# Banking Intermediation and Agricultural Outcomes: Evidence from Pakistan*

**Concept Note**

Faizaan Kisat [†] Ahyan Panjwani[‡]

January 3, 2022

## 1 Introduction

Why has agricultural productivity stagnated in Pakistan in recent years? This trend is problematic since agriculture accounts for over 19% of Pakistan's GDP and employs around 40% of its labour force. Many interventions in agriculture around the world have focused on a single dimension of treatment, e.g., credit, mechanization, or information.[1] However, results from these interventions are a mixed bag and misallocation continues unabated. While agricultural credit is widely available in principle, wedges continue to distort these markets resulting in long-standing inefficiencies as documented in Adamopoulos and Restuccia (2014), Foster and Rosenzweig (2017), Gollin, Lagakos, and Waugh (2014), Herrendorf and Schoellman (2015), Lagakos and Waugh (2013), and Restuccia and Santaeulalia-Llopis (2017).

We collaborated with a large financial institution in Pakistan (henceforth, B Bank) to investigate how agricultural productivity responds to reductions in information, credit, and supply chain frictions.[2] Specifically, there are three potential barriers to raising productivity: i) supply chain inefficiencies, ii) frictions in selling the output, and iii) lack of financing. We document that these three problems were interlinked; farmers grow low volumes and inferior quality of produce, which

*We are incredibly grateful to our advisor, Atif Mian, for his guidance, support, and patience. We would like to thank B Bank for their contribution and support. We are also thankful to Khawaja Hussain and Ismail Farooq for project management and research assistance.

[†]Department of Economics, Princeton University

[‡]Department of Economics, Yale University

[1]See, for example, Conley and Udry (2010) and Corral et al. (2020)

[2]Original name of the financial institution concealed for confidentiality purposes

they must sell through extractive selling institutions. Furthermore, these problems are exacerbated due to farmers' lack of personal funds and their hesitation to access formal credit options. Alternatively, farmers get financing on exorbitant rates from the middlemen, and are unable to escape this vicious cycle of poor production and inefficient selling. Therefore, it is extremely difficult for farmers to improve their crop yield, increase profits, and achieve any socioeconomic progress.

To address the highlighted issues, we teamed with B Bank to launch an innovative financial product in late 2019 to take an integrated approach towards the agriculture value chain. To resolve supply chain inefficiencies, B Bank connects the farmers with vendors of high-quality inputs (e.g., seeds, fertilizers, pesticides) and the latest mechanization services. Further, B Bank's in-house team of agronomists provides advisory to farmers on best agriculture practices and oversees their implementation throughout the crop cycle. To combat extractive selling institutions, B Bank connects farmers to local bulk buyers, who provide market-competitive prices and make payments within a stipulated timeframe. This step ensures that farmers get the merited return for their produce. The arrangement aims to improve net cash flows for farmers and spares them from additional transactions costs that are commonly charged by the traditional farming facilitators, i.e., the intermediaries or *arthis*.[3] All of this is done under the ambit of B Bank's development financing model, i.e., the bank facilitates provision of the aforementioned products and services through their partner vendors, rather than simply lending cash to the farmer. It recovers its own costs from the gross payoff.

We evaluate the efficacy of the project by conducting on-ground surveys and data collection at the farmer and plot level. Moreover, the team is also one of the pioneers in employing satellite imagery at this scale in Pakistan. Satellite remote sensing is used for real-time monitoring of crop health, and improvement of productivity through targeted advisory. This data is used to carry out analysis to assess the impact of the project on the farmer and Pakistan's agricultural industry in general.

[3]The arthi is a broker or middleman, who serves as the primary source of informal agricultural credit in Pakistan, providing two main services: i) giving inputs on credit during the sowing period, and ii) facilitating the sale of a crop after harvesting.

# 2 Timeline

## 2.1 Pilot Phase

The project's pilot phase consisted of two crop cycles: maize in spring 2020 in Okara District, Punjab, followed by rice in the latter part of 2020 in Gujranwala District, Punjab.[4] Specifically, spring maize is sown between February and May and harvested around June. Rice is sown between July and August, with harvesting completed around November.

