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# KhetScore

## Impacts of using digital technologies to unlock credit and insurance for marginal farmers in Odisha

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**Agriculture, fishing and forestry**



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# KhetScore: Impacts of using digital technologies to unlock credit and insurance for marginal farmers in Odisha

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## Summary

Many small and marginal farmers in developing countries lack the liquidity necessary to purchase inputs that could increase their productivity. They are often further limited in their ability to access credit because they lack the necessary collateral or documented land rights. In addition, their reliance on agriculture inextricably links their livelihoods to an increasingly variable natural environment.

Together, these liquidity, credit, and risk constraints make it difficult to cope with frequent weather shocks and prevent potentially profitable investments in their farms that could raise them out of poverty traps. Reducing risk and promoting investments that increase agricultural productivity are therefore important strategies to reduce hunger and poverty, enhance incomes and food security, and strengthen the resilience of the world's poor.

This report describes the design and endline survey findings of an impact evaluation of "KhetScore" an innovative, proprietary credit-scoring methodology developed by Dvara E-Registry (DER) that uses digital technologies, including satellite remote sensing combined with ground reference data, to unlock credit and insurance for small and marginal farmers in Odisha, a state in eastern India.

This impact evaluation serves as a case study to provide insights into how digital technologies can help to improve agricultural risk management. The project evaluated a novel financial product that has, in theory, the potential to ameliorate credit constraints by eliminating the need for documented land rights and burdensome collateral, while simultaneously allowing farmers to manage weather-related agricultural risks.

KhetScore leverages emergent digital technologies—such as satellite imagery and other remote sensing, coupled with machine learning and crop analytics—to generate farm-specific credit scores even in the absence of land titles. It thus expands and increases the inclusivity of rural credit. At the same time, loans provided under this scheme are coupled with a crop insurance product that can compensate the lender in the event of adverse conditions, thus alleviating collateral requirements and helping farmers to decouple agricultural investments.

We implemented a cluster-randomized trial with approximately 1,800 potential KhetScore clients from 58 villages in the district of Jajpur in eastern Odisha. These 58 villages were randomized into two groups: a treatment arm and a control arm. In the treatment arm of 29 villages, farmers were offered a digital credit product bundled with insurance to protect them from the risk of crop failure. In the control arm, also comprised of 29 villages, farmers were not offered loans based on the KhetScore credit scoring methodology but may have accessed other sources of credit. Both the KhetScore loans and crop insurance offered in the treatment arm relied on satellite imagery and smartphone pictures for crop monitoring.

Through this randomized trial, we analyzed how recent advances in remote sensing and crop analytics can reduce transaction costs and overcome information asymmetries and documentation requirements in the provision of financial instruments for marginal farmers. We also analyzed the extent to which this improves farmers' access to credit and insurance, increases investments in agriculture, raises farm incomes, and enhances food security and well-being. The evaluation was designed to test this hypothesis, paying

particular attention to gender, since women and other marginalized farmers are less likely to hold documented land rights, thereby restricting their access to credit and insurance. KhetScore aims to address precisely these barriers that are most pronounced among women and other marginalized farmers.

At baseline, we found evidence supporting this hypothesis. While women expressed lower demand for credit and were less likely to take up credit, baseline findings suggested that the intervention may have larger effects for female clients. Women, more often than men, reported that the introduction of KhetScore, and its bundling with insurance, would make them more likely to apply for loans and that they would be interested in borrowing larger amounts.

During this impact evaluation, we found beneficial impacts on a wide range of agricultural, gender parity, and mental health outcomes. In particular, the evaluation demonstrated the potential for KhetScore to have transformative effects on the rural economy by increasing financial literacy, credit and insurance uptake, farm profits, and women's empowerment, and easing some of the mental health stresses that often accompany near-subsistence agriculture.

The evaluation also faced several challenges. First, during the ongoing COVID-19 pandemic, the baseline survey (held in early 2021) was administered by phone, and therefore components had to be split into three separate rounds; this reduced response rates over time, especially among family members who were not directly targeted by Dvara E-Registry. In-person data collection, which took place in the endline survey, helped to increase response rates among this respondent group.

Second, our power calculations that followed baseline data collection showed that a lower number of clusters (due to implementation challenges and a realignment of project partners), and higher than expected intra-cluster correlations for targeted impact variables, worsened our minimum detectable effect sizes relative to those found in the initial power calculations (prepared prior to research activities).

Throughout the project, we coordinated closely with Dvara E-Registry to ensure high levels of uptake of the intervention to minimize further losses in statistical power. However, for outcomes on rabi season production, when fewer farmers cultivate, we sometimes found that statistical power was too low to detect meaningful effects.

Finally, the insurance product bundled with KhetScore loans rarely triggered payouts, in part because the evaluation was focused on three seasons in good-weather years. This suggests that the impacts reported in this evaluation are not driven by ex-post insurance payouts, but by either the ex-ante risk reduction provided by the insurance product, or the provision of credit to a population with limited options to access liquidity for their farms. Disentangling the effects of credit and insurance, and assessing the impacts of the bundled solution in years with worse weather conditions, remain areas for future research.

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## Abbreviations and acronyms

| | |
|---|---|
| DER | Dvara E-Registry |
| IFPRI | International Food Policy Research Institute |
| MFI | Microfinance institution |
| PMFBY | Pradhan Mantri Fasal Bima Yojana |

# 1. Introduction

The livelihoods of approximately two billion people—or 26.7% of the world population—livelihoods depend on agriculture (FAO 2018). Agriculture is an important source of income, especially for households living in rural areas of low- and middle-income countries. In 2017, the agricultural sector accounted for 57.4% of the total employment in sub-Saharan Africa and 42.2% in South Asia (ILO 2018).

Smallholder farmers, however, frequently lack access to formal financial services that can help them to investment in agriculture. Furthermore, agriculture is inherently risky, as farms are exposed to extreme and increasingly variable weather conditions and other natural hazards, such as pests and diseases. To reduce their risk exposure, farmers tend to diversify, investing in low-risk activities that reduce expected production and incomes.

The combination of risk and liquidity constraints prevents farmers from expanding their farms and investing in high-risk but profitable cash-crop activities or productivity-enhancing technologies, such as improved agricultural inputs, irrigation, and machinery. These constraints also prevent them from capturing the full range of benefits from specialization, causing a loss of efficiency and potentially trapping farmers in a low-level, steady-state equilibrium. Reducing risk, increasing liquidity, and promoting investments that increase agricultural productivity are therefore important strategies to reduce hunger and poverty, enhance incomes and food security, and strengthen the resilience of the world's poor.

Due to their marginal landholdings, the private sector often considers the transaction costs of working with smallholder farmers to be too high to offer formal financial products such as credit and insurance. Markets for such products are also challenged by asymmetric information about farmers' risk exposure and their ability to repay.

For instance, indemnity insurance—the main form of agricultural insurance provided in developed countries—is too expensive to provide to smallholder farmers in remote areas, as it requires on-site loss verification by a specialized insurance adjuster. It can also be prone to information-asymmetry problems, such as moral hazard or adverse selection, thus increasing premiums to unsustainable levels (Hazell, Pomareda, and Valdés 1986). Small and marginal farmers also often lack the documented land rights required by banks as collateral, or by government-sponsored financing schemes to determine eligibility for loan or insurance program subsidies.

This report describes the findings of an impact evaluation of KhetScore, an innovative tool that employs digital technologies to unlock credit and insurance for small and marginal farmers in the state of Odisha in eastern India. This innovation leverages the increasing availability of high-resolution satellite data, computational power and image processing analytics, increased smartphone penetration, and expanding mobile network coverage in rural areas.

Together, these factors have introduced new methods to monitor crops and management practices, assess crop damage, and estimate yields for marginal farmers with small landholdings—thereby enabling new applications in the provision of agricultural credit and insurance. Large-scale programs for agricultural risk management

have indeed begun to adopt digital technologies, for example the use of remote sensing to predict livestock mortality to provide pastoralist farmers with a social safety net (Chantarat et al. 2013), or improved weather-based modeling of food insecurity and associated humanitarian response costs to facilitate risk pooling and insure countries against drought (Kramer, Rusconi, and Glauber 2020).

At the same time, it is important to evaluate the impacts of these technologies, as such advances do not guarantee improved access to high-quality credit and insurance, or increased investment. Reliable and cheap assessment of production losses remains challenging in complex landscapes.

Moreover, even as yield-estimation techniques improve, the value of an index insurance contract for the insured depends largely on how well it captures losses when people suffer most. Strategically improving the collection and accessibility of reliable ground-referenced data on crop types and production could facilitate this task. The effective use of digital technologies requires blending technical knowledge of both their capabilities and limitations, with an understanding of their influence on the value of programs to increase access to rural credit or agricultural risk management (Benami et al. 2021).

To fill this gap, this impact evaluation assessed how KhetScore, through its use of remote sensing and crop analytics, can reduce transaction costs and overcome information asymmetries and documentation requirements in the provision of financial instruments for marginal farmers. It also investigated the extent to which this improves their access to credit and insurance, investments in agriculture, incomes, food security, and well-being. The evaluation pays particular attention to gender, since female farmers frequently lack the documented land rights required by formal lenders to qualify for a loan—a condition that KhetScore has the potential to eliminate.

The remainder of this report is structured as follows. Section 2 describes the intervention, including an overview of our theory of change and monitoring plan. Section 3 presents our evaluation questions and methods, including the design and timeline of the evaluation, ethics, sampling and data collection methods, secondary data, and our empirical specification based on our trial registry and pre-analysis plan.

Section 4 describes the findings on the intervention’s implementation fidelity, descriptive statistics, and baseline balance, and impacts as estimated from the endline survey data at both the aggregate level and for male versus female farmers, followed by a discussion of cost effectiveness in Section 5. Section 6 presents major challenges and lessons learnt and concludes with recommendations for policymaking and future research.

