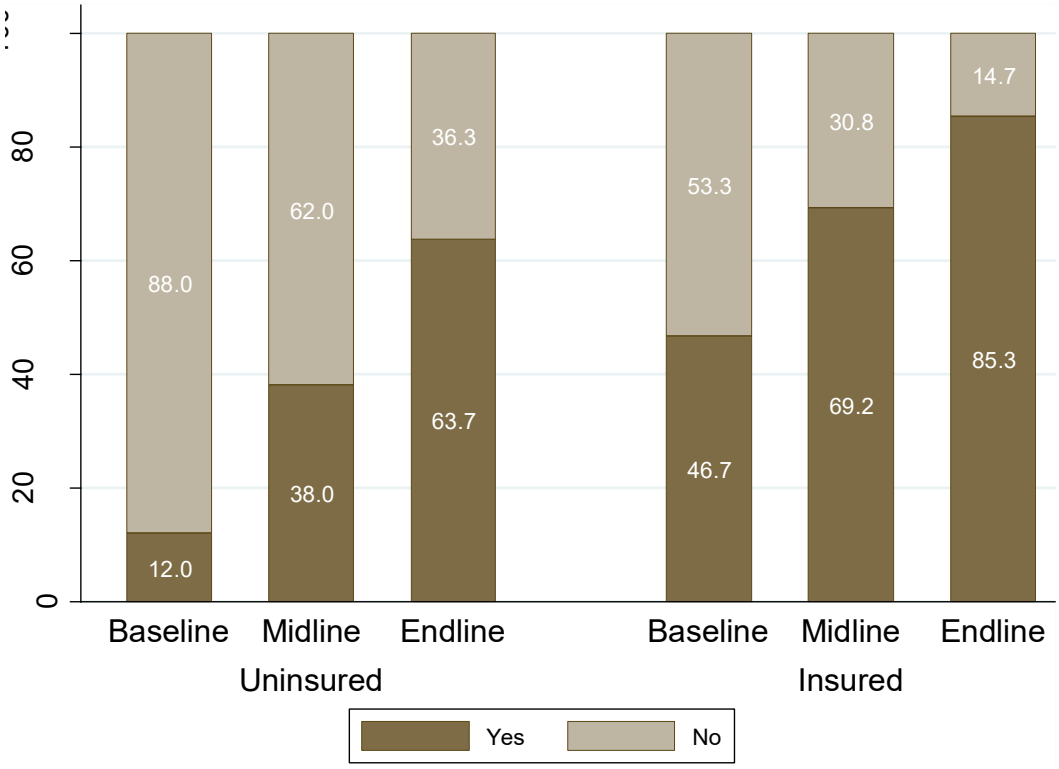


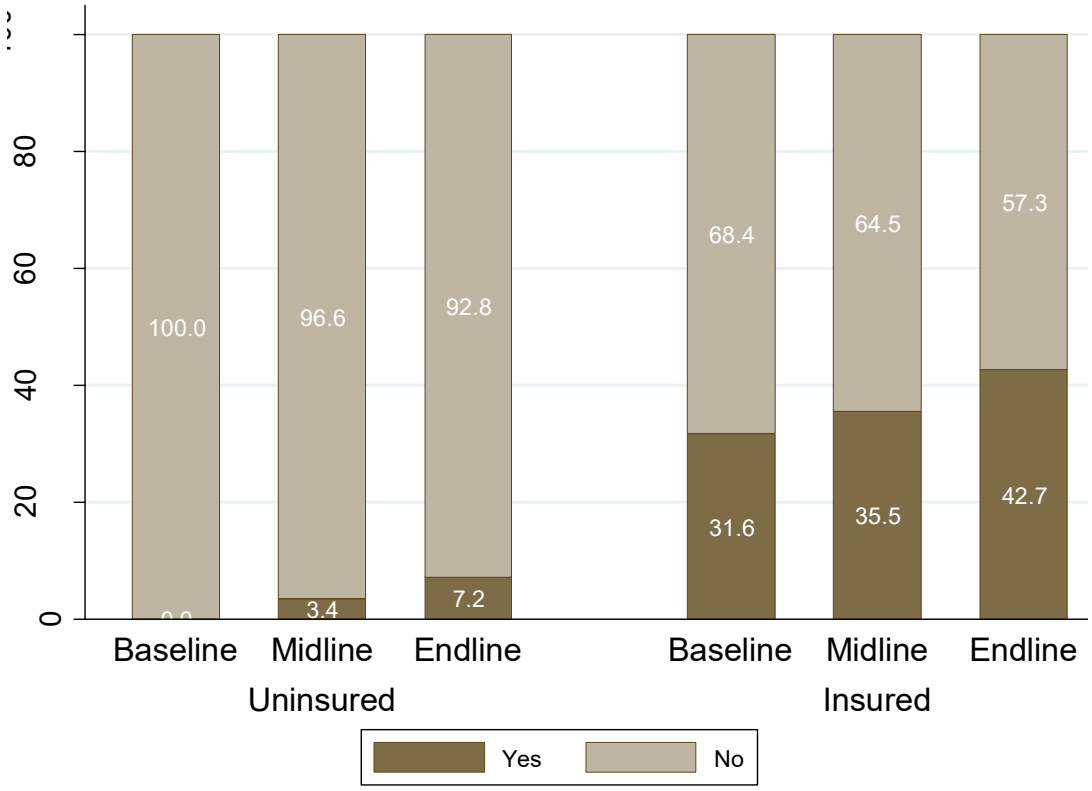
Figure 25 presents the progression of WII uptake for the three waves of survey. As expected, farmers in the treatment group had a higher rate of reported insurance uptake than those in the control group. Between baseline and endline, the number of producers reporting informed uptake increased by about 10 percent in the treatment group. This rather small increase is also observed in the control group, although it is lower in that group. Greater flow of information and communication about WII from different sources (mostly informal), including our surveys that farmers have progressively more access to, could explain this increase.

It is also important to consider that informed uptake significantly increased in each of the groups. At midline, the reported insurance uptake rate was 3.4 percent for the uninsured group, while in the insured group, 35.5 percent of farmers had purchased the product

(according to their reporting). This result is intriguing in that we obtained confirmation from the three implementing agencies we collaborate with that no farmer in the insured group was insured in 2020, when we carried out the midline survey. This is consistent with the issue of lack of information between the farmers and their affiliated FO, as discussed earlier.

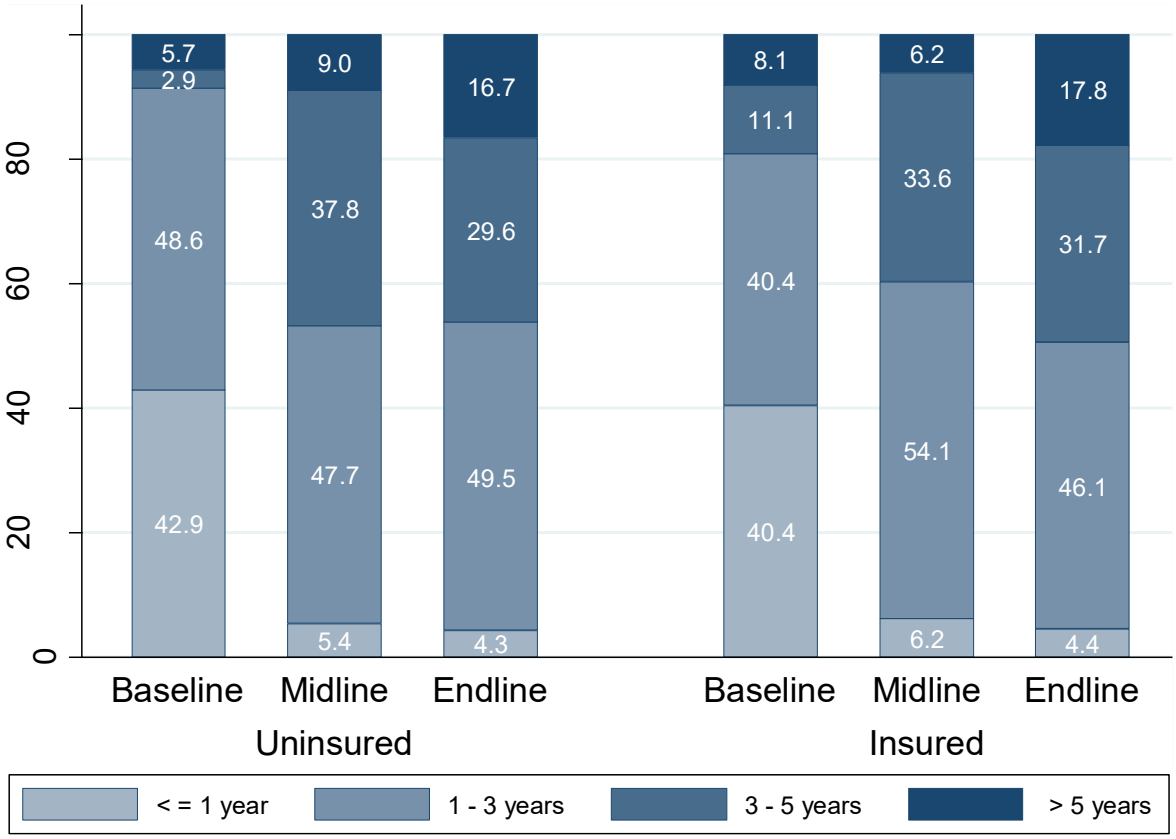
At baseline, most farmers in the insured group thought they had not been insured, while majority (especially all farmers in the CCPA FO) had been insured. At midline, the opposite was observed: while none of the farmers were insured due to implementation issues between the insurer and the FO serving as aggregators in the treatment group (described in more detail in Section 3.3.b), a high number of farmers (35.5% for the treatment group) thought that they had been insured. This could be explained by the fact that since the baseline survey, more farmers knew about the insurance product and, hence, thought that their organization still offered insurance as part of the package of services they paid for at the beginning of each season. Indeed, as presented in Figure 24, the percentage of farmers reporting to have heard about the WII crop insurance product since the baseline kept increasing from baseline to endline.

Figure 25: WII product uptake (purchased based on declarations)



Farmers in the treatment group have the longest-standing knowledge about the insurance product, with 17.8 percent of them having been aware of the product for more than five years at endline, compared to the control group, with 16.7 percent (see Figure 26). We also observed that farmers' years of experience with insurance expanded since baseline for both the treatment and control group. Indeed, the percentage of farmers with less than 1 year of experience significantly decreased (from 42.9 to 4.3% for control group and 40.4 to 4.4% for treatment group). Meanwhile, the number of farmers with the longest experience (more than 5 years) grew (from 5.7 to 16.7% for control and from 8.1 to 17.8% for treatment group).

Figure 26: Number of years of knowledge of the insurance product



Farmers generally access diverse sources for insurance-related information. For the treatment group, the organizations farmers are affiliated with (COOPEC and CCPA) remain the primary sources of information about insurance, although family and friends, the radio, and other sources play an increasingly important role as sources of information about insurance for the two groups. Even though they are the main source of information, Figure 27 showed farmers in the treatment group tend to rely progressively less on their FO—from 42.4 percent at baseline to 25 percent at endline. Other sources of information seem to gain importance over time for farmers in both groups. For the treatment group these other sources' importance increased from 3 to 22.8 percent between baseline and endline, and in the control group, it went from 22.9 to 44.6 percent.