Field activities were severely affected due to COVID-19-related restrictions on fieldwork. B bank and the project team could not conduct farmer outreach and surveying on scale. As a result, both crop cycles in the pilot phase were conducted on a limited scale, with five and ten farmers in each cycle, respectively.

After sowing was completed for a particular crop, we carried out our baseline survey. The survey consisted of two parts: i) geocoding farm plots and ii) collecting demographic information from participants and acreage contracted with B bank.

Post-harvest, we conducted an endline survey: a detailed instrument surveying about the entire crop cycle, including yield, pricing, inputs used, and overall feedback of the project.

## 2.2 Maize & Rice 2021 Crop Cycles

Building on from the pilot phase, we carried out our first mid-scale intervention in spring 2021 for maize the Okara district. The project area was over 3,000 acres of land belonging to 78 farmers. The cultivation area of these farmers ranged from 10 to 150 acres, with most farmers contracting 30 to 40 acres with the financial institution.

As mentioned before, we conducted our baseline and endline surveys during designated periods. In the middle of the crop cycle, we also carried out the first round of our low performer intervention, see Section 3.2.

We have also conducted our baseline survey for rice in 2021. The endline survey will be completed once the crop has been harvested.

[4] In the local context, the maize crop was part of the annual *rabi* cycle while the rice crop was part of the *kharif* cycle.

### 2.3 Future Crop Cycles

We plan to include potato as one of our targeted crops in 2021. Sowing took place in October 2021 and harvesting will be completed in January 2022. Baseline survey, low performer treatment, and endline survey will take place accordingly.

The rest of 2022 will consist of the same crop cycles and activities as 2021: spring maize, kharif rice and potato crop. While the sample size will be larger, it will still include participants from the 2021 cycles. As a result, we will be able to design a unique panel dataset. A detailed illustration of the project timeline is shown in Appendix Figure A.1.

## 3 Empirical Strategy

### 3.1 Within farmer strategy

B Bank markets its project to local farmers in designated areas before the start of a particular crop cycle. Interested farmers opt in and specify the land area that they want to allocate for B Bank's project. The bank then carries out its vetting process, which includes financial due diligence and verification of the farmers' documents. In this manner, the final sample consists of all plots (whether the plot is contracted to B Bank or not) of farmers who have opted in and cleared the vetting process.

Within this model, our main aim is to compare plots contracted with B Bank versus plots used by the *same* farmers for personal use ("non-B Bank") for the same crop. It is important that a substantial percentage of the farmers in the sample (at least over 30%) have non-B Bank acreage for the same crop in a cycle. In cases where a farmer has both B Bank and non-B Bank plots, our strategy flexibly controls for any farmer unobservable characteristics that do not vary with a farmer's contracting decision.

Our primary econometric specification is as follows:

$$y_{pf} = \beta_0 + \beta_1 \cdot \mathbf{1}\{p = \text{B-Bank}\} + \gamma_f + \varepsilon_{pf}$$

where $y_{pf}$ is the outcome (e.g., yield) for plot $p$ managed by farmer $f$, $\mathbf{1}\{p = \text{B-Bank}\}$ is an indicator variable which is 1 if the plot was contracted with the bank, and $\gamma_f$ is farmer fixed effect. The coefficient of interest is $\beta_1$: the within-farmer difference of contracting a plot with the bank.

### 3.2 Satellite data cross-randomization

We used satellite data to introduce a separate treatment arm called the "low performer" treatment, as displayed in Figure 1. The intervention employs remote sensing to identify lagging plots during the crop cycle, and targets a random group of farmers within the sample.[5]