# 2. Intervention

## 2.1 Description

The project evaluated the impacts of KhetScore, an innovative tool that uses digital technologies to unlock digital credit and insurance for small and marginal farmers in Jajpur district in the eastern Indian state of Odisha. KhetScore was designed by our implementing partner, Dvara E-Registry (DER), a social enterprise operating at the intersection of agriculture and financial technology (“fintech”) in India.

KhetScore provides a means to: (1) digitize information on a farmer's land parcels, even in the absence of documented land rights; (2) create plot-level agricultural credit scores by estimating past and current productivity from satellite imagery, with smartphone images used as a source of ground-truth information; and (3) verify crop damage a farmer may have experienced due to extreme weather or other natural hazards, in order to resolve insurance claim settlements. The resulting plot-level KhetScore reports inform financial institutions in the provision of their credit and insurance products, with automatic and instant disbursement of credit when investments are due, and crop insurance coverage to help farmers de-risk their crop loans and agricultural investments.

DER applied KhetScore to strengthen the provision of financial services in the context of our impact evaluation through the following activities:

1. **Product training:** As a first step, interested clients were trained on the new product in two blocks of Jajpur district. DER had initial financing from a small COVID-19 pandemic response grant to de-risk agricultural credit, and from its parent company, the Dvara Trust (a trust fund based in Chennai, India).[1]

   After successfully demonstrating the viability of the KhetScore model, DER attracted additional financing from other financial service providers, most importantly Avanti Finance, a private firm based in Bangalore, India. DER organized product trainings for a mix of male and female farmers. With assistance from frontline workers (*krushak sathi*), DER coordinated all field-level activities for this project.

   Two to three *krushak sathi* were deployed per block (sub-district administrative unit) and reported to the DER project coordinator. They were heavily involved in activities such as mobilizing farmers and facilitating trainings and meetings in the field.
2. **Loan applications and insurance enrolment**: After completing the product training, interested clients had an opportunity to apply for a new crop loan. Farmers taking out loans were also signed up for a bundled insurance product from HDFC ERGO General Insurance; however, they could register for the insurance alone if they were not interested in crop loans.

   Insurance premiums were fully subsidized, but the ultimate goal was to integrate them into the loan cost; farmers enrolling only in the insurance would need to pay for the full premium. The sum insured was INR 30,000 per acre, regardless of whether the farmer signed up for insurance while taking a loan, or took insurance as a stand-alone product. Risks covered by the insurance product included excess rainfall, hailstorms, wind, animal attacks, pests, diseases, landslides, and localized unseasonal rainfall during the harvest period.

[1] We were initially planning to work with loans underwritten by microfinance institutions (MFIs), but lockdowns to curb the spread of COVID-19 made it difficult for the microfinance sector to collect repayments from customers, and the increased risks perceived among banks and other financial institutions reduced total funding available for MFIs. With support from the CGIAR Platform for Big Data in Agriculture and the Dvara Trust, we established a guarantee fund that supported this project by covering DER for possible defaults. This guarantee fund helped DER to move forward with independent lending operations without relying on an MFI, and to disburse loans tailored to agricultural operations.

3. **Plot-level agricultural credit ratings**: DER agents registered the personal details of applicants and submitted georeferenced images of their plots through a dedicated smartphone application, “Doordrishti.” These georeferenced images were used to digitize the location and area of the parcels on which a farmer was growing crops.

   Using this information, combined with satellite imagery, the KhetScore methodology was used to generate plot-level agricultural credit scores, which were meant to predict a farmer’s potential cash flow from agriculture. DER uses the following six variables to construct a KhetScore, with varying weights depending on a variable’s impact on predicted cash flows: productivity (with a weight of 40%), changes in health or vegetative growth (20%), moisture (15%), mechanical damage (13%), nutrient availability (7%), and land area (5%). DER used KhetScore reports to approve loans and determine their size.

   Specifically, a KhetScore could range between 20–100 points, and plots with a value of 50 points or higher were approved for a loan. DER specifically targeted farmers who had a KhetScore exceeding 40, indicating reasonable creditworthiness. This criterion helped in assessing the farmers' financial stability and their ability to manage loans responsibly.
4. **Loan disbursement and crop monitoring:** DER disbursed crop loans for approved applications, and initiated crop monitoring based on regular repeat images of the registered plots. These images were captured and submitted by DER field representatives once every two weeks for each registered plot. The initial idea was that farmers could use these images to demonstrate acceptable management of loaned funds and use them to request additional tranches of the loan for subsequent phases of the season (e.g., to finance additional inputs or labor for harvesting during years that farmers expect higher yields), although we have limited data on the extent to which this actually happened. Clients repaid their loans after harvest.
5. **Claims processing and loan repayment**: Crop images allowed the project partners to monitor crops, particularly the extent to which a crop was visibly damaged by natural causes not captured by the index (e.g., idiosyncratic drought risk, hailstorms, floods, pests, disease). The timing of crop damage (i.e., the crop growth stage during which a natural hazard occurred) was used in determining crop losses. This was performed by independent agricultural experts working with DER, who reviewed the pictures anonymously, and declared a percentage of visible crop losses for each registered plot. These image-based loss assessments were then used to trigger crop insurance payouts.

   Eligible farmers received their payouts directly from our insurance partner (HDFC ERGO) into their bank account and could use these towards loan repayment. However, as farmers were the recipients of these insurance payouts, they could choose to use them differently and optimize the use of funds. In future, the insurance and loan products maybe be integrated more formally into an interlinked risk-contingent credit solution.

The KhetScore credit facility was designed around agricultural operations. Future loans were provided to farmers in a subsequent season subject to timely repayment of prior

loans and availability of funds, but farmers were granted a certain degree of flexibility in loan repayment to maximize the chances that they would be able to repay. In the rare case that a farmer did not repay a loan, the concerned *krushak sathi* and project manager would work with them for proper follow-up and counseling. Also, farmers could be granted additional time to repay the loan when the reason was genuine.

## 2.2 Theory of change

The central premise behind our theory of change (Figure 1) is that risk and credit constraints cause marginal farmers to underinvest in commercial agricultural activities. Access to sound financial instruments is limited because of asymmetric information in credit and insurance markets, which becomes a problem especially for small farmers who lack documented land rights as collateral or means of verification for government-sponsored programs, such as the national crop insurance scheme, Pradhan Mantri Fasal Bima Yojana (PMFBY), to support crop farming.

The main option for these farmers to finance their investments is to use informal credit or group loans from a microfinance institution (MFI). Such loans are uninsured, and farmers often risk social sanctions when unable to repay, which may discourage them from investing in profitable agricultural activities that could expose them to the risk of being unable to repay their loan. In describing our theory of change below, we will discuss the inputs (I) that were employed in the generation of outputs (O), subject to some maintained assumptions (A). In this evaluation, we will analyze whether these outputs assisted in the realization of a series of primary outcomes (PO).

This project introduced farmers to new agricultural credit and insurance products (I1). If this activity reached credit-constrained and risk-rationed farmers (A1), we expected higher awareness among our target group (O1). The lender offered farmers the opportunity to apply for the product with georeferenced crop images in lieu of land records to verify access to land (I2).

If farmers were interested in the product, and their main constraint was an absence of land records (A2), we expected approximately 50 of the targeted clients to successfully apply for the product (O2) (expected demand was high because we were targeting a population that had already expressed an interest in agricultural credit by participating in the product training).

The lender (DER) used remote sensing and crop images to monitor production, and disbursed loans based on this (I3). We assumed that DER field staff could send in crop images (A3). Our hypothesis was that this facilitated the automatic and instant disbursement of credit when investments were due (O3).

The crop images, along with weather and/or vegetation data, were also monitored in claims settlements; in cases where farmers incurred significant losses due to natural causes, the insurance would trigger payouts towards loan repayment to reduce the risk of farmers being unable to repay and become too indebted (I4). An important assumption here was that the insurance index, combined with crop images, provided an accurate assessment of production losses, and that farmers with unaffected levels of production would not fail to repay (A4). Through this mechanism, insurance could enhance repayment rates (O4).

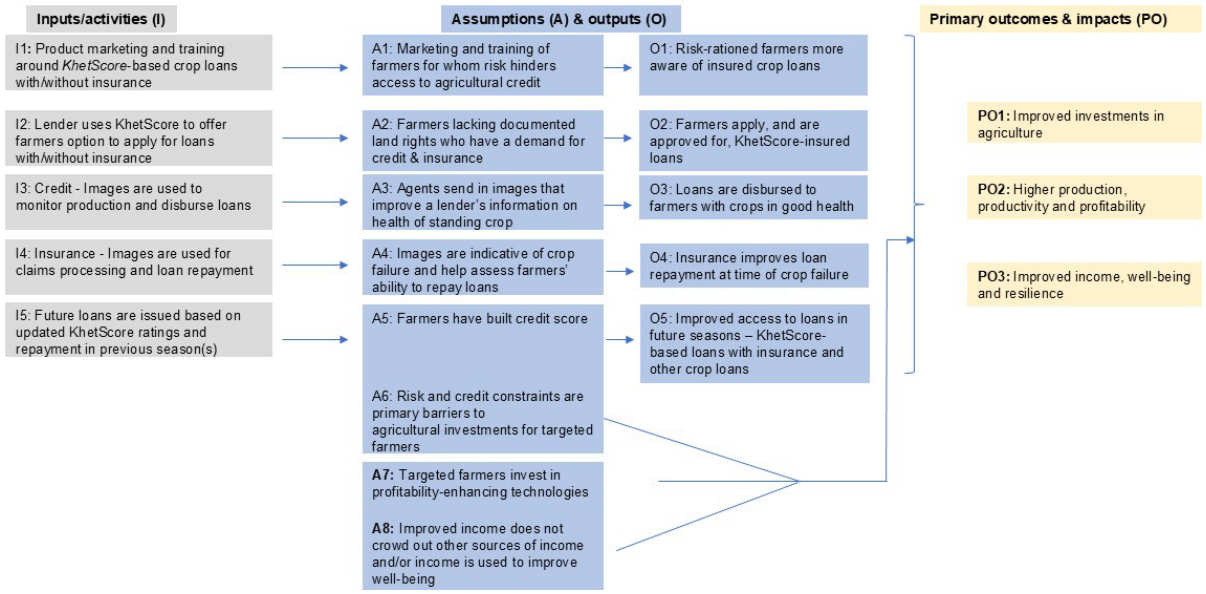
In subsequent seasons, farmers could reapply for the loans on the condition that they had not defaulted on previous loans (I5). We assumed that farmers satisfied with the product would still be interested in taking credit in subsequent seasons, but farmers would also have begun building their credit scores (A5), which would result in continued uptake of either the insured credit product or other formal loans (O5).