Figure 27: Source of knowledge about crop insurance

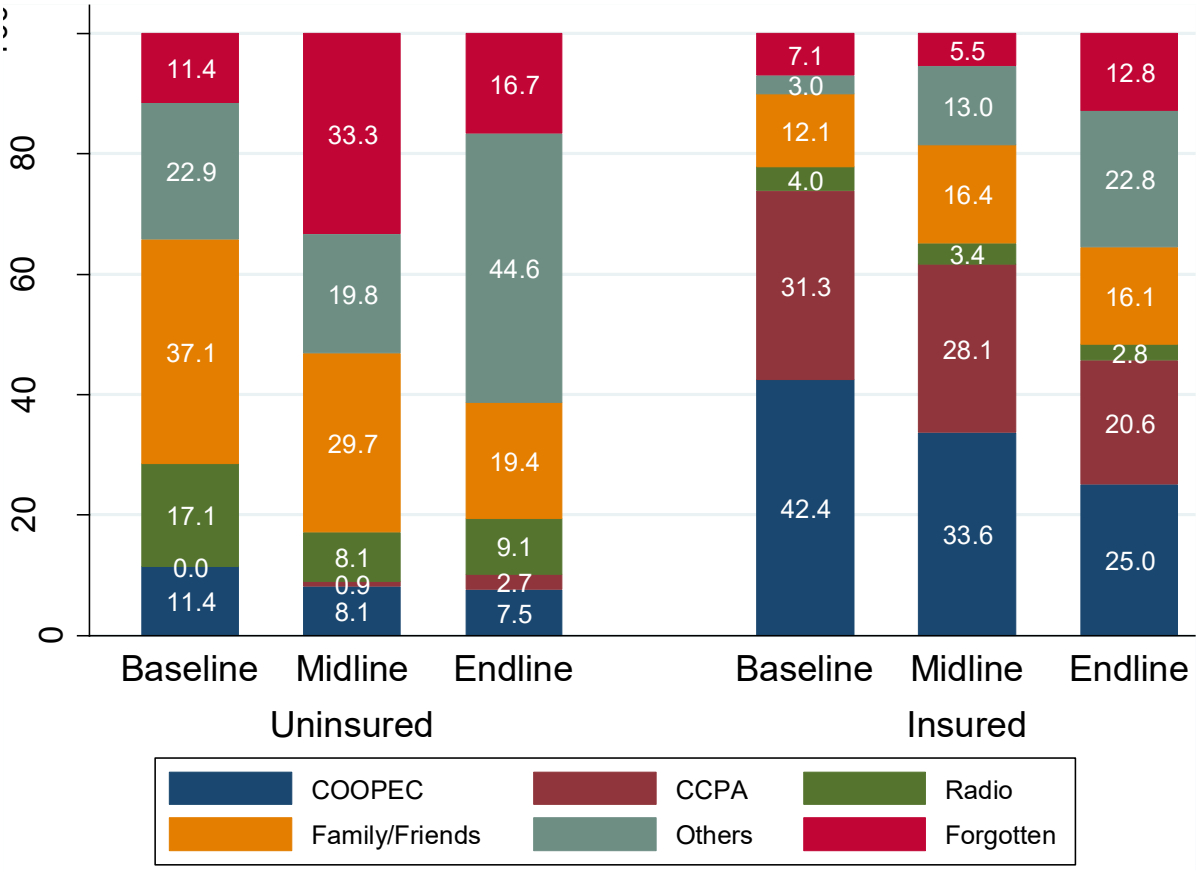


Table 16 presents experience with insurance in general, WII uptake, and its understanding across groups. Figures for the uptake results are the scores in terms of type of different insurance product purchased. Producers in the treatment group purchased the highest number of different types of insurance (including products such as car insurance, health insurance, crop insurance, etc.) compared to the control group. This experience with insurance constantly rose from baseline to endline for both groups (from 0.58 to 1.1 year on average). In terms of experience with WII uptake, the number of years of experience in the control group is very low (0 at baseline and 0.12 at endline). However, we note a decrease in the knowledge of crop insurance with fewer farmers on average reporting to know the product from baseline to endline for the treatment group. For the control group, while the average knowledge of insurance decreased between baseline and midline, it increased between midline and endline.

Among those who stated to understand the functioning of WII, we evaluated how many had a correct understanding (based on questions about the perils the product covers). In the three rounds of survey, few producers had a correct understanding of the policy coverage. However, it is surprising to observe, except for baseline, that control group farmers had a better understanding of how insurance works. Even though the differences were not statistically significant, they show there are still efforts ahead to provide detailed and understandable information to the farmers taking the insurance.

Table 16: Declared uptake and understanding of WII insurance

	Obs		Mean		Std.Dev		T-test
	C	T	C	T	C	T	T/C
BASELINE							
Uptake of any type of insurance	292	212	1	1.91	0	1.38	-0.91***
Uptake of crop insurance	292	212	1.16	1.89	0.58	1.28	-0.73***
WII uptake experience (# years)	292	212	0	0.58	0	1.16	-0.58***
Knowledge of crop insurance	35	99	0.11	0.33	0.32	0.47	-0.22**
Correct understanding of WII	3	23	1	2.09	0	1.20	-1.09
MIDLINE							
Uptake of any type of insurance	292	212	1.09	2.05	0.52	1.43	-0.95***
Uptake of crop insurance	292	212	1.30	2.26	0.79	1.35	-0.96***
WII uptake experience (# years)	292	211	0.02	1.06	0.24	1.52	-1.04***
Knowledge of crop insurance	111	146	0.07	0.29	0.26	0.45	-0.22***
Correct understanding of WII	1	10	3	2.40	.	1.51	0.60
ENDLINE							
Uptake of any type of insurance	291	212	1.20	2.27	0.74	1.49	-1.08***
Uptake of crop insurance	291	212	1.92	2.58	1.27	1.31	-0.67***
WII uptake experience (# years)	291	211	0.12	1.10	0.56	1.63	-0.98***
Knowledge of crop insurance	185	180	0.12	0.26	0.32	0.44	-0.14**
Correct understanding of WII	10	19	2.70	2.11	1.25	1.24	0.59

Note: This table explores uptake and understanding of WII among farmers (under model 1)
Source: Authors.

9.5 Food Security

Both groups reported a decrease in food security from baseline to endline. Treatment groups have a slightly better food security status, even though the differences are generally not significant

The food consumption score (FCS) assesses household's dietary diversity and nutrient intake by calculating different specified food groups consumed and the frequency at which they were consumed during the past seven days. Meanwhile, the dietary diversity score provides insights into food consumption diversity with information from the previous day. Findings summarized in Table 17 show that the FCS decreased from baseline to endline for the two study groups. We observed differences between treatment and control group (in favor of the treatment group), but these are significant only during baseline. The same trends are also observed for the other food security indicators, which all decreased over time. It is also important to note that differences were statistically significant between treatment and control group for all food security indicators. However, these significant differences were no longer observed at midline and endline. Women are heavily affected, with their household diversity score dropping by 13 percent between midline and endline for each group.

Table 17: Food security indicators

	Obs		Mean		Std.Dev		T-test
	C	T	C	T	C	T	T/C
BASELINE							
Food score consumption	292	212	115.22	121.59	28.72	33.25	-6.37**
Internal Household Dietary Score	292	212	8.90	9.22	2.03	2.18	-0.32*
Dietary Diversity Score for men	292	212	8.48	8.87	2.22	2.40	-0.39*
Household Diversity Score women	292	212	8.46	8.89	2.24	2.37	-0.43**
MIDLINE							
Food score consumption	292	212	113.88	117.00	36.98	35.36	-3.12
Internal Household Dietary Score	292	212	8.37	8.69	2.63	2.53	-0.32
Dietary Diversity Score for men	292	212	7.87	8.24	2.96	2.73	-0.37
Household Diversity Score women	292	212	7.87	8.28	2.91	2.72	-0.41
ENDLINE							
Food score consumption	292	212	108.27	109.44	35.85	36.02	-1.17
Internal Household Dietary Score	292	212	8.20	8.55	2.31	2.71	-0.35
Dietary Diversity Score for men	292	212	6.76	7.28	3.35	3.38	-0.52*
Household Diversity Score women	292	212	6.80	7.21	3.37	3.41	-0.40

Note: This table provides food security metrics, including months of sufficiency and coping mechanisms (under model 1).
Source: Authors.

9.6 Estimating the endline impact

We assumed that the channel for impact as part of the provision of the bundle of insurance and credit includes two types of benefits: (1) a direct benefit from fully informed uptake of the insurance product bundled with the credit, and (2) indirect benefits that come from the additional security the insurance products bring in the agricultural loans supply market and could lead to a better access to inputs for all producers affiliated with organizations proposing crop insurance.

9.6.1 Estimating the potential indirect benefit

We first evaluate the potential indirect benefits that may come from access to the bundled service from an aggregator that provides the WII product combined with agricultural input credit. For that, we consider all farmers affiliated with both COOPEC and CCPA FO who have declared themselves insured, no matter whether they have effectively (or think they have effectively) purchased the insurance product or not, and compare them with the farmers in the control group. We call this the impact of access to the bundle of services. Results of the matched double difference that follows our identification methodology and analysis plan revised at endline are presented in the Table 18.

A total of 154 farmers surveyed during each round of survey (baseline, midline, and endline) are considered for the treatment group (farmers insured at least once during the period of the study). For the control group, 201 farmers were considered. These are farmers who have reported to have not purchased WII during any of the crop seasons. The first column of Table 18 present the list of the indicators for which we have performed the calculation of the double differences. The baseline differences (D1) are presented in column 2, the midline differences (D2) are in column 3, and the endline differences (D3) in column 4. Regarding the impact, the midline double difference between baseline and midline (D2–D1) is presented in column 5, the double difference between midline and endline (D3–D2) in column 6, and the endline double difference between baseline and endline (D3–D1) in column 6.

No change is observed in the socioeconomic characteristics of the farmers in the treatment group, suggesting no effect of the bundle on farmers' well-being except for cooking energy, which very significantly increased between midline and endline (D3–D1). Indicator of exposition to shocks, coping strategies, and adoption of good practices reveals a negative trend in the progression of the production volume of main crops, groundnut, and millet when comparing baseline and midline. Interestingly, the trend increased at endline and was quite like its baseline level for most of the indicators related to shocks and adaptation strategies. For example, the midline positive effect on exposure to shocks that suggests that treated farmers faced more shocks between baseline and midline than the control group did not hold when comparing baseline to endline or midline to endline. Regarding changes in agricultural practices and adoption of new agricultural practices, we observed a significant decreasing trend when comparing baseline to midline and baseline to endline, suggesting less change in treated farmers' production habits during the study period than that of the control group.

Access to the bundle did not affect the number of farmers who reported access to formal or informal credit. No significant effect was found for these two indicators, at midline or endline. Indicator of membership in FO revealed a significant decrease in the number of farmers holding membership in these organizations. The decrease was significant between baseline and midline and baseline and endline. However, between midline and endline, the trend was still decreasing but at a lower rate and not at a statistically significant level. Access to the bundle for farmers holding membership in FOs seems also not to guarantee them better access to credit through those organizations. In fact, even though FOs in the treatment group provided credit to more farmers than FOs in the control group, the number of farmers who reported access to credit through their organization decreased significantly between baseline and midline. However, the access to credit through affiliated organization expanded after the midline (during endline), even though less so than at baseline. We observed the same trend when it comes to the amount of the loan received from the affiliated organization. During baseline, the difference between treatment and control groups was small but positive, suggesting that the treatment group was receiving more credit. However, at midline, we observed the opposite, with the control group declaring more credit on average. At endline, we observed a return to the baseline situation, with the treatment group reporting a higher amount than in baseline compared to the control group. However, no differences between baseline, midline, and endline were significant for credit received from affiliated FOs.

Regarding the uptake of insurance products in general, regardless of the type of product (i.e., health insurance, crop insurance, and car insurance), we could not find a significant change. When it comes to crop insurance, the difference between treatment and control groups, which was very significant during baseline and midline (76 and 88%), decreased a lot (36%) during endline, thus leading to a significant negative effect at endline. For knowledge of crop insurance and receiving information about it from affiliated FOs, we observed no significant difference between baseline to midline or endline.

For the progression of results of the agricultural seasons, we analyzed the data of the 2018 agricultural season for baseline, 2020 for midline, and 2021 agricultural growing season for endline. The results of the progression of agricultural indicators for these seasons are presented in the last section of the table. Overall, the performance of the indicators did not change, except for the volume of production consumed and donated between baseline and endline seasons. We noted significant positive progress in the volume of production consumed and donated of 214 and 89.8 kilograms, respectively between the first and the

last round of survey. It is worth noting that the government fixes selling prices for groundnut in Senegal. Therefore, it is not surprising that no difference was found in the trend of the treatment and the control group between the survey periods when it comes to selling prices.

Table 18: Results of the matched difference-in-differences: impact of the bundle

	Baseline difference (D1)	Midline difference (D2)	Endline difference (D3)	Baseline/ Midline difference (D2-D1)	Midline/ Endline difference (D3-D1)	Baseline/ Endline difference (D3-D1)
SOCIOECONOMIC CHARACTERISTICS						
Number of children under 5 years	-0.39	-0.53	-0.30	-0.14	0.23	0.09
Size of the household	-1.04	-0.49	-0.60	0.55	-0.11	0.44
Dwelling floor material	-0.04	-0.08	0.02	-0.03	0.10	0.06
Dwelling roof material	0	0.07	0.01	0.07	-0.06	0.01
Dwelling wall material	-0.01	-0.01	0.12	0.00	0.14	0.14
Cooking energy	-0.02	-0.20	0.15	-0.19	0.35***	0.17
Households' assets	-0.13	0.02	-0.11	0.15	-0.13	0.02
Owned land	0.26	-0.01	0.04	-0.27*	0.05	-0.22
TLU	0.53	-0.56	0.28	-1.09	0.84	-0.25
SHOCKS, COPING, AND ADOPTION OF GOOD PRACTICES						
Progress of prod. of groundnut	0.26	-0.27	0.25	-0.53***	0.52**	0.00
Progress of prod. of millet	0.33	-0.20	0.11	-0.53**	0.31	-0.22
Progress of prod. of maize	-0.15	-0.32	-0.12	-0.16	0.20	0.03
Months of grain cover	0.94	0.51	0.42	-0.43	-0.09	-0.51
Exposure to shocks	-0.14	0.19	0.01	0.34***	-0.19	0.15
Length of the lean period	-0.28	-0.05	-0.19	0.23	-0.14	0.09
Coping for food shocks	-0.03	-0.11	0.07	-0.09	0.18	0.10
General coping strategies	0.15	0.05	0.15	-0.10	0.10	0.00
Changes in practices	0.34	-0.04	-0.03	-0.39**	0.01	-0.37**
Adoption of good practices	0.19	0	0.04	-0.19	0.04	-0.15
ACCESS TO CREDIT AND MEMBERSHIP IN FOs						
Any formal loan	0.12	0.20	0.13	0.08	-0.07	0.01
Any formal agri loan	0.06	0.09	0.06	0.03	-0.03	0.00
Any informal agri loan	0.05	-0.04	0	-0.09	0.04	-0.05
Membership in FOs	0.72	0.54	0.46	-0.18***	-0.08	-0.26***
Any agri loan from FOs	0.31	0	0.13	-0.31**	0.13	-0.18
Amount of agri loan FOs	6843.35	-16949.33	86454.55	-23792.68	103403.88	79611.20
EXPERIENCE AND UPTAKE OF INSURANCE						
Any type of insurance	0.87	0.96	1.03	0.09	0.07	0.16
Crop insurance (WII)	0.76	0.88	0.39	0.12	-0.49***	-0.37**
Knowledge of crop insurance	0	0	0.16	0.00	0.16	0.16
Receive info about WII from FOs	0.08	0.33	0.33	0.24*	0.01	0.25*
FOOD SECURITY						
Food score consumption	5.85	1.91	1.37	-3.94	-0.53	-4.47
Internal Household Dietary Score	0.44	0.14	0.39	-0.30	0.25	-0.05
Dietary Diversity Score for men	0.44	0.10	0.33	-0.34	0.24	-0.11
Household Diversity Score women	0.51	0.03	0.22	-0.48*	0.19	-0.29
AGRICULTURAL PRODUCTION						
Value of seeds	12691.34	29557.53	20804.27	16866.19	-8753.26	8112.93
Value of fertilizers	10885	636.99	10076.53	-10248.01	9439.54	-808.47
Value of other inputs	8024.29	-2728.89	-1976.47	-10753.17	752.42	-10000.76

	Baseline difference (D1)	Midline difference (D2)	Endline difference (D3)	Baseline/ Midline difference (D2-D1)	Midline/ Endline difference (D3-D1)	Baseline/ Endline difference (D3-D1)
Total value of inputs	34800.63	26316.20	30411.55	-8484.43	4095.34	-4389.09
Area cultivated	0.13	1.09	0.21	0.96	-0.89	0.08
Investment per ha	8951.74	7871.54	4094.51	-1080.20	-3777.03	-4857.23
Production volume	252.23	223.67	508.89	-28.56	285.22	256.66
Production sold	221.89	253.55	110.57	31.66	-142.98	-111.32
Price for most sales	-4.03	-2.09	4.47	1.94	6.56	8.50
Consumed production	-31.45	1.11	182.57	32.56	181.46**	214.02***
Donated production	-25.35	-15.71	64.46	9.63	80.17*	89.80***
Income (as declared)	48509.84	71229.65	28132.11	22719.81	-43097.54	-20377.73
Sales value	38607.34	76836.34	36836.80	38229.00	-39999.54	-1770.54
Donations' value	1283.75	-3600	36310.14	-4883.75	39910.14	35026.39
Consumed value	-11274.7	-1221.95	72950.50	10052.75	74172.4**	84225.2**
Total prod. value	87757.33	71331.40	202380.5	-16425.94	131049.10	114623.16
Net income	9825.48	39098.82	168036.9	29273.34	128938.06	158211.40

Note: This table estimates the impact of bundling insurance and credit on agricultural investments and household well-being. Results align with Model 1, assessing indirect benefits for all insured farmers (A, B, C1, C2).
Source: Authors.

9.6.2 Estimating the potential direct benefit of an informed uptake

We assume that it makes no difference to farmers' behavior whether they only believe that they have crop insurance or are insured. In the same way, farmers who believe that they are not insured will not take insurance into account in their decisions, even if they are insured but unaware of that fact. Based on these two assumptions, we consider all farmers who reported that they believe they had been insured (at least once during the four years of observation between baseline and endline) to estimate the potential direct benefit of WII coverage. Results of the progression of agricultural performance for these types of farmers in both the mandatory and voluntary group are presented in Table 19.

A total of 53 farmers surveyed during each round of the survey (baseline, midline, and endline) were considered for the treatment group (farmers insured at least once during the period of the study). For the control group, 163 farmers were considered. As in the case of estimating the potential indirect benefits, socioeconomic characteristics of farmers who reported they had been insured at least once between the baseline and the midline did not change much, except for the indicator of cooking energy. Like in estimating the direct benefit in Table 18 above, we notice a significant increase between midline and endline, suggesting that more households shifted to improved cooking energy than in the control group.

Regarding how farmers appreciated the progress of the production level for the main crop they grow, as in estimating potential indirect benefits, we have considered levels of production of the 2018 agricultural season for baseline, 2020 for midline, and 2021 agricultural season for endline. There was a positive difference or no difference between treatment and control groups during the baseline for the three main crops grown, while during midline, the same differences were all negative before becoming positive again during endline. This suggests that during the initial year of the COVID-19 pandemic (2020), the production for the main crops was lower than the previous year (2019), while the baseline harvest and endline harvest were positively assessed compared to their preceding years. Overall, the baseline/endline difference was not significant. A significant change could only be observed when comparing

baseline and midline results for the progress of millet production (significant decrease); midline and endline results for the production for the same crop (significant increase); or midline endline results for the production of groundnut (significant increase).

For the level of exposure to shocks and the duration of the lean period, we noted a significant increase between baseline and midline, suggesting that during midline, compared to the control farmers, the treated farmers were exposed to more shocks and experienced difficulties to get food for their households during a longer period than at baseline. Considering changes in agricultural practices and adoption of new agricultural practices, we noted almost the same changes in estimating the indirect benefit as when comparing baseline and endline or midline and endline data for direct benefit estimates. Between baseline and endline, there is a significant decrease in the number of actual changes the farmers in the treatment group reported compared to the control group.

No difference is observed between all treatment and control groups when it comes to direct loans (agricultural or not, formal or informal). For the two indicators measuring membership in FOs and agricultural loans accessed through these organizations, we saw a significant decrease when comparing baseline to midline and when comparing baseline to endline, thus confirming the results shown in Table 18.

However, we also noted an increase during endline, after the decrease at midline, for the indicator of access to credit through the affiliated FO, which could mean a post COVID-19 recovery. More interestingly, there is a significant difference, although at a 10-precent significance level only, between the amount of credit the treatment group reported to have received from their affiliated FOs and the amount farmers in the control group affiliated with FOs reported. We noticed an important increase, which was 19 times larger between baseline and endline in favor of the treatment group.

We observed a small increasing trend for the indicator of insurance uptake, considering all types of insurance products (car insurance, crop insurance, or health insurance). Regarding informed uptake of crop insurance or WII, there is a significant decrease between baseline and endline, confirming also the results obtained in estimating the indirect effects. However, this is observed in the context of increasing access to information about index-based insurance for the farmers of the treatment group since the baseline survey.

For food consumption score, we noticed no significant change during the period of assessment due to access to the bundle. We can say the same about the outcomes of the agricultural seasons. No clear change was observed in key outcomes such as level of investment and production volume or value. Only the volume of production consumed and donated between baseline and endline seasons changed, as in the case of the indirect results. At endline, we noted significant positive progress of the volume of production consumed and donated of 216 and 77 kilograms, respectively. We observed a similar positive effect on net income with a positive difference at midline, which becomes even higher at endline, resulting in a significant increase, albeit at a 10-percent significance level only. This means that farmers who have access to the bundle and are aware of being insured may end up with more net income. We specify that the net income is a calculated value, which subtracts the total value of the input of the season from the value of the production (whether it is sold effectively or not).

Table 19: Results of the matched difference-in-differences: impact of informed uptake of crop insurance, namely WII

	Baseline difference (D1)	Midline difference (D2)	Endline difference (D3)	Baseline/ Midline difference (D2-D1)	Midline/ Endline difference (D3-D1)	Baseline/ Endline difference (D3-D1)
SOCIOECONOMIC CHARACTERISTICS						
Number of children under 5	-0.36	-0.56	-0.15	-0.20	0.42	0.22
Size of the household	-0.70	-0.58	-0.52	0.12	0.06	0.18
Dwelling floor material	-0.04	-0.12	0.04	-0.07	0.16	0.09
Dwelling roof material	-0.02	0.09	0.04	0.11*	-0.06	0.06
Dwelling wall material	-0.04	-0.13	-0.01	-0.09	0.12	0.03
Cooking energy	-0.02	-0.29	0.13	-0.27*	0.42***	0.15
Households' assets	-0.09	0.06	-0.11	0.15	-0.17	-0.02
Owned land	0.27	0.02	0.11	-0.25	0.09	-0.16
TLU	0.87	-0.37	0.79	-1.24	1.15	-0.09
SHOCKS, COPING, AND ADOPTION OF GOOD PRACTICES						
Progress of prod of groundnut	0.06	-0.26	0.24	-0.32	0.50**	0.18
Progress of prod of millet	0.24	-0.30	0.16	-0.54**	0.45**	-0.09
Progress of prod of maize	0	-0.39	-0.08	-0.39	0.31	-0.08
Months of cereal cover	0.71	0.29	0.39	-0.42	0.10	-0.32
Exposure to shocks	-0.11	0.16	-0.01	0.27**	-0.17	0.10
Length of the lean period	-0.33	0.01	-0.23	0.34**	-0.24	0.10
Coping for food shocks	0.08	-0.23	-0.02	-0.31	0.21	-0.10
General coping strategies	0.13	0.07	0.17	-0.06	0.11	0.04
Changes in practices	0.28	-0.02	-0.09	-0.30	-0.07	-0.37**
Adoption of good practices	0.15	0.07	0.04	-0.07	-0.04	-0.11
ACCESS TO CREDIT AND MEMBERSHIP IN FOs						
Any formal loan	0.16	0.17	0.14	0.01	-0.02	-0.01
Any formal agri loan	0.09	0.08	0.07	-0.01	-0.01	-0.02
Any informal agri loan	0.03	-0.05	0.03	-0.08	0.08	-0.01
Membership in FOs	0.75	0.57	0.48	-0.19***	-0.08	-0.27***
Any Agri loan from FOs	0.22	-0.11	0.18	-0.33*	0.28	-0.04
Amount of Agri loan FOs	6085.44	-47866.67	121562.5	-53952.1	169429.2*	115477.1*

	Baseline difference (D1)	Midline difference (D2)	Endline difference (D3)	Baseline/ Midline difference (D2-D1)	Midline/ Endline difference (D3-D1)	Baseline/ Endline difference (D3-D1)
EXPERIENCE AND UPTAKE OF INSURANCE						
Any type of insurance	0.84	0.84	1.14	0.00	0.30*	0.30*
Crop insurance (WII)	0.78	0.86	0.45	0.08	-0.42**	-0.34**
Knowledge of crop insurance	0	0	0.14	0.00	0.14	0.14
Receive info about WII from FOs	0.11	0.42	0.39	0.31**	-0.03	0.28*
FOOD SECURITY						
Food score consumption	7.01	4.07	1.36	-2.93	-2.71	-5.64
Internal Household Dietary Score	0.46	0.18	0.43	-0.28	0.24	-0.03
Dietary Diversity Score for men	0.37	0.19	0.27	-0.18	0.07	-0.11
Household Diversity Score women	0.39	0.10	0.16	-0.29	0.06	-0.23
AGRICULTURAL PRODUCTION						
Value of seeds	11992.34	34727.56	23115.37	22735.22	-11612.19	11123.03
Value of fertilizers	10385.82	301.72	12883.75	-10084.10	12582.03	2497.93
Value of other inputs	6570.54	-4585.71	-100	-11156.25	4485.71	-6670.54
Total value of inputs	30852.05	30224.16	33967.63	-627.89	3743.47	3115.58
Area cultivated	0.10	0.19	0.26	0.09	0.06	0.15
Investment per ha	9219.68	11300.07	2571.53	2080.38	-8728.53	-6648.15
Production volume	197.42	284.66	604.57	87.24	319.92	407.15
Production sold	188.15	263.73	96.25	75.59	-167.48	-91.90
Price for most sales	-4.68	-4.72	4.85	-0.04	9.57*	9.53
Consumed production	-17.81	44.67	198.66	62.47	153.99	216.47**
Donated production	-14.47	-20.87	62.94	-6.40	83.81	77.41*
Income (as declared)	39273.23	71978.87	15893	32705.64	-56085.87	-23380.23
Sales value	31672.55	78692.61	33606.76	47020.05	-45085.85	1934.21
Donations' value	1335.94	-5325	42902.30	-6660.94	48227.30	41566.37
Consumed value	-6726.43	8547.14	81096.22	15273.57	72549.07*	87822.6**
Total prod. value	92559.8	84380.3	252495.5	-8179.5	168115.3	159935.7
Net income	17371.3	50284.5	210936.0	32913.2	160651.5	193564.7*

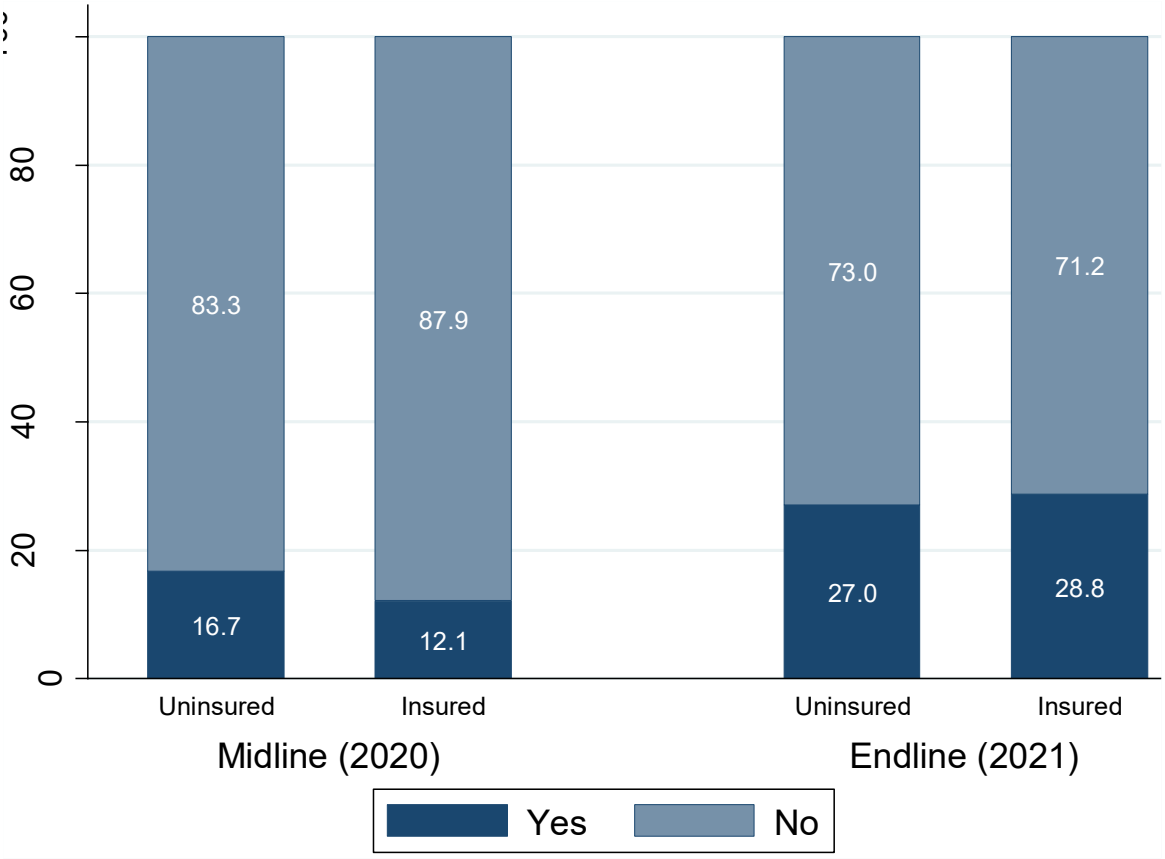
Note: This table evaluates the impact of informed WII uptake on agricultural and socioeconomic outcomes. Results focus on Model 2, which includes profiles A, C1, and C2.
Source: Authors.

9.6.3 The COVID-19 pandemic: knowledge, effects and responses

During the midline survey, in January 2021, all survey participants, regardless of the study group they belonged to, reported to have heard about the COVID-19 pandemic. The vast majority also stated that they were afraid of COVID-19 (about 82% in the treatment group and almost 84% in the control group). At the same time, during the midline survey, awareness of precautionary measures to prevent the spread of the disease seemed to be high—98 percent reported knowing about the standard measures to take to avoid contracting COVID-19.

Participants were also asked whether there were any difficulties COVID-19 caused that led them to reduce their household consumption. Figure 28 shows that 16.5 percent of farmers in the control group faced such difficulty during the midline survey, compared to 15.7 percent in the treatment group. In 2021, the endline survey revealed an increase in the number of farmers who reduced their household consumption and who attributed it to the COVID-19 pandemic—27 percent in the control group and 28.8 percent in the treatment group.

Figure 28: Reduction of household consumption due to the COVID-19 pandemic



Regarding access to agricultural inputs, the results are almost the same between midline and endline. About 40 percent of the control group farmers reported that they had faced difficulties in accessing seeds in 2020, and among them 33.5 percent thoughts this was because of the COVID-19 pandemic. In the treatment group, the percentage of farmers who reported having faced difficulties in accessing seeds in 2020 was around 34 percent, of which 43 percent attributed those difficulties to the COVID-19 pandemic. In 2021, during the endline survey, 32 percent of no-insured farmers reported difficulties accessing seeds and among them, 52 percent thought this was due to COVID-19. For the treatment group, the figures are higher, with about 42 percent reporting difficulties accessing seeds and 65 percent thinking this was due to COVID-19 (see Figure 29 and Figure 30).

Figure 29: Proportion of farmers with difficulties in accessing seeds in 2020

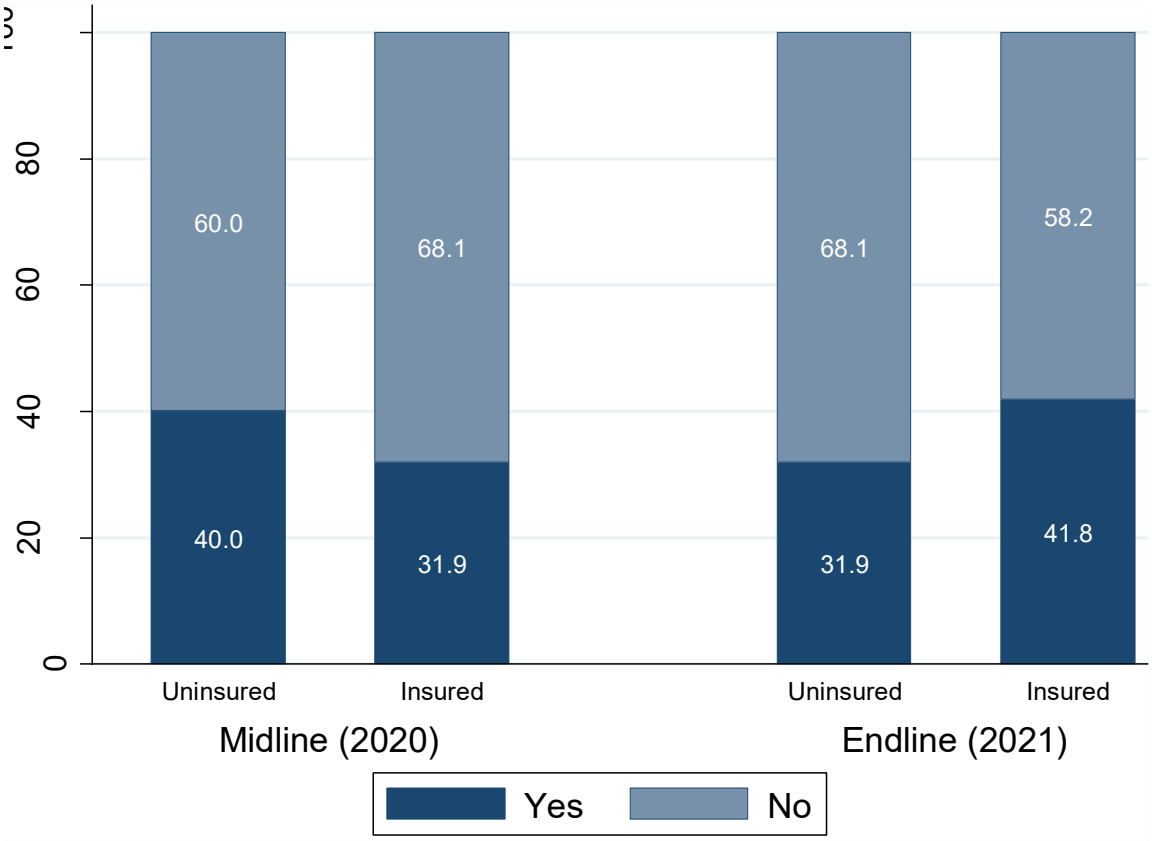
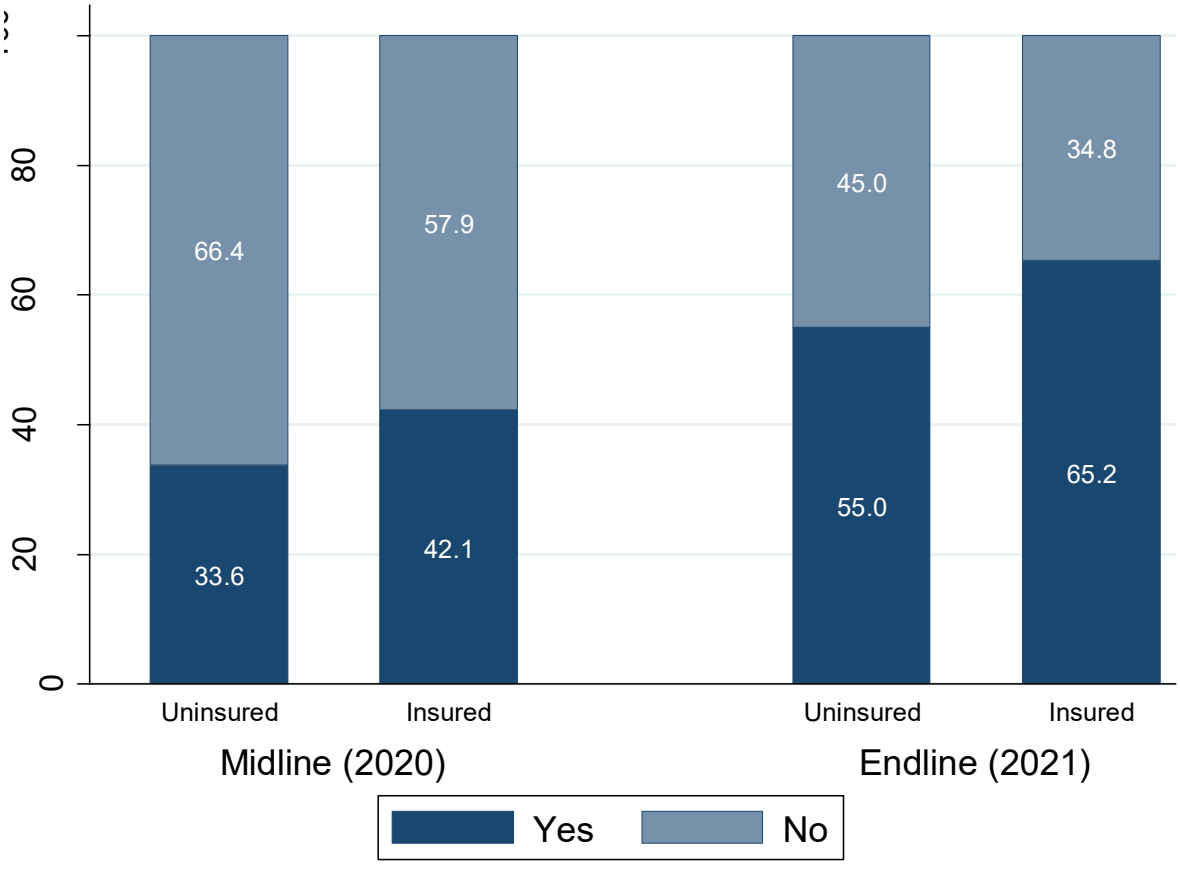


Figure 30: COVID-19 cited as a reason for difficulties in accessing seeds



Similarly, farmers faced difficulties in accessing fertilizer, in part due to the COVID-19 pandemic. In each group, about a third of farmers experienced such difficulties at midline in 2020, and about a quarter at endline (Figure 31). When interviewed at the midline, almost one-third of the farmers in the control group and the treatment group thought that this was due to COVID-19. For the endline survey, 57.6 and 74.6 percent of the farmers who declared facing difficulties in accessing fertilizers in the control group and the treatment group, respectively, attributed these challenges to COVID-19 (Figure 32).

Figure 31: Difficulties in accessing fertilizers

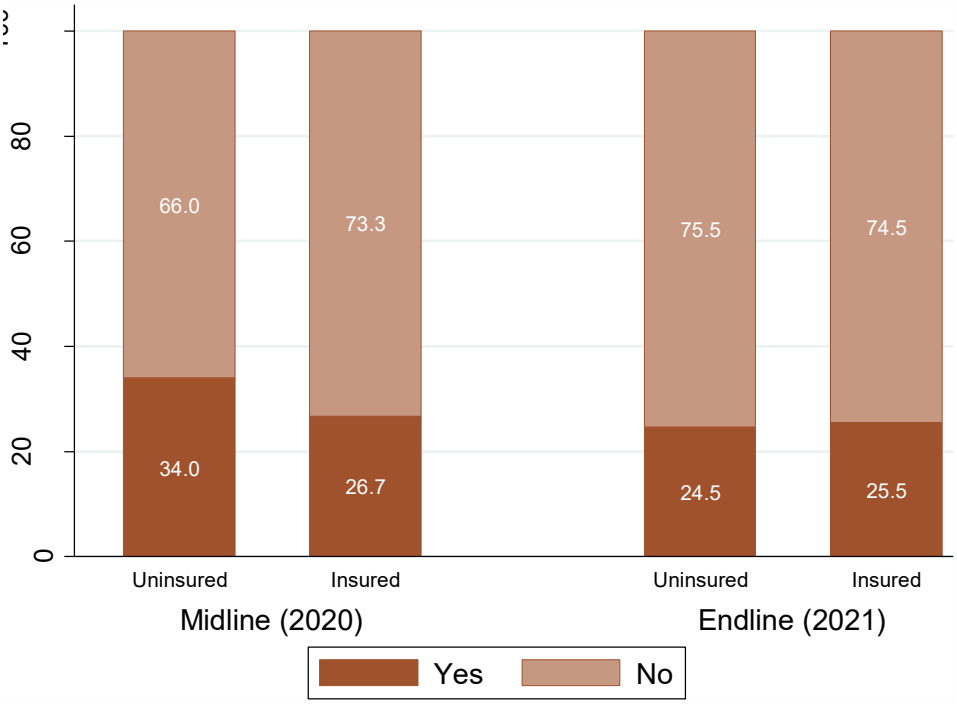
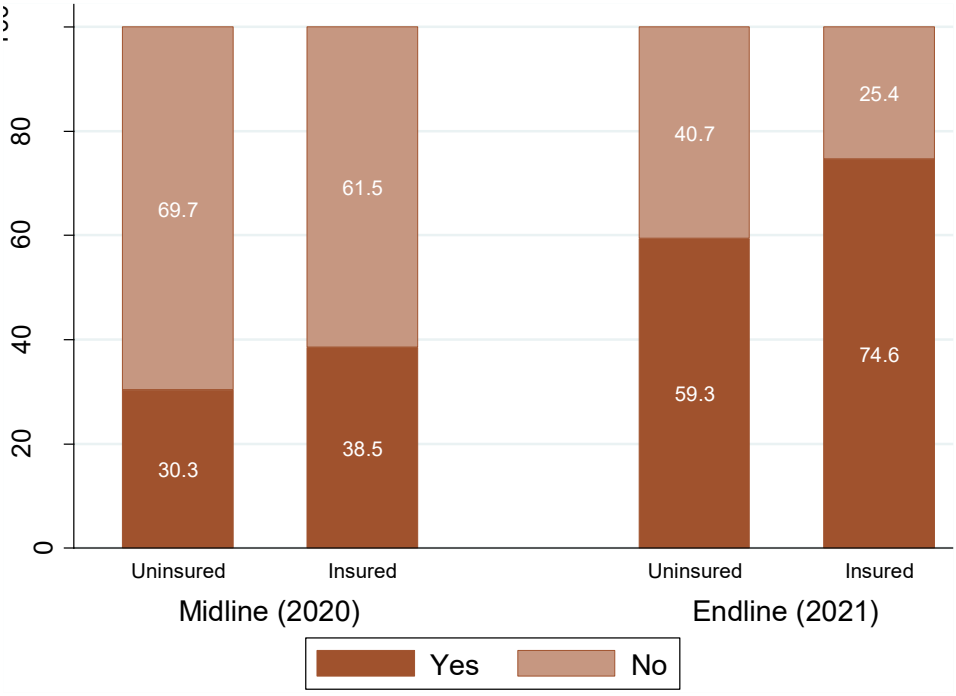
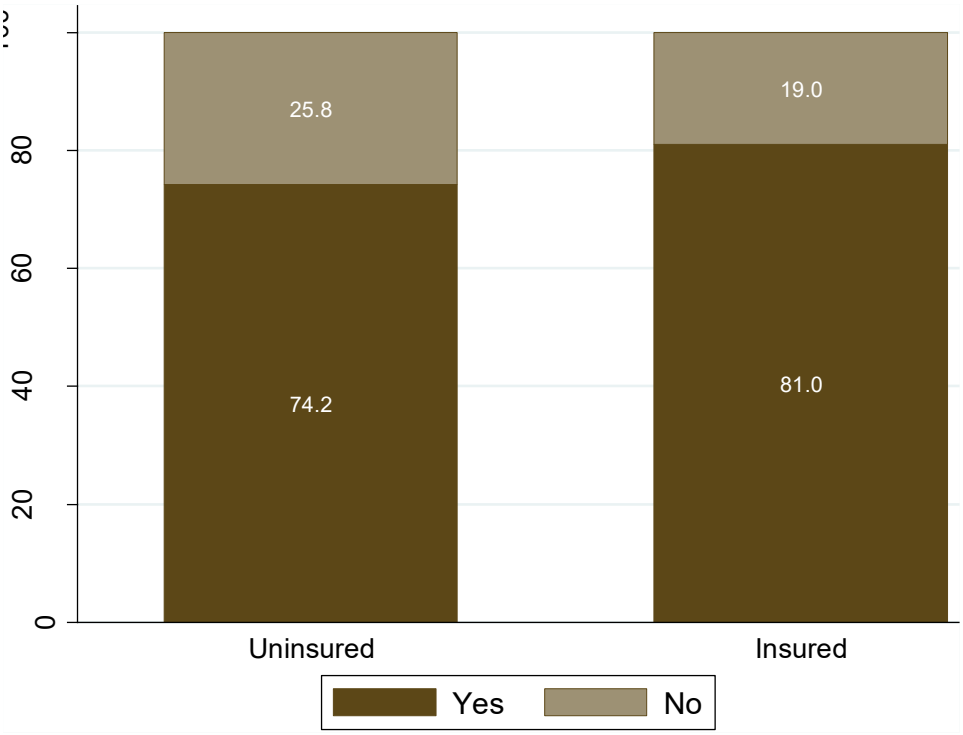


Figure 32:COVID-19 cited as a reason for difficulties in accessing fertilizers



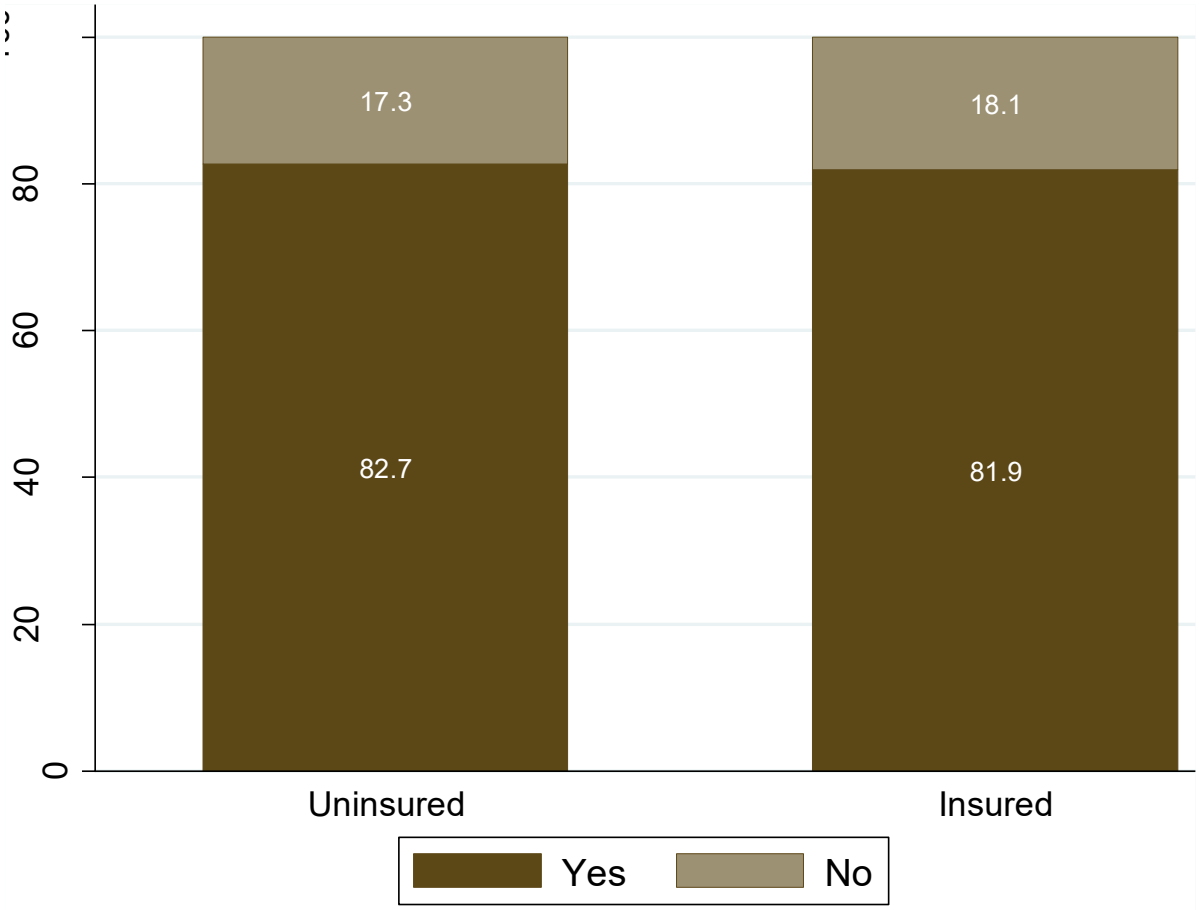
The difficulties farmers faced in accessing agricultural inputs may be explained by the closing of rural markets and lockdown as part of the COVID-19 restriction measures. From March 14 to May 12, 2020, the Senegalese government introduced social distancing measures to limit the spread of the virus in Senegal. Those measures included the closing of the rural weekly markets (so-called *Louma*) which are the most popular markets in rural areas of Senegal. Every year, at that period, the weekly markets are the place where farmers exchange a part of last year's production to have cash in their hands with which to buy food they do not produce, medicine, or other goods. It was expected that the closing of the *Loumas* would have a severe impact if it continued because the trade in livestock and agricultural products is an additional source of income during the lean season for many rural households. The participants in our study were not spared from this situation that affected the whole country. Figure 33 shows the percentage of farmers who reported that they had crop or livestock they could not sell due to the COVID-19 pandemic. A vast majority of the farmers in all groups—74.3 percent in the control group and almost 80 percent in the treatment group—reported having crop or livestock they could not sell.

Figure 33: Percentage of farmers with crop or livestock unsold due to COVID-19



Between 83 and 80 percent of the farmers in all groups (treatment and control) reported receiving support from the government or another organization to cope with the negative consequences of COVID-19 on their living standards (see Table 20 below). The Government of Senegal had put in place a large program of support for 1 million households in the country (more that 60% of the Senegalese population). The support targeted the poorest identified through the National Unique Registry, which combines community-based targeting and surveys to identify the poorest households in all areas of the country. In 2018, it included 588,673 households (Ndiaye et al. 2019) and has been expanded as part of the COVID-19 food distribution program to 1 million poor households. Because most poor households are in rural areas, our results seem to confirm receipt of the government's support by the population in our study area.

Figure 34: Any COVID-19 support received from government, NGOs, associations, etc.



To assess whether there were differences in the extent to which COVID-19 affected the treatment and control groups, Table 20 presents the results from a test. In general, COVID-19 seems to have had similar consequences on the different groups, except for the percentage of farmers who have had difficulties in accessing seeds and fertilizers due to COVID-19, which were higher in the treatment group than the control. This difference was exacerbated in the endline. A more significant number of farmers in the treatment group had difficulties accessing seeds or fertilizers and thought this was due to COVID-19 than in the control group.

Even though this difference is not very large, it may counteract parts of a potential positive effect that insurance may have had on investment behavior. This would be the case if farmers in the treatment group who wanted to increase their agricultural activities because they had obtained insurance coverage were unable to do so because they struggled to access seeds and fertilizer due to the pandemic.

Table 20: Insights on the effects of the COVID-19 pandemics

	Obs		Mean		Ttest
	C	T	C	T	T/C
Midline					
Being afraid of COVID-19	369	230	0.84	0.83	-0.01
Crop/livestock unsold due to COVID-19	369	230	0.74	0.80	0.05
Consumption reduced due to COVID-19	369	230	0.17	0.16	-0.01
Difficulties in accessing seeds	369	230	0.40	0.34	-0.06
- COVID-19 cited as reason	221	148	0.33	0.43	0.10*
Difficulties in accessing fertilizers	369	230	0.34	0.30	-0.04
- COVID-19 cited as reason	239	153	0.30	0.39	0.09*
COVID-19 support from Gov, NGO, etc.	369	230	0.83	0.80	-0.02
Endline					
Consumption reduced due to COVID-19	201	153	0.27	0.29	0.01
Difficulties in accessing seeds	201	153	0.32	0.42	0.09*
- COVID-19 cited as reason	136	89	0.52	0.65	0.13*
Difficulties in accessing fertilizers	201	153	0.25	0.25	0.01
- COVID-19 cited as reason	151	114	0.58	0.75	0.17***

Note: This table highlights the effects of the COVID-19 pandemic on access to credit, inputs, and practices. While not explicitly linked to Models 1 or 2, it contextualizes challenges faced by all farmer profiles (A, B, C1, C2).
Source: Authors.

10. Discussion of findings and lessons learned

10.1 Verification of the theory of change and its underlying assumptions

Hypothesis 1: Voluntary incentivized bundling of insurance and credit increases its informed uptake (not verified).
In terms of informed uptake or understanding of WII, midline results showed no specific advantage of voluntary bundling of insurance and credit compared to mandatory bundling (see midline report). Therefore, offering insurance as a voluntary add-on to credit, rather than as part of a bundle where insurance is mandatory for those taking out credit, seems insufficient to increase informed uptake of insurance.

For the endline, we could not verify this hypothesis due to the shift in the policy of FOs that had, in the past, offered voluntary bundling, then in 2021, switched to mandatory bundling.

After pooling voluntary and mandatory bundling, there was a significant decrease in the number of farmers reporting uptake of the product at midline and when the insurance became mandatory, during endline for the voluntary group, the same significant decreasing trend was evident.

Overall, assessment of the bundle's impact on uptake reveals a significant decrease between baseline and endline, with more people reporting no uptake of crop insurance, even though some of them may be insured without knowing it (Table 18). Table 19, which estimates the impact for farmers who reported being insured (i.e., who either knew they were insured or thought they had been insured even though they were not) also shows an important decrease in the treatment group's score of uptake of crop insurance between baseline and midline compared to the control group.

From the FGDs, it seemed that people were increasingly frustrated by the lack of communication and visibility of the insurance company. Several COOPEC farmers mentioned having opted out after a few initial seasons of taking out insurance coverage when the product had first been introduced (while it was still a voluntary add-on to credit).

Hypothesis 2: Informed and desired uptake of WII (i.e., when it is voluntary) stimulates adoption of higher level of investments, technology adoption, and improvements in agricultural practice in the long term through applications for higher amounts of credit (not verified).

Our midline findings have also shown no significant difference in the level of investment per hectare between farmers in the voluntary and those in the control group, in any of the different agricultural seasons considered from baseline to midline. Only the mandatory group had a significantly higher level of investment per hectare than the control group for all seasons. However, no significant changes are found in terms of investment per hectare either of the two groups between baseline and midline seasons. In both models considered, a significant decrease in the category of farmers who declared the highest number of changes to their existing agricultural practices was noted in the voluntary group at baseline. This suggests that the voluntary group returned to old agricultural practices between baseline and midline, even with access to the bundle and regardless of whether farmers were aware that they had been insured or not.

In the different FGDs organized during the midline and endline with COOPEC and CCPA farmers (men and women), there was a general sentiment that insurance did not actually help when in difficulty, so it was not a reason to change behavior in production decisions.

> Insurance does not seem to influence people’s decision in most cases, it is only perceived as increasing costs. — COOPEC, male member

While some COOPEC female respondents voiced similar concerns around insurance not influencing their decisions, or them not understanding the value of insurance, several mentioned increasing the amounts of fertilizers and seeds as a result of insurance coverage, because it allows them to transfer some risk and is perceived to facilitate access to credit.

> Because the insurance serves us as a guarantee, I also use more fertilizers and seeds. — (COOPEC, female member)

Interestingly, several people mentioned taking more risks when first obtaining insurance, but then reverting to their previous investment behavior. In some cases, this was the result of experiences people had, where they thought the insurance should have paid out, but it did not (or they did not realize that it had paid out).

> At my level, I had taken more risks in the first year, when I was told about the benefits of insurance, but I did not continue. During this season, I had taken out credit for fertilizers and agricultural equipment. Unfortunately, the rains were not sufficient, and my harvest was not profitable. Insurance hadn't done anything for me, however. To be honest, I don't understand how insurance works. — COOPEC, male member

The endline results confirmed these midline findings, regardless of the bundling modality, when insurance was proposed as a condition for accessing credit.

In sum, insurance is largely not perceived as a sufficient risk management strategy to support increased investment in seasonal agriculture. Some people had initially increased investments, after they first obtained insurance coverage, but over time, many of them have lost trust in the insurance product supplying a reliable protection of such investment. Others did not see insurance as a reason to increase investments from the start, viewing the product as unreliable or not beneficial to them. During FGDs, participants often mentioned people not having witnessed any payouts and, therefore, not seeing a reason to change how much they cultivate and invest at the start of the agricultural season.

Hypothesis 3: Mandatory bundling of index-insurance and credit leads to an increase in uninformed and undesired uptake (verified).
The uptake of crop insurance decreased between baseline and midline survey in all groups (mandatory bundling, voluntary bundling, and control) and between baseline, midline, and endline when comparing treatment (regardless of the type of bundling) and control groups. This suggests a low renewal rate of crop insurance and aligns with the decreasing percentage of farmers holding membership in FOs, considering that membership is one of the main channels for accessing crop insurance.

No significant change was observed in the level of treatment group's knowledge compared to the control group at midline and endline. In addition, among those who reported being insured, in the treatment group, there was a large positive increase in the percentage of farmers who had received information about WII from their FO between baseline and endline (see Table 18 and Table 19). This means that FOs contributed to the education of their members, especially in the group of farmers who were aware they had been insured compared to those in the control group. However, between midline and endline, and coinciding with the generalization of mandatory insurance in the COOPEC FO, we no longer observed this increasing trend for the indicator of access to information on crop insurance from FOs.

Despite the increase in the percentage of farmers reporting that they knew the crop insurance and the growing share of those who said they knew it through their FOs, it is difficult to say whether their understanding was correct. This is highlighted in Figure 24, under the source of crop insurance knowledge, which shows a decrease in the number of famers reporting their FOs as source of information about crop insurance and who in turn, rely more on informal sources of information such as friends, families, or other unspecified sources. This is also reflected in the confusion among farmers about their insurance status and understanding, which was evident from the percentage of farmers reporting that they had been insured during the 2020 season, while in fact, they had not been insured through their FOs. Further evidence of the decrease in the level of knowledge is the significant positive score of correct understanding of WII (by farmers who declared knowing about WII and how it works) during baseline, which decreased drastically during midline and endline.

FGDs also confirmed the quantitative findings about the decrease in knowledge and understanding among the insured group. At midline, in the CCPA group, there were again farmers describing that they did not realize they had been insured, but were then asked to repay insurance premiums as part of repaying their loans for other inputs, which in some cases, they were initially unable to do or were unaware of the obligation.

At least in part, the lack of confidence in insurance as a risk management strategy (see discussion on hypothesis 3 above) also seems to have been reinforced by a limited or wrong understanding of contract conditions and the resulting unjustified expectations about when the policy would pay out.

During the endline FGDs—when both FOs implemented mandatory bundling—there were frequent mentions that insurance should pay out when the harvest fails, but not much evidence of a more detailed understanding of payouts depending on rainfall deficit (with the exception of a few individuals) or about how payout triggers are linked to rainfall during different plant maturity stages.

> The insurance people said that if we cultivated and the harvests were not good, they would compensate us. But we have not seen this promised assistance. — Female respondent, CCPA

> Index insurance is different from other types of insurance. Some farmers were trained and supposed to share the information with others at the base. But certain people here think that insurance must compensate each time there is a bad harvest. So, the main problem is related to communication, so that we know the conditions and criteria for pay outs. — Female respondent, CCPA

Hypothesis 4: Uninformed and undesired uptake as a result of mandatory bundling of insurance with credit does not increase the level of agricultural investment, stimulate technology adoption, or improve agricultural practices (verified).
Although the mandatory group had the highest level of investment in all baseline and midline seasons compared to the other groups, these significant positive differences did not change over time and hence, could not be attributed to the intervention. As verified under hypothesis 3, in the mandatory building group, uptake seemed to be less informed than in other groups. However, we observed no change in the level of agricultural investment, adoption of new agricultural practices, or changes in agricultural practices in any of the treatment groups. Endline results confirm this and do not show a difference between the insured and uninsured, and thus across the different crop seasons since baseline. Therefore, we could not affirm that the uninformed, and potentially undesired, uptake due to mandatory bundling of insurance and credit has any influence on the levels of agricultural investment, technology adoption, or improvement of agricultural practices.

During FGDs, some male CCPA members highlighted increased risk-taking potential related to insurance and mentioned having done this (e.g., cultivating additional crops), but many seemed to have lost confidence because they had not received payouts although they had experienced difficulties (see also discussion of results under hypothesis 2 above). This was Farmers from both CCPA and COOPEC confirmed this during endline FGDs.

Lack of influence of insurance on investment behavior appears to be in part related to an incomplete understanding of what the insurance actually covers—for instance, people were not speaking about rainfall deficit, but more broadly, about assistance in the event of difficulties related to the rainy season or an expectance of payouts in the case of flooding, which is not actually covered under the WII insurance policy provided through COOPEC and CCPA in the context of this study.

> … [T]his year, my field was completely devastated by the floods, and I notified the insurer. They had promised to send an agent to come and see and how to compensate me, but since then, I have not seen any insurance agent and so far, nothing. — CCPA, male member

> To tell the truth, the hopes evoked by insurance, which had prompted us to invest more, are disappointed [sic]. We no longer have trust. — CCPA, male member

Hypothesis 5: Mandatory bundling of index-insurance and credit can be perceived as positive and have positive effects on the agricultural activities of producers, if it is accompanied by a clear understanding of the role risk transfer has in the insurance product (N/A).

As shown in Table 16 on declared uptake and understanding of WII insurance, the percentage of farmers who reported to know and understand the functioning of WII was higher in the treatment group than in the control group in each of the surveys. However, after matching between treatment and control, we could not confirm these differences (see Table 18 and Table 19). Therefore, the percentage of farmers who reported to know and understand the WII product in the treatment group did not significantly change relative to the changes in the control group during the different crop seasons considered in the study. Because reporting of knowledge and understanding of the WII product is subjective, we introduced an objective indicator of correct knowledge based on a set of yes-or-no questions farmers were asked in each survey round. Table 16 shows no significant difference between farmers in treatment and control groups who reported to know about and understand the WII product when it comes to their actual correct understanding determined based on the factual, yes-or-no questions. However, after matching, because the percentage of farmers who reported to know about and understand the functioning of the product was low, we could not calculate the effect the bundle may have had on the progress of the indicator of correct understanding.

In addition, the results of model 2, which includes only farmers who reported uptake of the insurance product as add-on to their agricultural credit, we note no significant change in any of their agricultural baseline indicators at midline. Consequently, we could not confirm hypothesis 5, not because we did not find any impact, but because the number of farmers understanding the functioning of WII was insufficient for conducting the analysis.

Hypothesis 6: High-risk, high-return investment options, if adopted by the farmers who reported being insured, will lead to increased income and improved living conditions (verified).

We observed no difference in the trend pertaining to the level of insured farmers' investment compared to the control farmers during all agricultural seasons considered. The area of land cultivated and the level of investment per hectare, for example, were higher in the treatment group during all the seasons, but the difference decreasing across the season, although not significantly. When it comes to production volume, we noted no difference when comparing the progress of the treatment group's results from baseline to endline.

However, we noticed an increasing trend when considering the results of the farmers who reported at least once to be aware that they had been insured. This led to an increase in the volume of the treatment group's production consumed and donated compared to the control group. Besides, when considering the value of the total production volume and subtracting

the value of the total inputs, we find a significant (though at 10% only) increase in the net income of the treatment group compared to the control group between baseline and endline.

This positive change in the net income could be explained by the area of land cultivated, which also increased positively between baseline and endline, in the treatment group compared to the control group. Simultaneously, for the same agricultural seasons considered, the area of land cultivated in the treatment group structurally decreased. These results could be interpreted as an investment strategy in the treatment group, which consists of investing less in agricultural input per hectare while increasing the area of land cultivated to generate a decent volume of production and net incomes.

High-risk, high-return investment options in inputs exclusively, if adopted by farmers like it seems to be the case in the treatment group compared to the control group, do not necessarily result in an increase of income or improved living conditions among farmers who do not know that they are insured (model 1).

However, we determined that the group of farmers who reported to be insured and managed to combine modest investment level in agricultural inputs with increased area of land cultivated did end up with the highest return (net income). If increasing cultivated land is considered a high-risk, high-return investment, then the hypothesis 6 is confirmed for the group of farmers who reported being insured.

Hypothesis 7: Indemnifications received after a harvest loss enable farmers to avoid debt, payment default, and indirect losses in the long run (N/A).
Our interviews with the representatives of the two FOs revealed that there were no payouts for COOPEC during the three years of effective coverage of their members, while CCPA, for the 2019 season, did receive payouts of CFA 20.5M (USD 35,000) in total. The organization estimated that the payout was low and contested the amount. Eventually, after a long period of negotiation with the insurer, they received an additional payment of CFA 2.05M (USD 3,500). However, in different rounds of surveys, we asked about the farmers' experience with payouts, and at baseline, only 10 farmers in the treatment group (3 farmers in the voluntary group and 7 farmers in the mandatory group) stated that they had received a payout from their crop insurance coverage. At midline, these figures were still low, with only 16 farmers reporting to have received a payout in the treatment group and none in the control group. Finally, in the endline survey, only 5 farmers in the treatment group and 1 farmer in the control group reported to have received a payout.

Knowing that CCPA received a payout for the 2019 season, the farmers' lack of awareness in their insurance status seems to be reflected in their lack of awareness about payouts. It is difficult to verify whether farmers actually received a payout because to our knowledge, there are no farmer-level payout data available through CNAAS or at the CCPA level. As discussed earlier, CCPA comprises a network of GIPAs at village level and CNAAS only identify the areas where the index has triggered and consequently, the GIPA(s) that are in that area and should benefit from the payout. CNAAS hence delivers the payout money to the bank or the organization that has subscribed in its own name to cover its portfolio (in the case of meso-insurance) or in the name of its different members or clients (in the case of micro-insurance). The Farmers' Organization's governance structures decide how the money paid by CNAAS is distributed across indemnifications. CNAAS claims to have specified to the banks and the FOs the list of the areas and concerned organizations every time the indices triggered and payouts were made.

Our interview with CCPA revealed that payouts were used for the repayment of a part of the loan the organization owed and thus, that the farmers owed to the organization. However, we could not verify whether the organization actually used the money for repaying a part of the farmers' loan or not, and how this debt relief was passed on and communicated to the individual member farmers. A representative of a GIPA revealed to our supervisors during the midline survey that in 2020, for their specific GIPA, they did not let the farmers know that there had been no insurance that year and they collected the same amounts that farmers would have usually paid for insurance premiums to complete the repayment of the previous years' debt. There is, therefore, no guarantee that farmers were informed that the index triggered and they would have potentially only had to repay part of their previous loan. All this could explain the lack of farmers' awareness about payouts.

Hypothesis 8: Compensation received when a shock occurs contributes to reducing farmers' vulnerability and decreases the chances of them falling into chronic poverty in the long run (N/A).
For the same reasons mentioned above—lack of awareness about the payouts and poor transparency about how the organization uses the payouts both at the top management and village association levels—we could not verify this hypothesis.

Hypothesis 9: The COVID-19 pandemic resulted in negative effects on production activities and farmers' well-being, affecting in the same way all treatment and control groups (verified).
Midline report showed that farmers in the COVID-19 pandemic had affected different groups in different ways. The most substantial negative impacts were felt in access to markets, which resulted in similar percentages of farmers being unable to sell parts of their crop and livestock production due to the pandemic. In all three groups, more than 70 percent of farmers reported they had faced unsold crop livestock and about 30 percent or more had experienced difficulties accessing seeds or fertilizers due to COVID-19 (see midline report).

There seems to have been a gender difference in the impacts of the COVID-19 pandemic because FGDs revealed that women had been particularly affected. Some COOPEC and CCPA women mentioned having to sell and consume seeds and livestock to make ends meet. They also reported increased pressure on fields, because people who had lost employment in the cities returned to the villages. These reports were consistent with what was observed during the preparation of the 2020 agricultural season, between April and June, when the official decision was made to close rural weekly markets (from March 14 to May 12) as one of the measures to limit the spread of the virus.

> The cultivable land for us women is also reduced since all the men who were in town came back to share the fields with us women and this reduced our individual production capacity. In any case, the harmful effects are innumerable. — CCPA, female member

During the endline survey, respondents still struggled with the impacts from the COVID-19 pandemic. According to respondents' statements, due to the prolonged duration of the pandemic and resulting supply chain and market disruptions, the prices of agricultural inputs, in particular fertilizer and seeds, increased substantially. Even though the harvest from the 2020 season was generally considered good, people described how their revenues were slowly "eaten up by COVID," due to movement restrictions, market closures, and unavailability or rising prices of agricultural inputs.

Although the percentage of farmers reporting difficulties in selling crop and livestock or accessing seeds and fertilizers due to COVID-19 is significantly higher in the treatment group than in the control group, we found no difference in the consequences on household consumption (see Table 20), neither at midline nor at endline. It seems that despite the difficulties closing of rural markets may have caused in 2020 (the midline crop season), the pandemic did not severely affect living standards of most farmers in rural areas.
As explained in the midline report, the COVID-19 support program that was established to help households in difficulties, targeting about 1 million households with food assistance packages,[14] could account for the low number of households that declared to have had to reduce their consumption. Overall, we can confirm that hypothesis 9 is verified and the negative effects of COVID-19 affected our study population in the same way.

However, with the endline data, we observe a more important increase in the number of farmers in the treatment group who continued to report COVID-19 as the reason for their difficulties in accessing seeds and fertilizers. Difficulties certain FOs experienced after the COVID-19 year in accessing some agriculture funding channels that were instead redirected to funding the post-crisis recovery could be the reason for this.

It is worth noting that most key indicators decreased, even though not always significantly, at midline for all groups, which coincided with 2020, the year of the COVID-19 pandemic, before increasing again at endline. This includes the following indicators: living standards (e.g., cooking energy); indicators of shocks and coping (e.g., progress of the production volume of the main crops—groundnut, millet. and maize—compared to the previous years and exposure to shocks measured by the number of shocks farmers are exposed to); indicator of access to agricultural loans from affiliated FOs; indicators of food security; and indicators of value of some production inputs (e.g., fertilizers). This confirms the negative effects of COVID-19 on the results of different groups compared to the control group because the disparity between the two groups for each of the above-listed indicators may have been reduced.

Hypothesis 10: Provision of crop insurance as add-on to credit results in more farmers benefiting from higher amount of loans (partly verified)
Model 1 results show that regardless of their level of awareness about insurance, the number of farmers in the treatment group who had access to credit through their FOs decreased significantly between baseline and endline compared to the control group. This is in line with the decreasing trend observed in the FOs' membership between baseline and the ensuing surveys. However, the amount of credit the farmers received from their FO increased significantly (although at 10% significance level only) for the farmers who declared that they were insured (at least once) between baseline and endline, suggesting that these farmers received a higher amount of credit from their FO thanks to the bundle. This could be explained by the de-risking role the crop insurance product plays in the sector, making the credit portfolio less exposed to climate shocks. There may also be an effect on the supply side of the index insurance sector, by de-risking credit portfolios.

These findings are consistent with the results from KIIs conducted at endline. Overall, at the level of FOs, there is an appreciation of the protection the insurance product offers for the organizations' loan portfolio, which would contribute to the supply-side effects observed in

[14] The assistance was composed of 100 kilograms of rice, 10 kilograms of sugar, 10 kilograms of pasta, 10 liters of oil, and 1 packet of 18 pieces of soap.

the quantitative analysis. At the same time, due to loan repayment issues experienced in the past, both CCPA and COOPEC have increased their screening and membership criteria (including an increase in annual fees in the case of CCPA) to reduce the risk of default in their portfolio, thus consolidating their memberships based on quality rather than quantity.

10.2 The landscape for agricultural insurance in Senegal is evolving

The Senegalese crop insurance sector is currently experiencing several changes that may have noticeable consequences for the future of WII in the country. Debates are increasingly centered on the sustainability of premium subsidies their burden on the government budget. The government subsidizes each agricultural insurance policy at 50 percent of the premium. The number of insurance contracts issued vastly increased over the past decade. Nevertheless, the agricultural insurance market and individual farmers benefit from government subsidies as well as from technical and financial support through international development partners. This masks the commercial market's development capacity and the ability to increase insurance growth and uptake over the long term without any external support. CNAAS has expressed concerns over this situation and has started considering exit strategy options.[15] FOs claim that the subsidy should be maintained or even increased, because the government has a role in protecting the sector from climate risks.[16]

Another trend revolves around shifts in insurance distribution models. Until 2017, the insurer (CNAAS) relied on FOs to distribute individual contracts to farmers, so the product was sold as in retail with FOs and financial institutions only serving as aggregators. Since 2017–2018, the insurer increasingly started issuing portfolio contracts with FOs, banks, and microcredit institutions, which are now accountants of premiums farmers pay. Thus, these new types of contracts are operated at the intermediary level, between the insurer and the FOs. This specific type of contract does not mandatorily imply adequately informing individual farmers who contribute to the premiums paid through the FOs about insurance, because technically, the farmer is not the insurer's direct client. However, FOs, banks, and microcredit institutions have all claimed to do their best to provide their clients with information about crop insurance. CNAAS has also declared continuing to organize yearly training sessions for the aggregators, during which it encourages the farmers' education about the insurance products. However, our findings show that FOs were not always effective in transmitting relevant WII information to their members. It is, therefore, unclear whether these new insurance distribution schemes will ensure correct information-sharing mechanisms through FOs in the long run. Additionally, the different stakeholders (insurance company, banks, and FOs) disagree over whose responsibility it is to undertake consumer education interventions.

For some observers, solutions may come from digitization because it could improve access to information for farmers, especially those with access to mobile phones. In partnership with the WFP, CNAAS currently works on a project of digitizing its clients' premium payments.[17] A recent report published through the project highlights challenges for the digitalization of insurance payments in rural parts of Senegal, and proposes design options to address them (CNAAS, WFP, SOFRECOM 2021). Another initiative, with the United States Agency for

[15] Interview with the director of CNAAS.
[16] Interview with president of CCPA.
[17] Interview with WFP and CNAAS.

International Development (USAID), explores the possibility of sharing climate information with insured farmers via mobile phones.[18]

More recently, in 2020, as part of the Digital Solutions for Rural Women's Disaster Resilience, UN Women introduced another digital initiative on the topic of crop insurance that involved CNAAS. The initiative's objective is to increase the level of awareness on agricultural insurance among women farmers in Senegal by developing mobile phone-based games and certifying distance training via phones. This makes it possible for a set of about 600 women to strengthen their knowledge and skills in agricultural insurance, as well as to facilitate their adoption and demand for existing products by linking them directly to insurance providers via mobile technology.[19]

10.3 Positive impact found only on access to agricultural credit

At midline, the results showed that most socioeconomic characteristics and other outcome indicators have not significantly changed because of the intervention. Endline results confirm this. We have seen no clear relation between WII and living standards of the farmers who have access to it in the way it is currently offered. Besides, like at midline, we could not find evidence of the intervention yielding any positive outcomes for the value of inputs (seeds, fertilizers, other inputs) at endline, after 4 years of observation.

Therefore, the data and results do not support the conclusion that farmers who have access to the credit and WII bundle adopt higher levels of agricultural investment.

However, we identified two key advantages the bundle provided:

1. Faster COVID-19 recovery
   The findings show that farmers who had access to the bundle, regardless of whether they could state they had the WII product or not, experienced a significant increase in the results for some key indicators between midline and endline. This yielded, for instance, an improvement in the energy they use for cooking. A significant improvement could also be noted in their appreciation of production volume of groundnut and millet crops in the current season compared to the previous season. Regarding the production volume-related indicators, the share dedicated to consumption significantly expanded between midline and endline because of the increased production volume. This could indicate that access to the bundle (credit + insurance) enabled a faster COVID-19 recovery given the decreasing (although not significant) trend observed between baseline (before COVID-19) and endline, which was followed by a significant increase between midline and endline (after COVID-19).

   However, from FGDs and KIIs, we also learned that FOs implemented some additional interventions during COVID-19 to support their membership during the pandemic. This included assistance in obtaining seeds and fertilizer. Therefore, we cannot exclude the possibility that the faster recovery was at least in part a result of these additional support mechanisms, not the bundle alone.

[18] Interview with CNAAS.

[19] Interview with UN Women.

2. Higher credit amount to FOs' members
   At midline, the results show a lower percentage of farmers who declared to have received agricultural credit from their FO than at baseline. This could be the reason a significant number of farmers in the treatment group did not renew their FO membership at midline and endline.

   However, compared to baseline, farmers who still held membership in the FOs in the treatment group and could say they knew they had been insured received significantly higher amount of credit than the control group. The intervention, hence, seems to have guaranteed access to more important loans to farmers who had the most information about the bundle, namely the fact that it included an insurance, even in the context of COVID-19 and scarcity of resources that may explain the decrease in the percentage of farmers who received credit from their organization. High fertilizer prices in 2021 could be one explanation for the higher amount of credit farmers in the treatment group received. According to the United Nations Food and Agriculture Organization, the prices of the fertilizers doubled between 2020 and 2021, because of the high and volatile energy prices, especially the price of gas, but also an increased price of maritime transport since COVID-19 (FAO 2022). Consequently, farmers needed a higher amount of credit for the same level of production and area cultivated.

We observed a significant decrease in the average uptake rate, despite increasing subscriptions nationwide that CNAAS reported. The reasons behind this discrepancy between renewal and subscription progress over time necessitate a closer analysis. It could be attributed to the fact that CNAAS largely shifted from individual to portfolio insurance as a business strategy. CNAAS' partners, such as the World Bank through GIIF, strongly support this goal. In this case, the main impact pathways rely on the expectation that portfolio insurance would make available greater volumes of credit, which are then backed by insurance, resulting in increased investment in agriculture and hence, income. This contrary to the direct impact channel associated with microinsurance (and tested in this study), whereby farmers who are aware of the protection insurance provides them, would seek more credit to extend "high-risk high-return" investments and thus, increase their income.

This led some actors to express their concern about the logic of business defeating the logic of development and change of family farms' production behaviors and attitudes toward risk. For instance, our results show no improvement in the level of exposure to shocks. Likewise, access to the bundle (in model 1) or insurance coverage (model 2) did not result in abandoning old production habits in favor of new agricultural practices.

10.4 Revision of the study design due to intervention changes

Between baseline and midline, FOs reported several implementation challenges that in turn had non-negligible consequences on their members. Those challenges are primarily related to the organizations' financing abilities to grant loans to their farmers, which are essential to facilitate access to agricultural inputs at the beginning of each season. Farmers usually access credit in part through public funds such as FADSR and other financial institutions. Financial impacts from the COVID-19 pandemic reduced the availability of such funds in 2020. Consequently, FOs had to rely on their existing resources and other funding mechanisms to serve their members. However, this was insufficient to meet the members' needs. Specifically,

CCPA received resources from the DER public funding program. Unfortunately, these resources and as a result, members' access to credit through the organization, were only available after the WII subscription window had already closed for the year. Accordingly, the COOPEC leadership did not share insurance premium prices with its booking offices in time to meet the insurance subscription window. As a result, none of the farmers in either of the treatment groups were insured through CCPA or COOPEC for the 2020–2021 season. Therefore, prior to the midline survey, we revised our pre-analysis plan to account for the absence of the intervention in year 3 and consider only 2 years of impact as midline results.

However, the midline survey surprisingly revealed that a substantial portion of the farmers in our study's treatment group "self-treated," because they reported to have been insured, while we had proof from their FO and the insurance company that they were, in fact, not insured. The percentage of farmers who stated they had been insured while that was not the case in year 3 is higher than the percentage of farmers in the voluntary group who knew they had been insured at baseline and similar to the baseline percentage in the mandatory group. Therefore, we concluded that there was no reason not to assume that farmers did not behave the same way as when the intervention was actually delivered because the type of intervention under consideration is not palpable; instead, it is a perceived sense of protection.

11. Discussion of limitations

11.1 The risk for selection bias due to the nature of the compared interventions

The underlying hypothesis of this evaluation is that bundling WII with agricultural credit can lead to increased insurance uptake, financial inclusion, and resilience among small-scale farmers in Senegal. This is based on the assumption that bundling reduces liquidity constraints at the start of the agricultural season, incentivizes higher return investment strategies, and provides a safety net in the event of climate shocks.

However, selection bias—both in treatment and between different treatment modalities—can occur. Specifically, unobservable characteristics such as risk tolerance, financial literacy, or information seeker attitudes may influence farmers' decision to join an FO. These characteristics can also influence both their decision to take up insurance and the subsequent outcomes of interest. Farmers with higher risk tolerance, financial literacy, or exposure to information might be more likely to adopt insurance voluntarily, while mandatory bundling could mask heterogeneity in awareness and acceptance.

To mitigate these challenges, this study design incorporated a comparison of voluntary (COOPEC/RESOPP) and mandatory (CCPA) bundling schemes. Sampling strategies and power calculations aimed to ensure that treatment and control groups were balanced in observable characteristics at baseline, as described in the sampling procedures. Nevertheless, the possibility of selection bias due to unobservable characteristics cannot be entirely ruled out, especially given the delivery mechanisms (e.g., aggregation by FOs).

The voluntary nature of insurance uptake in COOPEC/RESOPP could introduce an upward bias in the observed outcomes. Farmers who chose to participate may differ systematically from those who did not. The survey does not systematically capture these differences. Conversely, mandatory bundling in CCPA could obscure individual decision-making, reducing variability and potentially diluting observable treatment effects.

11.2 Uncontrolled factors that could violate parallel trend assumptions

The validity of the evaluation's causal inference relies partly on the parallel trends assumption, particularly in the matched difference-in-differences framework we employed. This assumption posits that in the absence of the intervention, treatment and control groups would have exhibited similar trends over time in the outcomes of interest, such as uptake rates, agricultural investments, agricultural productivity, and well-being indicators (i.e., income, food security, wealth index, etc.).

To support the credibility of this assumption, in the pre-analysis plan, the study verified comparability of treatment and control groups across observable characteristics such as demographic factors, access to credit, and prior exposure to insurance products. Besides, thanks to a large baseline survey, the methodology combined the difference-in-differences approach with matching. However, there are inherent challenges in verifying parallel trends due to unobservable characteristics, such as attitudes toward risk or exposure to external information campaigns, which may differ between groups.

The pre-intervention data revealed that the adoption of credit and insurance products varied substantially across geographic areas and institutions, partly due to local access to microfinance and previous pilot experiences with WII. This heterogeneity underscores the importance of controlling for geographic and institutional differences in the analysis. The sampling and matching procedures account for these variations by using stratified sampling to ensure representativeness within and across intervention's regions. However, despite these efforts to ensure balance, several factors could violate the parallel trends assumption:

- **Institutional differences:** Differences in COOPEC/RESOPP's and CCPA's operational procedures may have introduced systematic differences in farmers' experiences, even before the intervention. For example, COOPEC/RESOPP could have provided different types of technical support and advisory services, which might have influenced farmers' behavior beyond the intervention.
- **Awareness and information campaigns:** Variations in awareness campaigns about WII could have affected groups differently, leading to diverging trends before the intervention. Awareness is explicitly highlighted as a challenge in the evaluation, with farmers' limited understanding of insurance coverage identified at baseline.
- **External shocks:** Unanticipated shocks, such as the COVID-19 pandemic, affected agricultural financing and farmers' behavior during the evaluation period. These shocks might have had disproportionate effects across groups due to differences in institutional resilience or geographic exposure to virus spread and related consequences. Areas with higher levels of virus contamination may have faced greater socioeconomic constraints (e.g., lower income/livelihoods, additional markets barriers, constraints in financial inclusion, etc.)

11.3 The endogeneity problem in evaluating awareness-based treatment effects

The endogeneity problem in this study stems from the non-random distribution of awareness among farmers regarding their insurance coverage. Several factors influence awareness, including exposure to information, level of education, and access to social capital. Such factors also tend to be correlated with some of our key outcomes of interests—agricultural productivity, investment behavior, and level of resilience to shocks. This non-randomness poses challenges in accurately attributing observed impacts to the intervention itself, as opposed to farmers' underlying characteristics.

Farmers who are aware of their insurance coverage may exhibit systematic differences compared to those who are unaware due to characteristics such as financial literacy, risk tolerance, access to resources, or even their proactivity when it comes to looking for information related to their agricultural activities (leadership traits). These characteristics not only predispose them to being more aware of their insurance coverage, but also position them to achieve higher productivity or make riskier investments that are associated with high return. This introduces a self-selection bias, creating an endogenous relationship between insurance uptake awareness and outcomes. Additionally, the second model's focus on "aware" farmers as the treated group excludes insured farmers who are unaware, potentially underestimating the breadth of the intervention's influence while simultaneously overstating the effects within the "aware" subgroup.

Another limitation related to the awareness model comes from measurement challenges, which could exacerbate the endogeneity issue. By defining treatment solely based on awareness in that second model, this study assumes that awareness fully captures the effects of insurance. However, this assumption overlooks the behavior of insured but unaware farmers, who might not exhibit the same benefits or changes in outcomes as those who are both insured and aware. This further undermines the validity of the treatment variable.

The bundling modalities add another layer of challenges. COOPEC/RESOPP offers insurance on a voluntary basis, meaning that farmers who opt into the insurance bundle may already be inclined toward behaviors that lead to higher agricultural productivity. In contrast, mandatory bundling through CCPA may obscure such heterogeneity among farmers, because it applies uniformly, regardless of individual traits. This disparity between voluntary and mandatory bundling contexts could result in differential treatment effects and confound comparisons between the two modalities.

The limitations arising from these issues have significant implications for the interpretation of results. Awareness, being correlated with unobservable characteristics that drive agricultural outcomes, likely inflates the insurance's estimated effects on productivity and investment. This upward bias due to positive selection means that the observed impacts represent an upper bound of the true effects. Nonetheless, this bias also allows the study to confidently reject meaningful impacts for outcomes where no significant results are observed, suggesting that the intervention does not strongly affect those outcomes, even under optimistic assumptions.

For outcomes that do show significant positive effects, such as agricultural production under Model 2, we warrant caution in interpretation. These results may reflect both the genuine impacts of the intervention and the preexisting advantages of aware farmers, making it difficult to separate the two. This necessitates a careful framing of findings, acknowledging their potential overstatement due to selection bias.

Future studies should consider employing instrumental variable techniques to better isolate causal effects. For instance, farmers' level of regular participation in their FOs' activities or their proximity with the leader of these organizations could serve as instruments for awareness, mitigating endogeneity concerns. Additionally, collecting data on unobservable characteristics, like risk preferences or financial literacy, would help refine the analysis and improve the precision of estimates.

12. Conclusion

The objective of this work was to establish the situation at endline in terms of CCPA and COOPEC farmers' knowledge and uptake of the agricultural credit and insurance bundle. The report also assessed changes in agricultural investment and income, as well as in other socioeconomic variables and effects of the COVID-19 pandemic between treatment and control groups and over time.

COOPEC and CCPA FOs propose to their members who apply for an agricultural loan in the Senegalese groundnut basin WII as a mandatory add-on to credit, respectively. We conducted a survey among the farmers affiliated with these two organizations who participated in the baseline survey and so have at least once received the bundle (credit + insurance) during the baseline year, in 2018. These farmers were compared with those who live in the same localities, practicing agriculture under the same conditions, but who do not have agricultural insurance.

The baseline results already revealed that around half of the insured farmers in both treatment groups were not aware that they had been covered by insurance. The midline and endline results confirmed these findings about uninformed insurance uptake. Specifically, in 2020, a similar share of farmers considered themselves insured even though they were not due to interruptions in the implementation of the intervention that year.

In this context, we did not find positive impact for the main outcome variables the design initially targeted and which were based on the assumption that access to WII would increase investment level and improve living conditions. However, findings show that farmers who had access to the bundle recovered faster from the negative effects of COVID-19, which seems to have affected midline results. Indeed, we observed a decrease, although not significant, in key indicators between baseline and midline, while we noticed an increase between midline and endline for those same indicators. The recovery was significantly higher for farmers who had access to the bundle than for those who did not.

Furthermore, compared to baseline, the treatment group farmers who still held membership in the FOs and who reported to be insured received significantly higher amount of credit than the control group. This result was not verified for the treatment group farmers who could not state whether they were insured or not. Thus, the intervention seems to have guaranteed access to higher amount of loans to farmers who were the most informed about the bundle, namely the fact that it included an insurance, even in the context of the COVID-19 pandemic and scarcity of resources.

This result suggests that the de-risking role the insurance plays in the portfolio of the organizations that fund agricultural activities enables them to provide more credit to farmers, which would not have been the case otherwise. Our findings, thus, confirm some of the recent literature on insurance and credit bundles that finds, as a result of bundling insurance with credit, no increase in credit demand, but an enhanced credit supply.

Results at midline and endline show no changes in the level of investment or agricultural practices attributable to the intervention. In both CCPA and COOPEC FOs, producers were supposed to receive information about the insurance product and whether they were covered or not. Interviews with officials from both organizations showed that arrangements were made upstream to inform producers of all the decisions the organizations' leadership

makes, usually after consultation of members. Nevertheless, the organizations' and cooperatives' leaders at both the central and the local level, in villages, recognize real problems in the transmission of information, which in some circumstances, may not reach or be late to reach the intended recipient at the farmer level. Again, this finding is in line with others (e.g., Duchoslav and van Asseldonk 2018) who did not find a change in investment behavior as a result of bundling and in part, related this to the low level of information farmers have available.

Our results show that respondents' sources of information about crop insurance have become more informal over the years, relying primarily on families, friends, and others. In turn, they receive relatively less information from the organizations and companies that provide the product. Therefore, like at baseline, the results suggest a need for stakeholders to think about the means to strengthen the FOs' capacity to inform their members about all issues related to insurance.

Efforts are already underway to that extent, including options being explored for using mobile phones to establish a more direct connection between the farmer and the insurer, while recognizing the continued importance FOs will play as aggregators in this relationship.

Online appendix

Online appendix A: Results of sample size calculation

https://3ieimpact.org/sites/default/files/2025-09/TW13.II1026-IE-report-Online-appendix-A.pdf

Online appendix B: Details on variables/indixzcators construction

https://3ieimpact.org/sites/default/files/2025-09/TW13.II1026-IE-report-Online-appendix-B.pdf

Online appendix C: IRB approval letters

https://3ieimpact.org/sites/default/files/2025-09/TW13.II1026-IE-report-Online-appendix-C.pdf

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