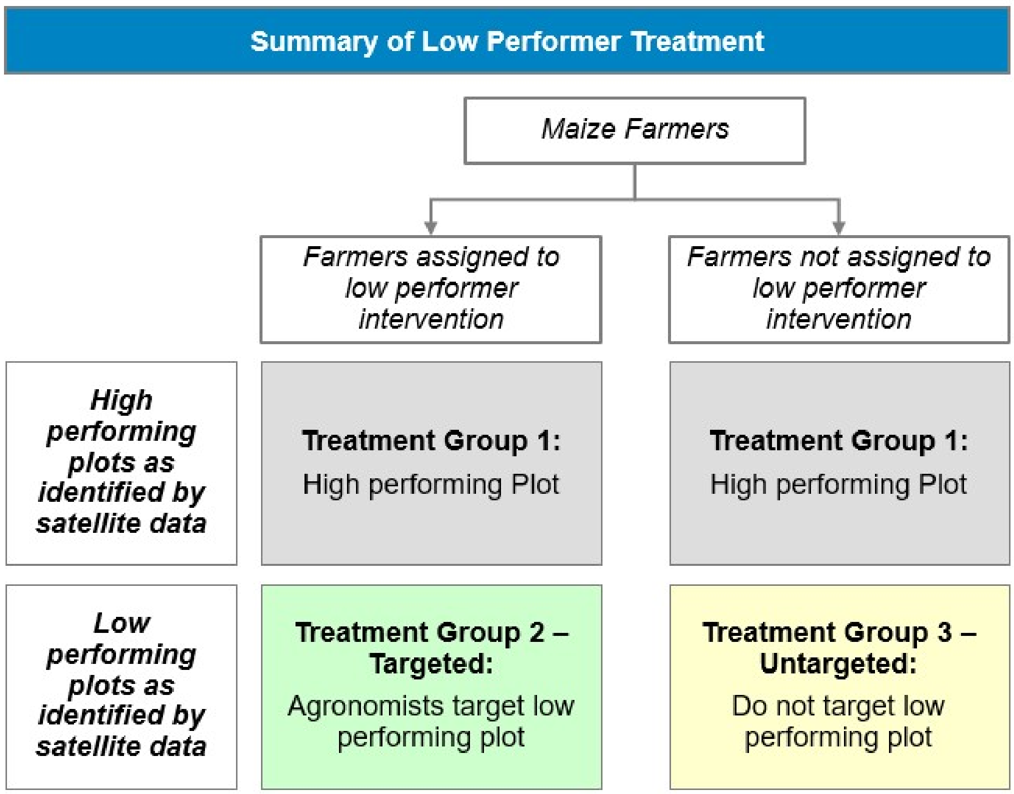


Figure 1: Summary of the low performer treatment process.

In terms of the satellite data specifications, we use the Green Chlorophyll Vegetation Index (GCVI) as our preferred index. This selection was done after careful reading of remote sensing literature which was relevant to our crops. GCVI can capture canopy greenness to a greater degree than other indices such as NDVI. Furthermore, it has previously been used to estimate maize productivity in a developing economy context.

For the low performer process, we randomize the sample at a farmer level into treatment and control groups. We also stratify by farm size and double-check that the sample is balanced.

Using the maximum value of median GCVI between 40-55 days after sowing, we identify plots

[5] For a discussion on the efficacy of remote sensing to estimate yield, see Lobell et al. (2020).

above or below the sample median. The latter (i.e., plots below the sample median) are considered low performing plots and are the only ones in the treatment group that are targeted and receive on-ground intervention.

For the on-ground intervention, B Bank sends an agronomy team to each targeted plot to investigate potential issues, and subsequently provide advisory services based on the issues at hand. This is done through a low performer advisory form (please refer to Appendix Figure A.2). Both the issues identified and the advisory provided are recorded on the form, which is shared with us at the end of the intervention.

Our estimating equation for the low performer intervention is the following:

$$y_{pf} = \eta_0 + \eta_1 * T_f + \varepsilon_{pf}$$

Our coefficient of interest is $\eta_1$; it is the average difference in outcomes associated with being assigned to the low performer treatment.

## 4 Preliminary Findings

### 4.1 Maize report

In spring 2021, 78 maize farmers with over 3,000 acres of land from Okara enrolled in the project. The farmers were surveyed at the time of sowing and harvesting. The data collected was primarily related to yield, price, revenue, and costs to evaluate the effectiveness of the project. Furthermore, we used plot geocoding to determine crop health at the plot-level using remote sensing, see Section 4.2 for details.

Our results are based on comparing B Bank-contracted plots and non-B Bank plots for the same group of farmers.

Before sowing began, we conducted soil testing for a randomly selected subset of contracted and non-contracted plots. We found that there was no significant differences in soil health between land that was allocated to B Bank and land that was used for personal farming. In our survey form, we have also asked farmers how they decided which part of their land to allocate to B Bank. There was no systemic pattern that determined land allocation. The combination of soil tests and survey responses provide re-assurance about the validity of our empirical strategy.

Our overall findings from this crop cycle suggest that removing transaction costs associated with the traditional supply chain can result in material efficiency gains.

We find that B Bank plots yield 106 maunds per acre[6] on average compared to 102.1 maunds per acre[7] for non-B Bank plots, suggesting that any productivity gains from enrolling in the project are marginal.

B Bank farmers report getting PKR 1,310 per maund on average from the contracted bulk buyer, compared to an average of PKR 1,250 being offered in the market (net of all intermediary deductions). Therefore, the formal market making process resulted in better pricing for clients by eliminating costly frictions embedded in the traditional market.

Average revenue per acre for B Bank farmers is PKR 139,000 per acre compared to PKR 128,000 per acre on average for non-B Bank farmers in the region; an increase of 28%. This difference is primarily due to the superior price offering by B Bank, since yield is similar for both sets of plots.

B Bank has also provided an edge to farmers through its economies of scale and forward contracting. We find that the bank has provided inputs to its contracted farmers at a 7% lower cost than the market. This is because B bank facilitates the procurement of inputs before sowing when prices are lower than usual. During the crop cycle input prices rise as region-wide demand for inputs increases.

In terms of overall costs, B Bank-contracted plots have a cost of PKR 54,100 per acre, on average, versus PKR 74,600 for non-B Bank plots. This is a difference of around 27%. Apart from lower input costs offered by B Bank, the difference also stems from a more efficient use of resources on B Bank-contracted plots. B Bank-contracted plots have a slightly higher yield than non-B Bank plots, but have a significantly lower cost associated with them. These efficiency gains are directly linked to the agronomic advisory provided by B Bank's field team.

Given the higher price and noticeable cost difference, B Bank-contracted plots report a profit of PKR 85,200 per acre while non-B Bank plots report a profit of PKR 46,400: a difference of 84%. Therefore, B Bank's project has positively and significantly impacted farmer profitability.

Apart from analysing metrics like productivity and profit, we have also assessed farmer feedback

[6] 10,500 kilograms per hectare. One maund equals 40kg.
[7] 10,100 kilograms per hectare

to B Bank's product and services, and their overall assessment of the agriculture value chain. 72% of the farmers agreed that using the bank as an intermediary is significantly more convenient than working with a traditional *arthi*.

Furthermore, 85% of farmers have said their incomes have been markedly higher this year. A third of the farmers report renting or purchasing more land for the next crop cycle by using their additional profits earned through the program. Additionally, more than half the farmers are interested in other banking products, including personal and agriculture loans.

### 4.2 Satellite data

Our analysis shows that remotely sensed GCVI is highly correlated with farmer-reported yields. Figure 2 displays a scatter plot of farmer reported yields against the median GCVI value of a plot during the maize flowering period (70-80 days after sowing). As shown in the figure, plots with higher yield per acre generally also have a higher index value of the GCVI. This positive correlation exists across all types of plots i.e., it is not only limited to B Bank plots that are receiving the program's product and services.

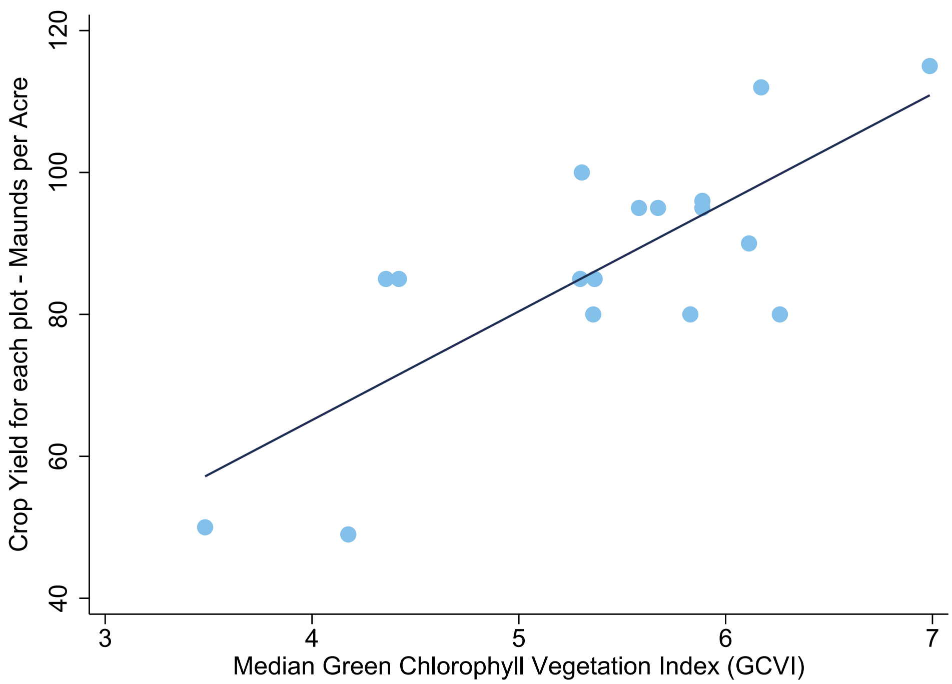


Figure 2: Farmer-Reported Yield vs. Median GCVI Values. Median GCVI value is the across plot median of the maximum GCVI value reported for a plot during the first phase of the maize flowering season (70–80 days after sowing).

Satellite data is available at a high enough frequency and resolution to be able to detect differences in crop health across plots owned by the same farmer. This fact is evidenced by Figure 3, which maps the GCVI time-series for two separate B Bank plots managed by the same farmer. The red line is for a plot where farmer reported yield was only 49 maunds per acre, whereas the green line is for a plot where the yield was 95 maunds per acre. Around 60 days after sowing, we can clearly see a divergence in the GCVI values for the two plots, with the eventual higher productivity plot consistently reporting a greater GCVI index. These findings suggest that satellite data-based indices can identify low performing plots in the middle of a harvest cycle. The bank can then provide targeted advice or enhance monitoring of these lagging plots to ensure that they catch up with healthier plots in advance of harvest, as is done through our low performer treatment arm.

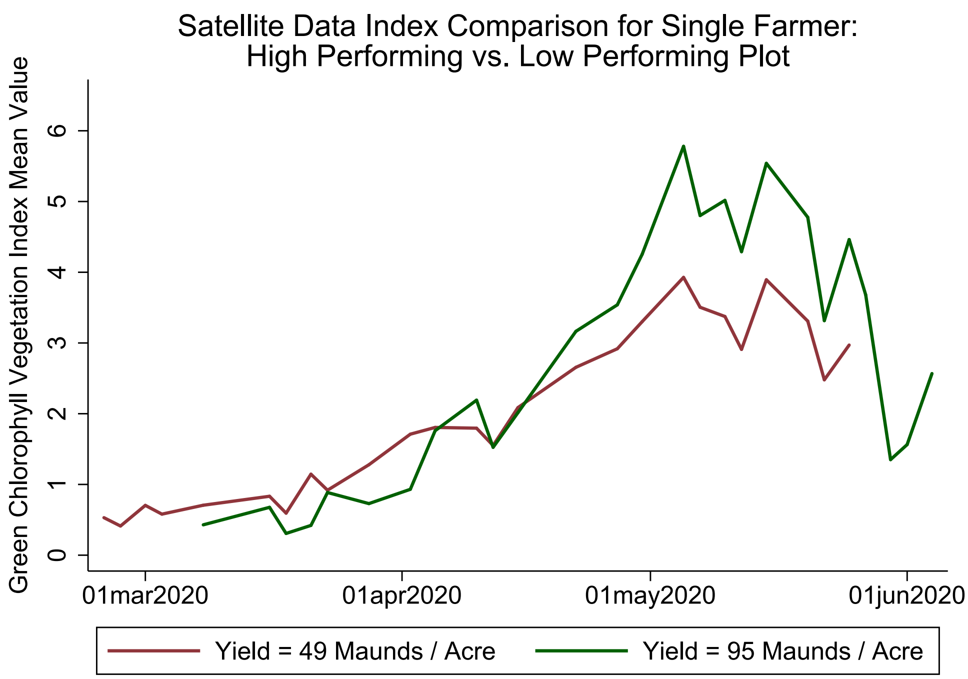


Figure 3: This figure plots the time series of median GCVI values for two plots managed by a selected B Bank farmer.

The findings of the low performer intervention have been interesting and diverse in nature. Firstly, crop health risks such as waterlogging, and pest attacks have been detected in some of the plots. In other cases, we have discovered sowing date discrepancies within a single plot, which means that a farmer had sown maize at different intervals on the same plot of land.

Our low performer analysis is also well-equipped to flag non-compliance issues, such as side-selling and early harvesting, which can pose a risk to B Bank's investment in these farms. Most interestingly, there is one plot in which wheat was inter-cropped with maize, while B Bank's team did not have this knowledge. B Bank only discovered this issue because our remote sensing approach flagged this plot as a low performer.

Using our algorithm, we generate plot-level heatmaps that give us a real time picture of the health of each maize plot. Heatmaps offer a great way of identifying potential discrepancies within a plot. The greener the heatmap, the stronger the crop health, and vice versa. As shown in the figure, the plot's unusual patterns and shifts in greenness alerted us about the possibility of a discrepancy, which eventually led us to detect the presence of wheat crop inter-cropped with maize on this plot.

We also observe that low performer identification directly impacts farmer behaviour. When farmers were informed by B Bank's field team that they were being monitored "from the sky," not only were they awed, but they also became more vigilant and less likely to obscure or conceal relevant information about the crop. This procedure ensures that farmers could not conceal any crop-related information from B Bank's field team, since satellite data will reveal any discrepancies. Overall, this intervention provides great promise with regards to the capacity and potential for remote sensing to positively influence yield, and reduce non-compliance, during a particular crop cycle.

## References

Adamopoulos, Tasso and Diego Restuccia (2014). "The size distribution of farms and international productivity differences." In: *American Economic Review* 104.6, pp. 1667–97.

Conley, Timothy G and Christopher R Udry (2010). "Learning about a new technology: Pineapple in Ghana." In: *American economic review* 100.1, pp. 35–69.

Corral, Carolina et al. (2020). *Autonomy and Specificity in Agricultural Technology Adoption: Evidence from Mexico*. Tech. rep. National Bureau of Economic Research.

Foster, Andrew D and Mark R Rosenzweig (2017). *Are there too many farms in the world? Labor-market transaction costs, machine capacities and optimal farm size*. Tech. rep. National Bureau of Economic Research.

Gollin, Douglas, David Lagakos, and Michael E Waugh (2014). "The agricultural productivity gap." In: *The Quarterly Journal of Economics* 129.2, pp. 939–993.

Herrendorf, Berthold and Todd Schoellman (2015). "Why is measured productivity so low in agriculture?" In: *Review of Economic Dynamics* 18.4, pp. 1003–1022.

Lagakos, David and Michael E Waugh (2013). "Selection, agriculture, and cross-country productivity differences." In: *American Economic Review* 103.2, pp. 948–80.

Lobell, David B et al. (2020). "Eyes in the Sky, Boots on the Ground: Assessing Satellite-and Ground-Based Approaches to Crop Yield Measurement and Analysis." In: *American Journal of Agricultural Economics* 102.1, pp. 202–219.

Restuccia, Diego and Raul Santaeulalia-Llopis (2017). *Land misallocation and productivity*. Tech. rep. National Bureau of Economic Research.

# A Appendix

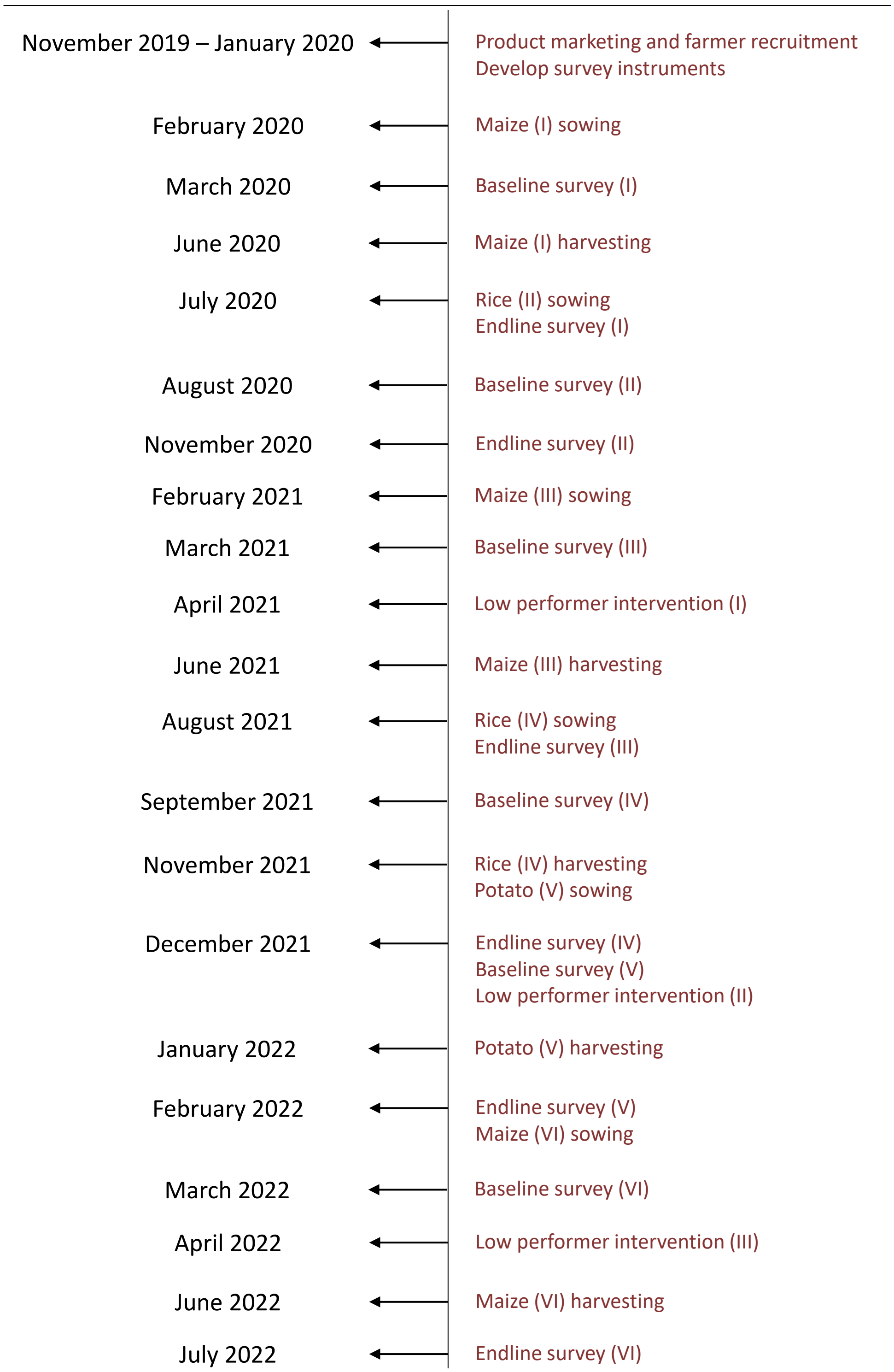


Figure A.1: Project Timeline

**AGRONOMY ADVISORY FORM**

**Section A (pre-filled)**

| | |
|---|---|
| Farmer Name | |
| Farmer CNIC | xxxxx-xxxxxxx-x |
| Farmer Phone No. | 03xx-xxxxxxxx |
| Region Name | N/A |
| Plot Number | 03 |
| Plot Coordinates | |

*Shaded area indicates target plot*

**Section B (to be filled by FO/Agronomist)**

FO/Agronomist Name ______________________

Reporting Date ____________

Issue(s) Identified (select all that apply) Pest ☐ Weather ☐ Fertilizer ☐ Water ☐ Other ☐

Details of Issue(s) Identified:

Advice Provided to Farmer:

Agronomist's Comments:

*NOTE: After completing the form, send the plot picture to your supervisor (Agronomist) via WhatsApp with the same "Farmer Name" and "Plot Number" (for example, "Murtaza Kamal 03")*

FO/Agronomist's Signature ______________________ Date ____________

Figure A.2: This figure shows the pre-filled form sent to the B Bank agronomy team. After identifying a plot as a low performer (relative to the entire sample), farmer details are included along with a map of the farm's constituent plots.