Assuming that risk and credit constraints were the primary barriers to agricultural investments for tenant and landless farmers (A6), we expected that there would be high demand for the products, and the loans would increase investments in agriculture. The terms of alternative sources of credit are generally unfavorable towards investments in profitable but risk-increasing cropping activities, and DER aims to improve upon these terms through its KhetScore methodology.

We expect insurance to encourage farmers to invest their crop loans in profit-optimizing instead of risk-avoiding cropping activities (PO1). This would lead to enhanced production and profitability (PO2), but only if farmers have the capacity to invest their money in the right technologies (A7). Improved income from agriculture—if it does not crowd out other sources of household income and is used for household gains such as health, education, assets, or savings, instead of temptation goods (A8)—would improve household income, well-being, and resilience (PO3).

The intervention could have had unintended negative consequences if farmers did not understand the product terms (e.g., the requirement to upload images of crop damage to be eligible for insurance coverage). Through investments in training, and putting in place a network of field agents, DER ensured that farmers who applied for credit and insurance understood how the product worked and the conditions under which they would receive payments. In addition, the field team carefully monitored and acted upon any negative incidents.

**Figure 1: Graphical depiction of theory of change**



## 2.3 Intervention monitoring plan

Our monitoring plan to track intervention rollout was closely linked to the theory of change and included indicators for the number of farmers (and the percentage of tenants/landless farmers) who:

1. Were trained on the new digital financial product and adequately aware (measured using a post-training test);
2. Were given the opportunity to apply for the new KhetScore loan and crop insurance product to protect the loan from the risk of crop failure;
3. Applied for the loan, and insurance coverage, through the Doordrishti app, a smartphone app developed for this project;
4. Were approved for the loan, as well as the total loan amount for which the farmer was approved, the total number of tranches in which the loan was to be paid, and average interest rates;
5. Sent in crop images to comply with requirements to receive loan and insurance claims (through DER field staff);
6. Received their loans on time (and for farmers who did not receive their loan on time, the average number of days by which the loan was delayed);
7. Reported crop damage due to natural causes and filed an insurance claim (through DER field staff);
8. Received insurance payouts towards loan repayment (and number of days needed for the claims settlement) (farmers who reported crop damage versus those who did not);
9. Repaid their loan (and the average number of days by which loan repayment was late) (separately for farmers with and without insurance); and
10. Were given the opportunity to reapply for the loans (separately for farmers who repaid their loan on time and those who did not).

We report on most, but not all, of these indicators in this endline report. We were unable to administer a post-training test, as the loan trainings were conducted during periods of COVID-19-related lockdowns, and in-person data collection would have been a large risk with benefits too small to make it worthwhile. The parameters within which loans were granted were already fixed and we did not approve loan amounts, nor determine other loan characteristics (Item 4). Crop images (Item 5) played a less important role in the intervention than initially anticipated and are therefore not reported. Data on the timing of the loan disbursements were collected through self-reported survey data.

Though repayment data is available, it shows very limited variation, which is why we do not discuss Items 9 and 10 in our intervention monitoring plan—given that they were related to analyzing whether insurance is connected to farmers' ability to repay, and whether preventing defaults through insurance can help farmers to secure access to future loans. For the same reason, we will wait until larger numbers of observations on repayment are available before working with DER to validate KhetScore, which is done by monitoring its accuracy in terms of farmers' actual ability to repay, and the repayment rates. This will be done in two ways:

- Comparing KhetScore reports with ground data (such as yields and agricultural profits) collected at the time of harvest through phone surveys and in-situ measurements; and

- comparing KhetScore reports with loan repayment behavior (whereby we will consider whether the client repays timely, partially, or becomes delinquent).

We will compare these metrics with those used by DER and other financial service providers to issue loans.

# 3. Evaluation questions, design, methods, sampling, and data collection

## 3.1 Primary and secondary evaluation questions

The overall objective of the impact evaluation was to assess the costs and benefits of using technology in the provision of financial services, particularly credit and insurance, to smallholder farmers. By providing a means to verify operational landholdings, monitor crop performance and agricultural management, and estimate damage for claims settlement, technology can help to improve overall product quality, reduce basis risk in crop insurance, and enhance access for small and marginal farmers without documented land rights. Our main evaluation questions were as follows:

1. Can financial institutions rely on KhetScore-based credit scores as a cost-effective alternative in lieu of conventional credit scores and in-person visits to operationalize crop loans (measured as the extent to which KhetScore is more predictive of yields, profits, and repayment behavior than current metrics used by financial service providers to sanction loans; and by financial service providers' future willingness to pay for KhetScore reports)?
2. Can this approach, by bridging existing gaps in access to documented land rights, improve farmers' access to credit and insurance (measured as the percentage of beneficiaries with sustainable levels of agricultural credit at reasonable interest rates, the percentage of beneficiaries with insurance, as well as credit repayment rates and insurance payouts during years with and without production shocks).
3. Can the approach piloted in this intervention improve (in the short run) sustained insurance uptake, that is, renewal, awareness, perception of quality and adequacy, insurance income; (in the medium run) agricultural investments, particularly during the winter (*rabi*) season, agricultural production and profitability; and (in the longer run) household income, consumption, resilience, wellbeing, and outcomes related to gender parity?
4. To what extent are the findings from this impact evaluation driven by offering farmers the option to bundle credit with insurance to de-risk profitable yet risk-increasing investments, and how access to insured loans influences the use of alternative strategies for risk mitigation?

In the present evaluation, we are unable to adequately address the first of these evaluation questions, primarily because there was so little default that it is difficult to assess the comparative advantages of the KhetScore methodology vis-à-vis more conventional approaches to lending. In future work, as the scale of operations increases, we hope to be able to observe sufficient variation with which to assess the relative merits of the KhetScore approach. We are also limited in our ability to address the effects of the bundled loan and insurance product on household resilience (a component of primary

outcome PO3 and explicitly mentioned in evaluation Question 3) since the study period coincided with fortuitous weather conditions, implying both that households were not exposed to serious shocks and that the insurance policy paid out quite rarely. In the absence of shocks and an insurance safety net, there is little that can be learned regarding the product's impacts on resilience.

Evaluation Question 3 refers to the effects of the credit/insurance bundle on household well-being. Well-being is a subjective and amorphous concept but must be concretely defined to operationalize an evaluation of the product's effects on this concept. In the present evaluation, we use a series of measures of perceived stress, which allow us to evaluate the effect of the project on mental health, which is a relevant measure of well-being.

We tracked potentially unintended negative consequences of the intervention, especially for targeted women, which could include an increase in workload and/or increasing inequalities between women when gender norms prevent a subgroup of women from acquiring KhetScore loans and insurance products. To enhance inclusivity of the intervention, we tested whether gender-transformative workshops as part of the product trainings helped to overcome such gender barriers. However, we did not any find effect from these workshops, and therefore DER did not include them in their product trainings for the sample targeted in this impact evaluation.

An additional unintended consequence, not specifically addressed in the present evaluation, is that by making it easier for individuals to borrow money, individuals may borrow imprudently, and either find themselves in unsustainable debt or engaged in a pattern of cyclical borrowing. This may be especially relevant in circumstances in which adverse weather or market conditions make it difficult or impossible for borrowers to repay loans.

Since the product in question is bundled with crop insurance (which can compensate the lender in situations where crop failure makes it difficult for borrowers to repay), and since the weather conditions during the study period were generally quite favorable, we remain confident that these undesirable consequences were not realized. Nevertheless, this remains a concern with myriad digital-credit products, and we will be exploring the potential for a bundled product like this to minimize the risks of over-indebtedness in an extension of the current impact evaluation, with funding provided by the Digital Credit Observatory of the Center for Effective Global Action at UC-Berkeley.

## 3.2 Evaluation design and methods

The intervention was implemented in Odisha, a state in eastern India, which covers over 1.56 million hectares of land, or 4.7 percent of India's total land mass. The state has four geographical regions: the northern plateau, the central river basins, the eastern hills, and the coastal plains. This diversity creates a rich set of agro-climatic zones, including low-lying coastal areas sharing a coastline with the Bay of Bengal, exposing the state to tropical cyclones and frequent prolonged floods, and rainfed uplands that suffer from moisture stress due to variability in rainfall.

Although around 49 percent of the state's total workforce is dependent on agriculture, farming in Odisha is a vulnerable activity exposed to many extreme weather risks, such

as cyclones, droughts, and floods, as well as pest attacks. Almost every alternate year, a part of Odisha is hit by natural calamities of varying intensity.

Nevertheless, Odisha is one of the largest producers of food grain in India, particularly paddy rice, with around 55 percent of its cultivated land used for food grain production. The state has two seasons: the summer monsoon (kharif) season, during which farmers mainly produce paddy rice, and the winter (rabi) season, during which most leave their land fallow.

However, the past few years have seen an increase in the share of rabi production, particularly for high-value crops like pulses and vegetables. A 49 percent increase in irrigated land has likely played a vital role in this development. Further promotion of investments in cultivation of high-value crops during the rabi season is considered an important channel to transform agricultural livelihoods in Odisha. The state is doing so by subsidizing agricultural implements, equipment, and diesel pump sets.

The status of the government-sponsored crop insurance scheme (PMFBY) in Odisha is not so promising. According to a 2018 World Bank Environment and Social Systems' Assessment (ESSA), state departments have limited resources to implement the scheme, thereby affecting its reach. Moreover, there is a lack of technical capacity to undertake capacity-building activities for farmers and banks in rural areas.[2]

In Odisha, a large concentration of marginalized, landless farmers fall outside the purview of the PMFBY scheme. Policymakers in the state have shown a strong interest in supporting these farmers by bringing them into the formal agricultural support system, and the state is very progressive in its use of digital technologies to support tenant and landless farmers through both credit and insurance.

Odisha policymakers from the Ministry of Agriculture are highly interested in research and proofs of concept for new financial services that can help farmers to improve agricultural productivity and manage risks. DER therefore has a memorandum of understanding with the Odisha state government to expand access to credit and insurance for these farmers. The project was implemented in two blocks of Jajpur, a district in Odisha's low-lying coastal plains (Figure 2), where tropical cyclones and frequent, prolonged floods constitute the main risks to agricultural production. In this district, agricultural activities are one of the primary sources of income, with paddy rice being the dominant crop.

Irrigation is available in Jajpur due to its proximity to the Mahanadi, the largest river in the state. This creates opportunities for farmers to expand production during the rabi season, but credit and risk are often cited as primary reasons for not investing in crop production during this season. Although farmers in Jajpur have relatively higher levels of education and literacy than farmers in other districts, sharecropping and marginalization of tenant farmers is still commonplace. Intercropping is not common in these districts,

[2] World Bank. 2018. Environment and Social Systems' Assessment: Agriculture Risk Resilience Insurance Access Program (ARRIA). https://documents1.worldbank.org/curated/en/897561540919710579/pdf/Draft-Environmental-and-Social-Systems-Assessment-ESSA-Agriculture-Risk-Resilience-and-Insurance-Access-Program-P165923.pdf

making it feasible to apply the existing KhetScore technology. We therefore selected this district as our study region.

**Figure 2: Map of Odisha with markers to indicate study locations in Jajpur District**

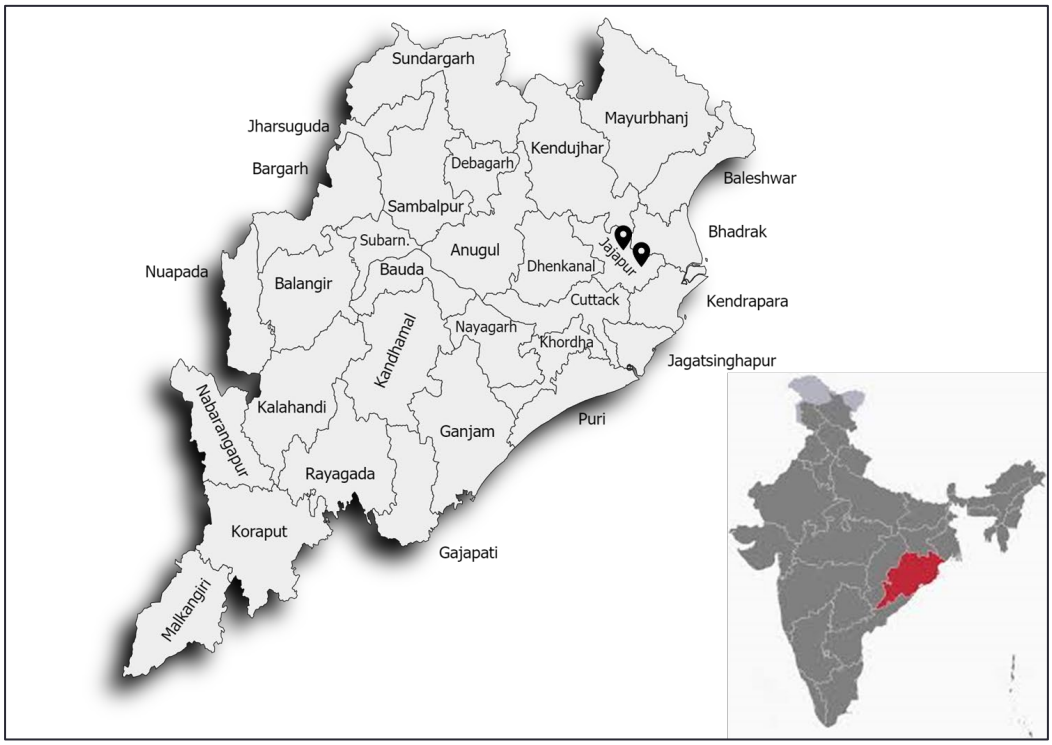



Figure 3 illustrates our impact evaluation design. We implemented a cluster randomized trial in 58 villages, from two blocks in Jajpur district (Jajpur and Dashrathpur blocks). We selected these blocks because of their high concentration of small and marginalized farmers and because of DER's existing operations in the two blocks. DER included all villages within these blocks, except those where lending operations were considered unviable due to the region's extreme flood exposure, which would have driven up insurance premiums and potentially jeopardized farmers' ability to repay their loans.

The remaining 58 villages from these two blocks were randomized into a treatment group (29 villages), where DER implemented the intervention, and a control group (also 29 villages), where DER recruited prospective clients to establish a sampling frame, without implementing any additional interventions.

DER had already been working in 25 villages in these two blocks, where it had an existing client base; however, it expanded operations to include an additional 33 villages to achieve the desired sample size.

**Figure 3: Evaluation design and sample size by treatment and control arms**



DER recruited additional prospective clients who were interested in agricultural loans (recruited clients) from all new villages, and for 9 of the 25 existing villages where DER had fewer than 10 existing clients, through their product trainings. Trainings were organized in each village with the help of the village head (*sarpanch*), regardless of treatment status. Anyone who identified agriculture as their occupation was allowed to attend. After an initial round of trainings during which the field staff had recruited primarily male clients, field staff were given explicit instructions to let go of stereotypes and not only target men, but also female household members involved in agriculture and interested in loans.

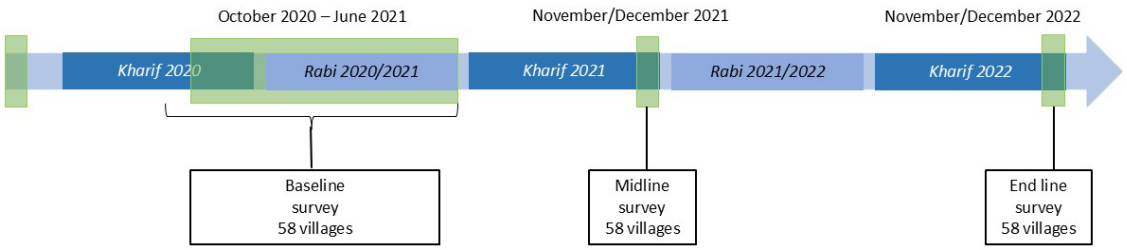
Randomization was done by researchers in private for both the 25 existing and 33 new villages prior to the product trainings implemented by DER. To ensure balancing of characteristics between treatment and control groups, we stratified villages by block; for existing villages only, we also stratified them based on whether they had an above-median number of recruited DER clients, or whether they had an above-median percentage of farmers that had taken loans in the past.

For the duration of the impact evaluation, the 29 villages assigned to the control group did not experience additional interventions by DER. In both treatment and control groups, farmers could access government crop loans and insurance (including under the PMFBY scheme) if they met the requirements around documented land rights—with the caveat that the insurance products under the PMFBY scheme were considered to have high levels of basis risk.

Figure 4 shows the timeline of the study activities. Client recruitment and the baseline survey were carried out in all 58 villages from October 2020 to June 2021. The intervention was implemented over three subsequent agricultural seasons (kharif 2021, rabi 2021–2022, and kharif 2022), with loan applications and insurance enrolment at the start of every season, and follow-up surveys at the end of the two kharif seasons in November and December.

Since the midline survey after the kharif 2021 survey was administered by phone, and focused on what farmers were planning to do in the rabi season instead of capturing our primary outcome variables, we focus on the post-kharif 2022 endline survey data in this report.

**Figure 4: Timeline of research activities**




Our initial study design included a larger number of clusters (90) for an equal overall sample size. However, due to changes in the project design from a realignment of program partners, we had to reduce the total number of clusters from 90 to 58 and increase the number of observations per cluster from 20 to approximately 30 households, on average.

We also found higher levels of intra-cluster correlation (ICC) than previously anticipated. For example, the correlation for total agricultural revenues per acre is nearly 0.25, while the ICC for the total cost of production (regardless of whether own labor is included) it is greater than 0.33. Arguably, some of the variables that were used for the preparation of the ex-ante calculations might not have been expected to demonstrate as much correlation within clusters, while some agricultural outcomes during seasons in which virtually everyone undertakes similar production (e.g., almost everyone cultivates paddy rice during the summer monsoon season) might be reasonably expected to demonstrate greater uniformity. These higher ICCs limit the additional information obtainable from each unit within each of the clusters.

We therefore updated our power calculations at the baseline. Table 1 presents the primary outcome variables that we identified at baseline, and their minimum detectable effect sizes for our baseline sample. For these calculations, we specified a statistical power of 0.8 (1 minus the probability of Type II error, $\beta$) with a significance level (probability of Type I error, $\alpha$) of 5 percent. We assumed a 50 percent uptake rate within our treatment sample.

Given the realignment of project partners, and the resulting reduction in project clusters and baseline sample size, the minimum detectable effects are larger than we had originally anticipated, and potentially larger than might otherwise be possible, other things remaining constant. In other words, the impacts of the intervention will need to be greater for us to be sufficiently powered to detect them (in some cases, greater than 1 standard deviation, assuming a 50% take-up rate). Alternatively, the uptake of the intervention would need to increase above the current assumption of 50 percent. We worked with DER to ensure that throughout each of the three implementation seasons, uptake was as high as possible.

**Table 1: Estimates of minimum detectable effect sizes for outcomes measured at baseline**

| | | | | Cohen's d (standardized minimum detectable effect) | | |
|---|---|---|---|---|---|---|
| | Mean | Std. dev. | ICC | No attrition | 5% Attrition | 10% Attrition |
| Total revenues per acre | 22,223.12 | 9,988.70 | 0.248 | 0.465 | 0.471 | 0.478 |
| Total land cultivated | 2.05 | 1.18 | 0.188 | 0.416 | 0.421 | 0.428 |
| Cost of production per acre (excluding own labor) | 13,607.34 | 5,861.04 | 0.332 | 0.527 | 0.533 | 0.540 |
| Cost of production per acre (including own labor) | | 11,919.40 | 0.353 | 0.542 | 0.548 | 0.555 |
| Agricultural profits per acre (excluding own labor) | 8,600.69 | 9,821.59 | 0.121 | 0.351 | 0.357 | 0.363 |
| Agricultural profits per acre (excluding own labor) | (3,706.84) | 13,697.25 | 0.184 | 0.412 | 0.418 | 0.424 |
| Return on investments per acre (excluding own labor) | 0.95 | 1.14 | 0.150 | 0.380 | 0.386 | 0.392 |
| Return on investments per acre (including own labor) | 0.03 | 0.60 | 0.162 | 0.392 | 0.398 | 0.404 |
| Empowerment | 0.06 | 0.91 | 0.290 | 0.498 | 0.504 | 0.510 |
| Mobility | 2.48 | 0.68 | 0.361 | 0.547 | 0.553 | 0.560 |

| | | | | Cohen's d (standardized minimum detectable effect) | | |
|---|---|---|---|---|---|---|
| | Mean | Std. dev. | ICC | No attrition | 5% Attrition | 10% Attrition |
| Minimum dietary diversity for women | 3.95 | 1.53 | 0.225 | 0.447 | 0.453 | 0.460 |
| Household dietary diversity | 7.57 | 1.36 | 0.190 | 0.417 | 0.423 | 0.429 |
| Food consumption score (method 1) | 92.37 | 33.84 | 0.353 | 0.542 | 0.548 | 0.555 |
| Food consumption score (method 2) | 81.11 | 25.83 | 0.314 | 0.515 | 0.521 | 0.528 |

*Notes: ICC = intra-cluster correlation. Power calculations carried out using baseline survey data, assuming a statistical power of 0.8 (1 minus the probability of Type II error, β) with a significance level (probability of Type I error, α) of 5 percent, and a 50 percent uptake rate within our treatment sample. Source: Baseline survey report.*

## 3.3 Ethics

The study obtained ethical approvals from the International Food Policy Research Institute (IFPRI)'s Institutional Review Board after evaluation of the study protocols and consent forms. These study protocols include several safeguards to ensure ethical data collection (e.g., all senior staff working on the project, including the IFPRI research analyst and senior DER team members, were required to take an ethics training).

Enumerator trainings also covered interview ethics. No major ethical issues occurred over the course of this study, in part due to the following safeguards that had been put in place in the study protocols:

1. Participation in the study was on a voluntary basis and all farmers received accurate information on what participation would entail before providing informed consent. Consent was gathered during each survey round, with consent forms providing the type of information required, based on international standards for human subject research.
2. There was no expected downside risk to farmers due to their participation in the study. The phone surveys were kept brief, and endline surveys did not take more than one hour per respondent. Clients in treatment arms received tangible benefits in the form of improved credit and insurance. DER had limited resources to roll out this new product, and random selection of villages to test the new product was as fair as possible.
3. We safeguarded sensitive data collected as part of the evaluation as follows:
    - Crop images, personally identifiable information, and financial information from DER and the insurer were encrypted and hosted on a secure server (SurveyCTO for survey data).
    - Before sharing data publicly one year after study completion, we will anonymize all data by eliminating personal identifiers (including direct information on GPS coordinates and identifiable structures from the crop images) to help prevent a breach of confidentiality.
    - The credit and insurance providers were not allowed to access individualized data collected through our surveys. For instance, the SurveyCTO server through which we administered the baseline survey is managed by IFPRI, not by DER staff.

4. As our study questionnaire included a number of sensitive questions, especially for female respondents, we took extra caution to train enumerators to verify that no other individuals were present during the interview. In this way, we were able to protect our research subjects from any potential repercussions and domestic disturbances after the interview.
5. Special efforts were made on both research and implementation sides to minimize the risk of project activities leading to COVID-19 transmission and to protect the safety of both respondents and field staff. Baseline and midline surveys were carried out via phone surveys. We switched to in-person data collection at endline because there was no longer a risk of community transmission. During implementation, DER closely adhered to the guidelines of the MFI Network, the self-regulatory body of MFIs in India. The guidelines issued on microcredit field operations in the context of COVID-19 (dated April 19, 2020) were as follows:
    a) Ensure that no more than four employees are present in the branch at any time.
    b) Ensure that no more than five customers are inside the branch and strictly ensure social distancing norms as prescribed by the government at all times (e.g., during customer interactions, meetings, trainings, lunchtime).
    c) Ensure that employees wear masks during face-to-face interactions, maintain social distancing norms and hygiene (regularly wash/sanitize their hands, especially after handling of cash and stationery).
    d) Ensure that group meetings and product trainings strictly follow social distancing norms, and all participants take self-precautionary measures such as wearing masks.

Finally, one of the intended outcomes of the research project is a credit model that relies less on in-person group meetings and allows lenders to monitor loans remotely.

### 3.4 Sampling and data collection

At baseline, we aimed to survey all clients who had been recruited by DER. That is, the farmer profiling meetings conducted by DER at the start of the impact evaluation served as our sampling frame, and all farmers within this sampling frame were approached for baseline surveys. Based on power calculations conducted whilst drafting the study proposal, we aimed to survey at least 1,800 farmers at baseline. Assuming a 3 percent attrition rate, this meant recruiting at least 1,854 clients through product meetings. The sampling frame ended up including 1,872 clients, of whom 1,810 were surveyed.

For the quantitative endline survey, we aimed to survey all clients who had been surveyed at baseline, as well as one other family member of the opposite sex (usually the client's spouse). The sampling frame ended up including 1,810 clients, of whom 1,621 were surveyed. We were able to identify and interview another family member for 1,294 of those 1,621 clients, for a total sample of 2,915 individuals.

**Table 2: Full study response rates**

| | Main client | Family member |
|---|---|---|
| **Total** | 1,810 | 1,810 |
| **Number of interviews completed** | 1,621 | 1,294 |
| **Non-response reason: death** | 36 | 39 |
| **Non-response reason: moved away** | 125 | 100 |
| **Non-response reason: not farming** | 9 | 53 |
| **Did not consent to be interviewed** | 19 | 127 |
| **Could not be reached** | 0 | 197 |

### *3.4.1 Survey instruments*

The endline survey was administered in person using computer-assisted personal interviewing through SurveyCTO. This was conducted with two household members: (1) the primary client targeted by DER, and (2) a family member, typically a spouse, sibling, or parent, who was acting as the guarantor on the loan. The survey included information about the respondent's demographics, household income, financial inclusion, credit practices, women's empowerment, insurance uptake and renewal, awareness and perceptions of insurance, income from insured crops, household and women's consumption, and women's mental health (Appendix B).

Questions related to insurance uptake and renewal, awareness and perceptions of insurance, and income from insured crops were asked only to the primary client. Questions about household and women's consumption, as well as women's mental health were asked only to the female member of the household. Other questions (related to demographics, household income, financial inclusion, and credit practices) were asked to both respondents in each household.

### *3.4.2 Survey implementation*

All surveys were conducted by a team of DER enumerators under the supervision of IFPRI researchers. All enumerators engaged in the data collection process had a high degree of familiarity with study protocols and computer-assisted personal interviewing (CAPI) instruments. The questionnaire was developed and programmed by IFPRI staff. Training on the survey instrument and SurveyCTO for data collection was conducted directly by IFPRI for seven male enumerators, three female enumerators, and a senior field coordinator. Testing and piloting of the instrument was carried out immediately after training, which allowed for the adjustment of survey instruments and overall protocols.

Enumerators were monitored by an IFPRI research analyst to ensure quality control, maintain high levels of productivity, and resolve challenges in the field. Implementing the survey electronically allowed for continuous monitoring of the number of interviews conducted and the implementation of numerous data-quality checks throughout the duration of the fieldwork. Inconsistencies in the collected data were communicated to DER on a regular basis via email and phone. In addition, weekly phone meetings were held between IFPRI and DER to discuss existing fieldwork issues and decide on corrective actions. Random checks on the accuracy of collected data were conducted jointly by the DER field coordinator and the IFPRI research analyst.

## 3.5 Secondary data

As secondary data, to verify the representativeness of our study sample at baseline, we used situation assessment surveys from the Government of India.[3] These surveys included measures of consumer expenditure, income and productive assets, indebtedness, farming practices and preferences, resource availability, awareness of technological developments, and access to modern agricultural technology.

At baseline, farmers in our study sample generally had operational landholdings larger than the average farmer in Odisha, but similar to the average farmer in India. Nonetheless, farmers in the study were more likely to be landless than either the nationally representative sample or that representative of Odisha state.

Although literacy rates were higher in our study sample than in the situation assessment survey samples, we also found higher rates of farmers belonging to scheduled castes and tribes than the national average (but comparable to the representative Odisha sample), and lower insurance uptake (especially compared to the Odisha sample), which is related to the high proportion of farmers in our study who did not own land. In this report, no other secondary data sources are being used.

## 3.6 Empirical specification

To estimate intent-to-treat (ITT) effects, we will use analysis of covariance (ANCOVA) estimators, in which endline values of dependent variables (outcomes) are regressed on a dummy variable, indicating whether the farmer was in the treatment group, controlling for baseline values of the dependent variable, and blocking fixed effects to account for stratification, clustering standard errors by village (given that randomization was clustered at the village level). That is, we will estimate the following econometric specification:

$$Y_{ib,1} = \alpha + \beta Y_{ib,0} + \delta_1 T_{ib} + \delta_2 T_{ib} \times Female_{ib} + \sum_{j=1}^{J} \theta_j x_{ijb,0} + \varepsilon_{ib} \quad (1)$$

where $Y_{ib,t}$ is the measure of outcome $Y$ for individual $i$ from block $b$ in period $t \in \{0,1\}$, with $t = 0$ and $t = 1$ indicating baseline and endline, respectively; $x_{ijb,0} = \langle x_{i1b,0}, x_{i2b,0}, \dots, x_{iJb,0} \rangle$ is a vector of covariates to control for variables on which we stratified our randomization (block, DER was already operating in the village at the time of recruitment), imbalances between households in the treatment versus control at the time of the baseline (whether the household cultivated in the rabi season, whether they had taken credit, and profits per acre), as well as a number of demographic controls from the endline survey (caste, literacy, age terciles, and gender of the primary client); $\varepsilon_{ib}$ is an identically distributed disturbance assumed to be independently distributed across villages, but correlated among members from the same village; $T_{ib}$ is a binary variable equal to 1 if individual $i$ from village $b$ was from a village randomly selected as part of the treatment arm; and $Female_{ib}$ (a binary variable equal to 1 if client $i$ from village $b$ was a

[3] Government of India. 2013. *Situation Assessment Survey of Agricultural households, NSS 70th Round: Jan - Dec 2013*. Ministry of Statistics and Programme Implementation, Government of India.

female) is interacted with $T_{ib}$ to test whether the product had differential effects on male ($\delta_1$) and female ($\delta_1 + \delta_2$) members of the treatment group.[4]

Table 7 (in Section 4.2.2 below) presents our outcome variables, and indicates which variables are available for each type of respondent. For outcome measures related to women's mental health and food consumption, we only have data on female respondents (since these questions were only asked of female respondents), but we can still estimate effects separately for women in households where the primary client is male versus female, and estimate Equation (1).

For other outcome measures (related to household income, financial inclusion, and credit practices), we have data for both the primary client and the other family member. In these cases, we will present estimates on the pooled sample, so that $\delta_1$ represents the treatment effect for male respondents, and $\delta_1 + \delta_2$ the treatment effect for female respondents, regardless of whether they are the primary client or another family member. As a robustness check, we will also estimate separate models for the primary client and the other family member.

Further, some outcome measures were not measured at baseline (including knowledge on insurance and difficulties in repaying a loan), or were specified differently at baseline and endline data collection; therefore, there are no comparable baseline measures for these outcomes that could be included in an ANCOVA regression. In such instances, if no other variable was available to serve as a proxy for the outcome measure, Equation (1) would be modified by dropping $Y_{ib,0}$, and the estimator is reduced to a single-difference estimator comparing simple (conditional) differences between treatment and control samples.

It should be noted that estimating Equation (1) yields (ITT) effects, which provide an estimate of the overall impact of KhetScore among households in villages randomly selected for inclusion in the treatment group. Assuming there is a positive correlation between taking KhetScore loans and various outcomes of interest, ITT effects will be a downward-biased measure of the beneficial impacts of KhetScore. [5] Nevertheless, these provide a conservative estimate of the overall program impacts, and may be of greater relevance to policymakers interested in the economy-wide impacts of such a program, rather than just the effects on members of the sample able to take KhetScore loans.

[4] Our pre-analysis plan specified that the heterogenous treatment analysis will be done for gender, age, and caste of the MFI client, in addition to whether the client experienced a shock. For brevity, this report only includes the heterogeneity analysis by gender, while heterogeneity analyses by caste and age are available upon request. Since no major climatic shock occurred during the project period, we could not analyze heterogeneity by whether the client experienced a shock.

[5] The pre-analysis plan specified that we would estimate the local average treatment effect. These estimates are qualitatively similar as the intention-to-treat estimates reported here but are (as expected) larger in magnitude. We will present the local average treatment effect estimates in the academic paper but have not included them in this report for ease of presentation.

# 4. Findings

## 4.1 Intervention implementation fidelity

This section describes different aspects of the intervention's implementation. We first discuss intervention uptake, in both treatment and control groups, through an analysis of administrative data. Next, we describe implementation delays related to fieldwork logistics and legal documentation requirements of the insurance company. Finally, we provide insights on enrolment, based on qualitative and quantitative data collected at midline.

Table 3 shows monitoring and evaluation data relevant to the reach and uptake of the intervention. Enrolment activities were carried out one to two months before the beginning of each season. Dedicated staff from DER reached out to all eligible farmers in each treatment village in person to invite them to apply for the KhetScore product. Column (1) presents, by season, the number of farmers offered the KhetScore product.

If the farmers agreed to apply, they would first have their cultivated plots registered for KhetScore generation, along with an initial picture taken through the Doordrishti app. Column (2) presents, again by season, the number of farmers who applied for KhetScore loans. Column (3) shows the number of farmers who were eligible for KhetScore, and for whom the loan was disbursed to their bank accounts.

Column (4) presents the number of farmers who enrolled in insurance in the respective seasons (farmers could sign up for insurance even if they did not take loans), and Column (5) shows the number of farmers who received payouts for those respective seasons.

On average, approximately 28 percent of the farmers who were offered KhetScore applied for it each season. Uptake was low in the initial phase of the project due to several challenges. First, COVID-19 lockdowns required DER staff to reach out to farmers via phone, which brought to light issues around farmer availability, lack of mobile penetration in Odisha, incorrect phone numbers, challenges with network connectivity, and rapport between DER staff and prospective clients. This was solved over time by a shift to in-person visits. In this sense, the continuation of activities over several seasons by the same staff was key to ensuring farmers' trust and cooperation.

Another challenge in the wake of the pandemic was financing the KhetScore loans, given that institutional lenders were hesitant at that time to finance microloans. However, using the small number of farmers that had KhetScore loans in the first season, DER was able to show the viability of its lending model, and mobilize additional funding for subsequent seasons. This explains the increase over time in the number of farmers who were able to apply for loans, received loans, and enrolled in insurance.

**Table 3: Number of participating farmers across implementation stages**

| Season/ crop | (1) KhetScore loan offered | (2) Applied for KhetScore loan | (3) Received KhetScore loan | (4) Enrolled in insurance | (5) Insurance payout made |
|---|---|---|---|---|---|
| Rabi 2020/21 (paddy) | 911 | 90 | 62 (68.9%) | 95 | 7 |
| Kharif 2021 (paddy) | 911 | 300 | 206 (68.7%) | 445 | 10 |
| Rabi 2021/2022 (paddy) | 911 | 350 | 319 (91.1%) | 319 | 0 |
| Kharif 2022 (paddy) | 911 | 280 | 223 (79.6%) | 430 | 0 |

*Note: Data were reported only for the treatment arm (N = 29 villages) since there was no intervention in the control villages.*

Table 4 presents application rates and product perceptions self-reported by 1,443 respondents in the treatment group, including primary DER clients and other family members. Consistent with the figures based on administrative data in Table 3 above, 41 percent reported applying for a KhetScore loan. The vast majority of these people also preferred this loan over traditional agricultural loans and would apply again in future. About three quarters of this sample agreed with the statement that KhetScore loans are reliable.

**Table 4: Perception of KhetScore loans**

| | Mean | N |
|---|---|---|
| Applied for Khetscore loan | 0.410 | 1,443 |
| Prefer Khetscore over other traditional agri loan | 0.407 | 1,443 |
| Will apply in future for Khetscore loan | 0.409 | 1,443 |
| Agree that Khetscore is reliable | 0.303 | 1,443 |

## 4.2 Impact analysis

### *4.2.1 Descriptive statistics and balance tables*

Table 5 provides descriptive statistics of the full sample of 2,915 clients and other family members surveyed at endline. About half (51.9 percent) of respondents were female. The average respondent was approximately 44 years of age, and close to one third of the total belonged to scheduled castes or tribes. About three quarters know how to read and write, with 71 percent having completed at least primary education, and 32 percent having completed at least secondary education.

Most households' incomes fell below INR 90,000 per year (US$1,210), or INR 247 per day (US$3.32), which means a two-member household would be below the poverty line of US$2 per day. About 30 percent earned an income between INR 90,000 (US$1,210) and INR 120,000 (US$1,613) per year, and only 15 percent had an income of more than INR 120,000 (US$1,613) per year. Virtually all respondents cultivated during the most recent kharif season, whereas fewer households (73%) cultivated during the most recent rabi season.

We collected data on credit-related variables for all respondents. Borrowing, especially from formal sector sources, was not very common. Only 23% and 11% of households took loans from informal and formal sources, respectively. The average loan was sanctioned 7.5 months prior, at which time the household had borrowed on average INR 28,304 (US$380), at an interest rate of 13%.

Households still owed an average of 55 percent of their loan at the time of the endline survey, but in total had an average of 10.5 months left to repay it, meaning that they only had an average of three months remaining to mobilize the funds needed to repay. Indeed, a sizable 41 percent of households with loans reported that they were facing difficulties repaying, and 82% said that there would be consequences associated with not paying the loan on time. Less than one fifth had other outstanding non-agricultural loans, and among these households, the average debt from non-agricultural loans was INR 19,938 (US$268).

The next set of variables relates to insurance knowledge and uptake. Less than half of all primary clients had ever heard of insurance. Among those who were aware, a large majority (85.5 percent) has heard of the PMFBY scheme, and fewer (62 percent) had heard of picture-based crop insurance. Very few households had heard of the Restructured Weather-Based Crop Insurance Scheme or other insurance products.

As a more nuanced measure of awareness, we also constructed an “insurance knowledge score” based on the number of correct responses to a series of true/false questions regarding general terms and conditions of crop insurance. Six questions were asked, and respondents received a point for every correct answer; the average respondent correctly answered 3.5 of the following six questions:

1. I have to pay (a premium) to be covered by crop insurance. (TRUE)
2. The insurance premium is typically a small fraction of the maximum insurance payout. (TRUE)
3. Crop insurance promises to pay compensation every season. (FALSE)
4. Crop insurance compensates for any amount of loss I may face for any reason. (FALSE)
5. If I don’t have any crop damage, the insurance company gives back my premium. (FALSE)
6. Crop insurance promises to pay compensation to me even if the price for my crop falls. (FALSE)

Despite low awareness rates, more than half of all respondents (59 percent) took up insurance in the study period; among these, close to two thirds (64 percent) renewed their coverage.

The next set of descriptive statistics relates to agricultural outcomes during the kharif 2022 season and the rabi 2021–2022 seasons. Whereas nearly all farmers cultivated during the kharif season, only 73 percent of farmers decided to plant in the rabi season, creating an opportunity for KhetScore loans to expand production at the extensive margin.

The average area cultivated among those who planted paddy rice was, on average, lower during the rabi season. However, total production, and thus productivity, was

higher, perhaps because only farmers with access to irrigation (who potentially have higher productivity) select into cultivating during rabi season. However, the cost of production during rabi was higher, and crops fetched lower prices, as determined by total revenue per acre. As a result, while profits were positive during the kharif season, farmers made a loss during rabi season, even before they included the opportunity cost of their own labor. Increasing profitability would thus be an important priority for KhetScore loans.

We also asked all respondents about their contributions to household decision-making, and the extent to which they had control over household assets. About 44–45% of respondents indicated that they contributed to decisions to borrow and in how to use this money. Close to three quarters had input into livelihood decisions, and 70% perceived having a degree of control over the use of income.

Finally, most respondents were considered adequately empowered in terms of their asset ownership, with close to 90 percent owning either land or at least three assets (which is how the Women's Empowerment in Agriculture Index defines its asset ownership indicator). It is important to note, however, that this sample includes both male and female respondents, and that each of these indicators of empowerment are significantly lower for women than for men. We are therefore primarily interested in whether KhetScore loans improve gender parity by increasing the proportion of women with control over these important aspects of life.

In order to collect crucial 3ie common indicators, female survey respondents were also asked to complete consumption and mental health modules. (In households where the female respondent could not be interviewed, we completed the consumption module with the male respondent.) We calculated a food consumption score, which is based on the frequency with which different food groups were consumed in the past seven days (scores in the range of 0–21 are considered poor, 21.5–35 are borderline, and those greater than 35 are acceptable).

We also assessed women's diets within the households using the Minimum Dietary Diversity for Women Index, which is based on dietary diversity in the past 24 hours (women must have consumed at least 5 out of 10 food groups for their diets to be considered sufficiently diverse). We also calculated a four-item stress indicator for mental health. While household-level consumption indicators were at adequate levels, we found that women's dietary diversity was poor, as they consumed, on average, only 3.8 out of the 10 food groups included in that indicator.

To measure mental health, we collected data among women about the stress levels they experienced. An individual's perceived stress was based on their responses to the following four questions:

1. How often have you felt that you were unable to control the important things in your life?
2. How often have you felt confident about your ability to handle your personal problems?
3. How often have you felt confident that things were going your way?
4. How often have you felt that difficulties were piling up so high that you could not overcome them?

**Table 5: Descriptive statistics for the full endline sample**

| | Full sample | | |
|---|---|---|---|
| | Mean | Std. dev. | N |
| Respondent is a female | 0.519 | 0.500 | 2,915 |
| Age of respondent | 43.63 | 8.867 | 2,915 |
| Belongs to schedule caste/schedule tribe | 0.318 | 0.466 | 2,915 |
| Can read and write | 0.747 | 0.435 | 2,915 |
| Completed at least primary education | 0.714 | 0.452 | 2,915 |
| Completed at least secondary education | 0.319 | 0.466 | 2,915 |
| Household income | | | |
| - Low (below INR 90,000 p/year) | 0.559 | 0.497 | 2,915 |
| - Medium (INR 90,000–120,000 p/year) | 0.29 | 0.456 | 2,915 |
| - High (above INR 120,000 p/year) | 0.146 | 0.354 | 2,915 |
| **Credit** | | | |
| Took up credit in last 12 months | 0.339 | 0.473 | 2,915 |
| Took loan from an informal source | 0.229 | 0.420 | 2,915 |
| Took loan from a formal source | 0.110 | 0.317 | 2,915 |
| How many months ago the loan was sanctioned | 7.49 | 4.065 | 987 |
| Total loan amount | 28,305 | 14295 | 987 |
| Interest rate | 13.12 | 1.461 | 987 |
| Outstanding loan | 15,523 | 10,791 | 987 |
| Number of months to repay the loan | 10.48 | 5.618 | 987 |
| Facing difficulty in repaying the loan† | 0.410 | 0.493 | 987 |
| There are consequences for not paying the loan on time | 0.824 | 0.381 | 987 |
| Respondent currently has outstanding non-agricultural loan | 0.177 | 0.382 | 2,915 |
| Outstanding non-agri loan | 19,938 | 11,681 | 516 |
| **Insurance** | | | |
| Has heard of crop insurance | 0.424 | 0.494 | 1,621 |
| - Aware of the PMFBY scheme existing in village | 0.856 | 0.351 | 687 |
| - Aware of Restructured Weather-based Crop | | | |
| Insurance scheme existing in village | 0.006 | 0.076 | 687 |
| - Aware of picture-based crop insurance existing in village | 0.620 | 0.486 | 687 |
| - Aware of other insurance products existing in village | 0.003 | 0.054 | 687 |
| Knowledge score on insurance | 3.489 | 1.244 | 687 |
| Insurance uptake: took insurance at least once | 0.586 | 0.493 | 1,621 |
| Insurance renewal: if took up insurance, took insurance twice | 0.635 | 0.482 | 950 |
| **Agriculture - kharif 2022 (summer) season** | | | |
| Cultivated in the season | 0.959 | 0.198 | 1,621 |
| Total production (in quintals) | 16.00 | 16.343 | 1,468 |
| Total productivity | 9.21 | 7.580 | 1,468 |
| Total land cultivated | 2.08 | 0.826 | 1,468 |
| Revenue per acre - in INR 10,000 | 1.36 | 0.928 | 1,468 |
| Cost of production per acre - in INR 10,000 | 1.15 | 1.021 | 1,468 |
| Profit per acre - in INR 10,000 | 0.24 | 1.009 | 1,468 |
| Return on investment per acre - in INR 10,000 | 0.36 | 1.249 | 1,468 |
| **Agriculture - rabi 2021–2022 (winter) season** | | | |
| Cultivated in the season | 0.729 | 0.445 | 1,621 |
| Total production (in quintals) | 25.40 | 18.976 | 992 |
| Total productivity | 13.44 | 5.217 | 992 |
| Total land cultivated | 1.92 | 1.069 | 992 |
| Revenue per acre - in INR 10,000 | 1.30 | 0.858 | 992 |

| | Full sample | | |
|---|---|---|---|
| | Mean | Std. dev. | N |
| Cost of production per acre - in INR 10,000 | 1.33 | 0.826 | 992 |
| Profit per acre - in INR 10,000 | -0.19 | 2.291 | 992 |
| Return on investment per acre - in INR 10,000 | 0.07 | 0.674 | 992 |
| **Household decision-making** | | | |
| Contributes to household borrowing decisions | 0.441 | 0.497 | 2,915 |
| Contributes to household decisions - how to use borrowed money | 0.446 | 0.497 | 2,915 |
| Input in livelihood decisions | 0.743 | 0.437 | 2,915 |
| Control over use of income | 0.701 | 0.458 | 2,915 |
| Asset ownership | 0.880 | 0.325 | 2,915 |
| **Consumption and women's mental health** | | | |
| Household food consumption score | 81.42 | 29.921 | 2,915 |
| Minimum dietary diversity for women | 3.840 | 2.017 | 2,915 |
| Women's mental health | 1.684 | 1.355 | 1,512 |

[†] *Question was conditional on not being less likely to apply for a loan and is therefore missing in a subsample.*

These questions were only asked of women, and responses were on a Likert scale that ranges from "never" (1) to "very often" (5). It is important to note, however, that the score can hold different meanings depending on the way in which the question is phrased. In particular, a response of "very often" to Questions 1 and 4 indicate higher degrees of perceived stress, while a response of "very often" to Questions 2 and 3 indicate lower degrees of perceived stress.

We look at the raw responses to each of these questions individually, but also construct a composite measure of perceived stress by first recoding the scores for Questions 2 and 3 so that a higher score indicates a higher degree of stress, and then take the average score over the four questions. The table below shows that the average score on our composite measure is 1.7, which indicates that responses are more skewed towards "never" and "sometimes" (associated with a score of 1 and 2, respectively) than to "often" or "very often" (which would attract a score of 4 or 5, respectively).

Table 6 summarizes the data collected at baseline (Panels A and B), as well as time-invariant characteristics collected at endline (Panel C), by treatment arm. The last column provides the p-value from a test for significant differences between treatment and control, with clustering of standard errors at the village level. We found that, overall, the variables are well-balanced across treatment and control, with only a few showing significant differences at the 10% level, as one would expect when testing multiple hypotheses. Overall, randomization resulted in two comparable samples.

Variables that were imbalanced at baseline include the percentage of farmers who were growing crops in the most recent rabi season (81% in the control group versus 65% in the treatment group) and the percentage of farmers purchasing goods and services on credit in the past 12 months (43% in the control group versus 55% in the treatment group). Farmers in the treatment group also had significantly lower stress levels and earned higher profits at baseline. At endline, farmers in the control group were more likely to belong to a scheduled caste or tribe instead of the general category or other backward castes, and we observe imbalances in the proportion of participants that can read or write. We will control for these differences in our impact estimates.

## Table 6: Descriptive statistics by treatment

| | Control | | | Treatment | | | |
|---|---|---|---|---|---|---|---|
| | N | Mean | Std. dev. | N | Mean | Std. dev. | p-value |
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) |
| **Panel A. Baseline characteristics – full sample** | | | | | | | |
| Female | 1,516 | 0.524 | 0.500 | 1,440 | 0.492 | 0.500 | 0.2650 |
| Age | 1,516 | 43.31 | 8.89 | 1,438 | 42.41 | 8.75 | 0.3298 |
| Can read and write | 1,516 | 0.854 | 0.353 | 1,440 | 0.876 | 0.330 | 0.5114 |
| Completed at least primary school | 1,516 | 0.792 | 0.406 | 1,440 | 0.731 | 0.443 | 0.1726 |
| Completed at least secondary school | 1,516 | 0.282 | 0.450 | 1,440 | 0.288 | 0.453 | 0.8869 |
| Household income | | | | | | | |
| - Low (below INR 90,000 per year) | 1,516 | 0.528 | 0.499 | 1,440 | 0.540 | 0.499 | 0.8759 |
| - Medium (INR 90,000–120,000 per year) | 1,516 | 0.280 | 0.449 | 1,440 | 0.271 | 0.445 | 0.8067 |
| - High (above INR 120,000 per year) | 1,516 | 0.191 | 0.394 | 1,440 | 0.190 | 0.392 | 0.9653 |
| Cultivated in last kharif* | 1,333 | 0.905 | 0.293 | 1,287 | 0.912 | 0.283 | 0.8224 |
| Cultivated in last rabi | 1,499 | 0.809 | 0.394 | 1,432 | 0.645 | 0.479 | 0.0058 |
| Purchased on credit in past 12 months | 1,516 | 0.431 | 0.495 | 1,440 | 0.551 | 0.498 | 0.0420 |
| Borrowed money in past 12 months | 1,516 | 0.254 | 0.435 | 1,440 | 0.260 | 0.439 | 0.8989 |
| Desired loan size for last season | 1,514 | 35878 | 15514 | 1,440 | 36,431 | 15,772 | 0.7297 |
| Willingness to pay to insure loan of INR 20,000 | 1,516 | 0.014 | 0.009 | 1,440 | 0.014 | 0.008 | 0.1470 |
| **Panel B. Baseline survey by primary client** | | | | | | | |
| Total cultivated land (in acres) | 716 | 2.011 | 1.127 | 651 | 2.093 | 1.227 | 0.6387 |
| - Small farmer (0–2.5 acres) | 716 | 0.770 | 0.421 | 651 | 0.728 | 0.445 | 0.4330 |
| - Marginal farmer (2.5–5 acres) | 716 | 0.212 | 0.409 | 651 | 0.247 | 0.432 | 0.4656 |
| - Medium farmer (5–10 acres) | 716 | 0.018 | 0.134 | 651 | 0.025 | 0.155 | 0.5348 |
| Cultivated paddy | 716 | 0.996 | 0.065 | 651 | 0.992 | 0.087 | 0.4186 |
| Cultivated lentil | 716 | 0.006 | 0.075 | 651 | 0.051 | 0.220 | 0.1270 |
| Cultivated vegetables | 716 | 0.006 | 0.075 | 651 | 0.026 | 0.160 | 0.3059 |
| Crop was damaged | 716 | 0.272 | 0.445 | 651 | 0.249 | 0.433 | 0.6955 |
| Ever had crop insurance | 798 | 0.026 | 0.160 | 722 | 0.039 | 0.193 | 0.3678 |
| Now has crop insurance | 798 | 0.011 | 0.106 | 722 | 0.018 | 0.133 | 0.3774 |
| Received pay-out from crop insurance | 798 | 0.008 | 0.086 | 722 | 0.011 | 0.105 | 0.5299 |
| Women's dietary diversity | 798 | 3.97 | 1.50 | 722 | 3.93 | 1.56 | 0.8060 |
| Household dietary diversity | 798 | 7.58 | 1.31 | 722 | 7.56 | 1.41 | 0.8983 |
| Food consumption score | 798 | 81.09 | 24.55 | 722 | 81.22 | 27.11 | 0.9761 |
| Stress indicator | 350 | 3.448 | 0.360 | 250 | 3.347 | 0.418 | 0.1395 |
| Total revenue per acre for all crops | 716 | 21,387 | 13,069 | 651 | 24,628 | 16,453 | 0.1531 |
| Total land cultivated for all crops | 716 | 2.011 | 1.127 | 651 | 2.093 | 1.227 | 0.6387 |
| Cost of production excl. own labor | 716 | 13,783 | 5,916 | 651 | 13,737 | 7,380 | 0.9712 |
| Profit from all crops excl. own labor | 716 | 7,604 | 13,023 | 651 | 10,891 | 14,040 | 0.0254 |
| **Panel C. Endline demographics – Full sample** | | | | | | | |
| Female | 1,473 | 0.50 | 0.500 | 1,442 | 0.54 | 0.499 | 0.308 |
| Age | 1,473 | 43.38 | 9.144 | 1,442 | 43.88 | 8.570 | 0.388 |
| Scheduled caste or tribe | 1,473 | 0.40 | 0.491 | 1,442 | 0.23 | 0.422 | 0.001 |
| Can read and write | 1,473 | 0.72 | 0.448 | 1,442 | 0.77 | 0.419 | 0.047 |
| Completed at least primary education | 1,473 | 0.72 | 0.451 | 1,442 | 0.71 | 0.453 | 0.928 |
| Completed at least secondary education | 1,473 | 0.31 | 0.463 | 1,442 | 0.33 | 0.470 | 0.641 |

*Notes: p-values are derived from a regression in which we regress the variable of interest on a variable indicating treatment, with standard errors clustered by village (our unit of randomization). We test whether the coefficient on Treatment is different from zero and report the p-value associated with the t-test statistic here. * Variable was added to the survey form at a later stage and is therefore missing for the first set of respondents.*

### *4.2.2 Research analyses*

Our impact evaluation focuses on several classes of socioeconomic outcomes, as described in Table 7 below. We begin this section by describing program impacts on the entire treatment group. In Section 4.2.3, we will examine the heterogeneity of these impacts among men and women in the sample. In particular, we are interested in the extent to which the program: (1) increased financial literacy, utilization of formal sources of credit, and financial resilience; (2) impacted agricultural investments, productivity, and total production; (3) increased women's empowerment by increasing their voice in household decisions; (4) improved food consumption and dietary diversity; and (5) reduced mental health burdens among women.

These results are presented in Tables 8, 9, 10, 11, 12, and 13, respectively. Several of these tables comprise separate panels that report overall treatment effects (Panel A) and heterogeneous treatment effects by gender (Panel B), with different columns reporting treatment effects for different outcomes and/or differentiating treatment effects among household members (primary DER client versus the other household member). In this section, we will focus only on results reported in Panel A, while the results presented in Panel B (which include gender dimensions) will be discussed in Section 4.2.3.

**Table 7: Summary of outcome measures examined through the impact evaluation**

| **Outcome measures** | | **How measured** | **Available for** | |
|---|---|---|---|---|
| Knowledge & uptake of insurance and credit | | | Main client | Other member |
| | Aware of crop insurance | Binary (= 1) if aware of crop insurance | ü | |
| | Knowledge score | Score ranging from 1–6 based on correct responses to a series of true/false statements regarding general terms and conditions of crop insurance | ü | |
| | Insurance uptake | Binary (= 1) if enrolled at least once in insurance in the last 3 seasons | ü | |
| | Insurance renewal | Binary (= 1) if enrolled at least twice in insurance in the last 3 seasons, conditional on having insurance at least once | ü | |
| | Credit uptake | Binary (= 1) if borrowed from any source | ü | ü |
| | Credit from formal source | Binary (= 1) if borrowed from a formal lender | ü | ü |
| | Credit from informal source | Binary (= 1) if borrowed from an informal lender | ü | ü |
| | Difficulty in repayment | Binary (= 1) if faced difficulty in repaying a loan | ü | ü |
| **Agricultural outcomes** | | | | |
| | Cultivated during kharif 2022 or rabi 2021–2022 | Binary (= 1) if cultivated during kharif (rainy season) in 2022 or rabi (winter season) in 2021–2022 | ü | |
| | Land cultivated for paddy rice | Area cultivated under paddy rice (acres) in kharif 2022 and rabi 2021 | ü | |
| | Total production | Quantity of rice produced in quintals, measured in kharif 2022 and rabi 2021 | ü | |
| | Productivity in kharif 2022 and rabi 2021 | Quantity of rice produced in quintals, divided by the total area cultivated under paddy rice (in acres, thus this variable is recorded in quintals per acre) | ü | |
| | Income from paddy rice per acre in kharif 2022 and rabi 2021 | Quantity of rice sold multiplied by the unit price, divided by the area of land cultivated under paddy rice (INR/acre) | ü | |
| | