Pre-Analysis Plan: Diffusion Through Dealers

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1 Introduction

Smallholder farmers are increasingly vulnerable to climate change, facing rising temperatures, erratic rainfall, and more frequent extreme weather events. These risks translate into substantial agricultural losses: smallholders typically harvest only 30–50% of their potential yield, and crop failures contribute to short-term hunger, persistent poverty, and long-term adverse effects on health and human capital. A key policy priority is therefore to identify effective and scalable ways to deliver climate adaptation technologies to smallholder farmers. Stress-tolerant seeds (STS) are a leading example of such technologies, as they can reduce crop losses and stabilize farm incomes. However, research shows that simply providing information has limited impact on adoption of agricultural innovations (Magruder, 2018). So, agricultural extension workers are used to encourage seed adoption by farmers. Dar et al. (2024) show that distributing stress-tolerant seeds directly to agro-dealers increased farmer adoption by more than 50% relative to traditional extension-based approaches.

Chickpea farmers in Gujarat face particularly severe climate-related production risks from Fusarium wilt, a soil-borne disease that can cause major yield losses and crop failure (K.Venkataramanamma et al., 2025; Jendoubi et al., 2017). Surveys conducted in 2022–2023 by Precision Development (PxD) and collaborators indicate that wilt is perceived as the primary production risk among chickpea-growing households in the study region, and 77% of farmers report having experienced chickpea crop damage from wilt at least once in the past decade. These risks are exacerbated by weather shocks: 47% of blocks experienced at least one chickpea-growing season in the past decade with rainfall more than two standard deviations below the long-run average. Wilt-tolerant chickpea varieties therefore represent a promising adaptation strategy for farmers in this region.

However, access remains a key barrier. Many farmers are unaware of the stress-tolerant varieties, and these seeds are often unavailable in local markets. Agro-dealers play a central role in addressing this constraint. They are trusted sources of information and the primary retail channel through which farmers obtain seeds and other inputs. However, agro-dealers may lack the knowledge, incentives, or experience to promote newly released technologies.

Experimental evidence from India demonstrates that working through local input suppliers can substantially increase farmer adoption of STS. For example, Dar et al. (2024) show that distributing stress-tolerant seeds directly to agro-dealers in the form of free trial seed packets increased farmer adoption by more than 50% relative to traditional extension-based approaches. While these results highlight the promise of the agro-dealer channel, prior interventions relied on relatively intensive and costly delivery models, such as in-person distribution by project staff. This raises a central policy challenge: how can effective agro-dealer–based approaches be implemented in ways that are both scalable and cost-effective? Moreover, do other agro-dealers respond quickly to changes in the inventories of their competitors? If so, then intervening with agro-dealers can happen at a smaller scale and competition and the pressure to retain customers will induce other agro-dealers to follow.

This project addresses these questions by evaluating a randomized intervention that promotes a wilt-tolerant chickpea variety (Pusa Manav) through agro-dealer networks in Gujarat. The intervention combines two scalable components. First, trial seed packets are distributed through existing distributor logistics and agro-dealer networks rather than direct project delivery. Second, agro-dealers receive low-cost digital advisory messages (e.g., via WhatsApp) providing information about the variety and guidance on stocking and recommending it. It examines how the agro-dealer to farmer distribution channel can be used at scale by leveraging existing distributor systems and dealer-to-dealer linkages to move trial seeds and information through private supply networks in a cost-effective and sustainable manner. The study design builds on pilot studies conducted in Gujarat in 2024 and 2025, which informed operational refinements and contextual adaptation.

1.1 Research question

The primary objective of this study is to test whether a low-cost, distributor-based seed distribution model combined with digital advisory services to agro-dealers can increase the stocking, promotion, and sale of a wilt-tolerant chickpea variety, and thereby expand farmer access to stress-tolerant seeds. More broadly, the study asks: How can dealer-to-dealer networks be used to provide a cost-effective and scalable way to diffuse a climate-resilient seed variety? Second, we look at issues around competition between agro-dealers. We design an experiment to detect spillover effects on untreated agro-dealers who compete with those treated. This allows us to look at market effects more broadly. It also allows us to understand how agro-dealers respond when their competitors upgrade their product offerings.

We examine impacts along the agro-dealer margin—including knowledge, experimentation with the seeds, stocking decisions, pricing, sales, and recommendations to farmers—as well as substitution away from other varieties. By identifying cost-effective ways to leverage private input supply chains, this research contributes evidence on how to scale agricultural climate adaptation technologies in low-income settings.

The study also sheds light on strategic interactions among dealers. Linking dealers through seed distribution networks may influence their sourcing behavior, not only for the focal chick-

pea variety but also for other inputs. Dealers may switch suppliers or form new buyer–seller relationships after observing the behavior of connected dealers, and linked dealers may themselves take on upstream roles. Effects on inputs beyond chickpea seeds would also allow us to study whether the intervention alters only variety-specific sourcing decisions or leads to broader changes in supply relationships within local input markets.

2 Experimental Design

This study is a randomized controlled trial designed to test scalable approaches to distributing a wilt-tolerant chickpea variety through agro-dealer networks in Gujarat, India. The intervention leverages dealer-to-dealer linkages to understand how climate-resilient seed technologies can diffuse through market channels. The study is implemented in 17 districts where chickpea is commonly grown and where Krushisharang (KS), the seed distribution partner, operates.

Agro-dealers in the study fall into two categories: Krushisharang (KS)–affiliated dealers and non-KS dealers operating in the same markets. KS dealers already have a commercial relationship with the seed distributor and regularly procure seeds through Krushisharang's supply chain. In practice, they serve as upstream suppliers within the local market and would act as wholesalers for nearby non-KS dealers if those dealers choose to stock the Pusa Manav variety in the future. Non-KS dealers are independent local retailers who do not have any existing relationship with Krushisharang. For the purposes of this study, non-KS dealers in each market are matched to the KS dealer operating in that market, reflecting existing or potential supply relationships. This matching structure mirrors how seed varieties would realistically move through local private distribution networks.

Randomization occurs at two levels: markets are assigned to treatment and control arms, and the agro-dealers are then randomized into treatment or spillover controls within treatment markets. The study includes **51 markets**, comprising a total of **701 agro-dealers**. Markets are first randomized into treatment and control arms:

- **Treatment markets:** 25 markets, containing 355 dealers (29 KS-affiliated and 326 non-KS dealers)

- **Control markets:** 26 markets, containing 346 dealers (34 KS-affiliated and 312 non-KS dealers)

To examine within-market spillover effects, we further randomize the treatment assignment among non-KS agro-dealers in treated markets. Within each treatment market, non-KS agro-dealers are paired by geographic proximity; one dealer within each pair is randomly assigned to receive trial seeds and associated materials while the other remains untreated (as part of a spillover control group). In 12 markets with an odd number of agro-dealers, the

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unpaired dealer was randomly assigned to either treatment or control. Of the 25 treatment markets:

- 13 markets have an equal split (50% treated, 50% untreated dealers),

- 6 markets have one additional treated dealer,

- 6 markets have one additional untreated dealer.

In treatment markets, the intervention creates linkages between KS-affiliated dealers, and other local non-KS affiliated agro-dealers.

- Each KS-affiliated dealer in a treatment market receives free trial seed packets of the wilt-tolerant chickpea variety for their own experimentation, an informational poster, a letter of participation as well as additional packets with the same contents intended for distribution to local non-KS dealers.

- Non-KS dealers randomly assigned to treatment in treated markets collect their trial seed packets through coordination with the KS dealer in their market, thereby creating a new dealer-to-dealer link.

- All KS and non-KS treatment dealers in treated markets get reminder voice or WhatsApp messages about the seeds' benefits and how they can procure them, and are provided with an informational poster describing the seeds' benefits.

In control markets, no dealers receive trial seeds, informational materials, or digital advisory services. These markets serve to measure overall program impacts relative to business-as-usual seed distribution through existing channels. Neither do untreated dealers in treatment markets receive trial seed packets or materials. These dealers allow measurement of spillover effects operating through local market interactions, such as changes in demand for chickpea seeds, information diffusion between dealers, and shifts in stocking behavior induced by nearby treated dealers.

2.1 Sampling

All participants are agro-dealer business owners operating in 17 chickpea-growing districts of Gujarat. The sample includes both KS-affiliated dealers and non-affiliated local agro-dealers operating in the same markets. Eligibility criteria require that the dealer:

- operates within selected study markets, and

- plans to stock chickpea seeds in Rabi 2025-2026.

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The KS-affiliated dealer list was obtained from Krushisharang administrative records. The non KS-affiliated agro-dealers were identified using publicly listed rosters and phone directories. These dealers were then contacted to verify if they met the eligibility criteria. The resulting sample reflects the broader population of agro-dealers in chickpea-growing regions of Gujarat and spans variation in geography, market size, and dealer characteristics.

3   Data Collection

Data will be collected through seven surveys of agro-dealers in our sample and through administrative data obtained through Krushisharang.

The surveys will be administered to the same panel of agro-dealers unless otherwise specified below. The first survey was conducted in October 2025 and the final survey will be conducted in December 2026. Most surveys will be conducted over the phone, with some of the survey rounds (survey 3, 4 and 5) being conducted in-person.

1. A listing survey that checks agro-dealer eligibility for the study

2. A seed distribution check survey monitoring receipt of the trial seeds and encouraging the dealers to try the seeds themselves or by giving them to a trusted farmer which was only conducted for the treated agro-dealers.

3. A survey to gather more information on dealers' customers, business volumes, stocking decisions, competition faced and their supply chain.

4. An experimentation survey that obtains dealers' perceptions about the new seeds, their willingness to stock the seeds in their shops and expected prices.

5. A secret shopper survey that conducts independent checks on whether dealers are recommending and stocking wilt-tolerant seeds.

6. A stocking survey to obtain information on changes to stocking – either because of stocking of the new wilt-tolerant seeds, or due to stocking of other new inputs.

7. A sales survey to study sales of the new wilt-tolerant seeds (as well as any other inputs) stocked by the dealers that season.

In addition, the study will use administrative data provided by Krushisharang (KS), our seed distribution partner, comprising order and sales records of chickpea seeds supplied to the KS-affiliated agro-dealers in the study blocks. The administrative dataset will complement survey-based measures by providing an objective record of agro-dealers' stocking and sales behavior.

3.1 Main outcomes

The collected data provide a set of key aggregated indices on dealer knowledge, dealer testing of the trial seeds, dealer stocking of the Pusa Manav seeds, dealer stocking of other varieties, dealers' size and reach of business, the dealers' relationships with their suppliers and other dealers, and the advice given by dealers to their customers. Each of these indices are populated by a set of outcomes obtained from the surveys. To create each aggregated index, we will fix the signs on each outcome variable listed based on our hypothesized effects. These outcomes will then be standardized and weighted by their variance to create the aggregated index or outcome variable that is used in our proposed regressions.

The aggregated variable along with the outcome variables used to populate it, their hypothesized direction from the treatment (positive, negative or zero effect) of effect on the treated dealers as well as the untreated dealers in the treatment group (spillover control group) , and if they will be transformed for the analysis are described in table 1.

4 Hypothesis and Analysis

The experimental design generates three relevant comparisons:

1. **Direct treatment effects:** the effect of receiving trial seeds (and associated materials) on treated dealers within treatment markets.

2. **Within-market spillover effects:** the effect on untreated dealers in treatment markets, relative to comparable dealers in control markets, capturing indirect effects through local market interactions (e.g., information diffusion, changes in demand, and strategic stocking responses).

4.1 Hypotheses

The intervention is expected to operate through two primary mechanisms: (i) increased dealer knowledge and experimentation with the Pusa Manav variety, and (ii) changes in local market competition and supply relationships. The hypothesized direction of effects for each outcome family follows the signs pre-specified in the outcome list mentioned in table 1.

H1: Direct effects on treated dealers. Dealers assigned to receive trial seeds and advisory materials are expected to update beliefs and gain experience with the Pusa Manav variety. This should increase knowledge, experimentation, stocking, sales, and recommendations related to Pusa Manav. Consistent with competitive reallocation toward the new variety, treated dealers are expected to substitute away from other chickpea varieties.

Table 1: Primary Outcomes and Hypothesized Treatment Effects

Outcome	Treated Effect Hypothesis	Spillover Effect Hypothesis	Level & Log Transform
Knowledge about Pusa Manav seeds			
Knowing about Pusa Manav	+	+	
Knowledge about its attributes	+	+	
From a list of varieties, picked Pusa Manav as:			
most wilt tolerant	+	+	
highest yield	0	0	
Doesn't require more fertilizer	+	+	
Doesn't require other input	+	+	
On testing Pusa Manav seeds			
If they received a trial package of seeds of Pusa Manav	+	0	
If they tried the seeds on their farm	+	0	
If the seeds are being grown by someone else they gave the seeds to	+	0	
If the seeds are being tried – either by them or by someone else	+	0	
Stocking Pusa Manav seeds			
Stocking Pusa Manav	+	+	
Quantity of Pusa Manav stocked	+	+	Yes
Revenue from Pusa Manav	+	+	Yes
Stocking Other Varieties			
Quantity of Other varieties stocked in Rabi	-	-	Yes
Number of other varieties stocked in Rabi	-	-	
Revenue from other varieties in Rabi	0	0	Yes
Size or Reach of Business			
Total sales	+	?	Yes
Share of customers in Rabi that are new (first-time) customers	+	?	
Any new inputs stocked	+	?	
New things they act as wholesalers/ retailers (first time):			
Seeds of other crops	0	0	
Fertilizer	0	0	
Pesticides/Insecticides	0	0	
Herbicides/Weedicides	0	0	
Fungicides	0	0	
Micronutrients / growth promoters	0	0	
Bio-inputs (biofertilizer/biopesticide)	0	0	
Equipment / irrigation accessories	0	0	
Others	0	0	
Relationships with their suppliers and other dealers			
Knowledge about the KS dealer in the block	+	+	
Number of new wholesalers in Rabi season	+	+	
Number of old wholesalers that weren't suppliers this time	+	+	
Purchased inputs or seeds from KS dealer in Rabi season	+	+	
Quantities of Pusa Manav stocked from KS dealer	+	+	Yes
Quantities of other seeds stocked from KS dealer	0	0	Yes
Quantities of Pusa Manav stocked from other sources	+	+	Yes
Quantities of other seeds stocked from other sources	-	-	Yes
Purchased inputs or seeds from KS dealer in kharif season	+	+	
Advice given to customers			
Advising / recommending Pusa Manav seeds	+	+	

Notes: If any of the outcomes we log-transform have 0s as outcomes, we will use an inverse hyperbolic sine transformation. The outcomes that are hypothesizes to have zero effects will be reported in separate tables, but excluded from the indices computed for our main results. "?" indicates an ambiguous effect.

Formally, for treated dealers relative to dealers in control markets, we hypothesize:

- **Positive effects** on indices and outcomes related to:
    - Knowledge about Pusa Manav
    - Testing/experimentation with Pusa Manav
    - Stocking, quantity, and revenue of Pusa Manav
    - Business expansion measures (total sales, new customers, new seed categories stocked)
    - Strengthened linkages with KS dealers and sourcing of Pusa Manav through KS
    - Recommending Pusa Manav to customers

- **Negative effects** on stocking of other chickpea varieties, reflecting substitution toward Pusa Manav.

- **Zero or limited effects** on non-seed inputs where systematic change is unlikely.

H2: Indirect spillover and competition effects on untreated dealers in treatment markets. Untreated dealers in treatment markets may be affected through two opposing forces:

1. Information spillovers: Knowledge about Pusa Manav and its performance may diffuse through dealer-to-dealer interactions, increasing awareness and potentially experimentation.

2. Competitive effects: Treated dealers may attract customers seeking the new variety, shifting demand away from untreated dealers or altering their stocking incentives.

As a result, for untreated dealers in treatment markets relative to dealers in control markets:

- We expect **positive effects on knowledge-related outcomes** due to information diffusion.

- Effects on **stocking and sales outcomes** may reflect competition:
    - Untreated dealers may reduce stocking of other varieties (negative effects) if market demand shifts toward Pusa Manav and they do not stock it.
    - Business size and customer measures may change depending on whether demand reallocation favors treated dealers (potential negative effects) or induces broader chickpea demand growth (potential positive effects).
    - Any change in demand for Pusa Manav seeds is unlikely to change their stocking behaviour for other inputs (limited or zero effects).

- Linkages to KS dealers may increase if untreated dealers respond strategically by sourcing through KS (positive), or remain unchanged (zero), consistent with the pre-specified outcome signs.

Overall, the sign of spillover effects on market and business outcomes is therefore an empirical question reflecting the balance between information diffusion and competitive substitution, while the direction of knowledge effects is expected to be positive.

4.2 Specification and Inference

We estimate the following intent-to-treat (ITT) specification:

$$Y_{i,m} = \beta_0 + \beta_1(\text{TreatMarket}_m \times \text{TreatDealer}_{i,m}) + \beta_2(\text{TreatMarket}_m \times \text{NonTreatDealer}_{i,m}) + \gamma X_{i,m} + \varepsilon_{i,m} \tag{1}$$

where Y_{im} is the outcome of interest for dealer i in market m, X_{im} is a vector of pre-specified baseline covariates (described below). TreatMarket_m is an indicator for whether market m is assigned to treatment. TreatDealer_{im} is an indicator for whether dealer i in market m is assigned to receive trial seeds/materials (defined only for dealers in treatment markets; equals 0 in control markets). $\text{NonTreatDealer}_{im}$ is an indicator for whether dealer i in market m is an "untreated" dealer in a treatment market (equals 0 in control markets). In this specification, β_1 identifies the average direct effect of treatment on treated dealers, relative to dealers in control markets. The coefficient β_2 identifies the average spillover effect on untreated dealers in treatment markets, relative to dealers in control markets.

All regressions will report standard errors clustered at the market level. Because the number of markets is small (51 in total), we will additionally report randomization inference (RI) p-values.

Primary outcomes are the pre-specified aggregated indices described in table 1. When analyzing families of related outcomes, we will adjust for multiple hypothesis testing by creating aggregate indices of outcomes. As mentioned earlier, to create each aggregated index, we will fix the signs on each outcome variable collected from the data, standardize them and weight them by their variance to create the aggregated index or outcome variable that is used in our proposed regressions. To further avoid concerns of multiple hypothesis testing, we will also report False Discovery Rate (FDR) q-values for the results on the indices. For any outcomes that are hypothesized to see zero effect from the treatment, we will report separate tables in the Appendix and exclude them when computing the aggregate indices used for our main results.

For continuous outcomes, we will report results in levels and in logs where appropriate. For continuous outcomes estimated in levels, we will winsorize the upper and lower 1% of the distribution. Some of the continuous outcomes, will also be reported in log form. The variables we intend to log transform are given in table 1. For continuous outcomes with zeros, we will use the following rule:

- If an outcome is strictly positive for all observations, we will use $\log(Y)$.

- If an outcome contains zeros, we will use the inverse hyperbolic sine transformation $\mathrm{asinh}(Y)$ as the primary transformation and will additionally report level specifications.

Further, if over one-third of the outcomes are zeroes, we will also report Tobit regressions in the Appendix (Bellemare and Wichman, 2020).

4.3 Covariates and Control Selection

The primary specifications will be estimated with and without baseline controls. When included, X_{im} will be selected from a set of baseline variables using post-double-selection (PDS) lasso. These variables are listed below:

- Other crops grown by dealers in Rabi 2024

- If chickpea was sold in Rabi 2024

- Caste information of the dealers

- Dealer's knowledge of chickpea varieties available in Rabi 2024

- Chickpea varieties stocked by the dealer in Rabi 2024

- If the dealers provide advice to farmers on what seeds to buy

- Dealers' total sales revenue for 2024

- Total chickpea seed volume sold in Rabi 2024

- Of the total seed volume sold in Rabi 2024, share sourced from the State Seed Corporation

- Of the total seed volume sold in Rabi 2024, share sourced from the Krushisharang

- In Rabi 2024, share of chickpea seeds sold as wholesale

- In Rabi 2024, share of chickpea seeds sold as retail

- The number of years the dealer has been selling chickpea seeds for

- If the dealer mentioned any of the following as one of 3 major problems mentioned by their chickpea buying customers in Rabi 2024:
  1. Insect pests (e.g., pod borer, aphids)
  2. Wilt
  3. Other diseases (blight, rots)

4. drought/too little moisture

5. flood/too much moisture

6. Untimely rain

7. heat or cold snaps

8. Seed quality/germination issues

9. Soil/nutrient management questions

10. Input price

11. Input availability

12. Market price uncertainty

13. Access to credit/finance

4.4 Heterogeneity

All of our heterogeneity analyses will be exploratory. We will estimate conditional average treatment effects (CATE) using machine learning methods (Wager and Athey, 2018). In addition, we will also examine heterogeneity by the importance of chickpea in a dealer's business, and by regions with realization of wilt conditions in Rabi 2025.

4.5 Power

The primary outcomes include dealer-level binary indicators such as whether the agro-dealer stocks the Pusa Manav variety. Because treatment assignment varies at the market level and dealer outcomes may be correlated within markets, power calculations account for clustering at the market (block) level.

The study includes 51 markets, with 25 assigned to treatment and 26 to control. Dealer counts per market range from 4 to 30, with a mean of 12.51 and a coefficient of variation of 0.47. We assume an intra-cluster correlation (ICC) of 0.3. Calculations are based on a one-sided test with a 5% significance level and 80% power.

Using pilot data from Rabi 2024, the baseline probability of stocking the target variety without intervention is 0.027. Under the design parameters above, the minimum detectable effect corresponds to an increase of approximately 13.5 percentage points in stocking probability between treated and control dealers.

Because untreated dealers are present within treatment markets, spillovers may attenuate the treatment–control contrast. As spillovers increase as a share of the direct effect, effective power to detect treatment impacts declines, implying that the study is best powered to detect direct effects on treated dealers, while spillover estimates are expected to be less precise.

References

Bellemare, Marc F. and Casey J. Wichman, "Elasticities and the Inverse Hyperbolic Sine Transformation," *Oxford Bulletin of Economics and Statistics*, 2020, *82* (1), 50–61. _eprint: https://onlinelibrary.wiley.com/doi/pdf/10.1111/obes.12325.

Dar, Manzoor H., Alain de Janvry, Kyle Emerick, Elisabeth Sadoulet, and Eleanor Wiseman, "Private Input Suppliers as Information Agents for Technology Adoption in Agriculture," *American Economic Journal: Applied Economics*, April 2024, *16* (2), 219–248.

Jendoubi, Warda, Mariem Bouhadida, Amal Boukteb, Mohamed Béji, and Mohamed Kharrat, "Fusarium Wilt Affecting Chickpea Crop," *Agriculture*, March 2017, *7* (3), 23. Publisher: Multidisciplinary Digital Publishing Institute.

K.Venkataramanamma, B. V. Bhaskara Reddy, and R. Sarada Jayalakshmi, "A Review on Fusarium Wilt of Chickpea Caused by Fusarium oxysporum f. sp. Ciceris and Its Biology," *Journal of Experimental Agriculture International*, September 2025, *47* (9), 149–162.

Magruder, Jeremy R., "An Assessment of Experimental Evidence on Agricultural Technology Adoption in Developing Countries," *Annual Review of Resource Economics*, October 2018, *10* (Volume 10, 2018), 299–316. Publisher: Annual Reviews.

Wager, Stefan and Susan Athey, "Estimation and Inference of Heterogeneous Treatment Effects using Random Forests," *Journal of the American Statistical Association*, July 2018, *113* (523), 1228–1242. Publisher: Taylor & Francis _eprint: https://doi.org/10.1080/01621459.2017.1319839.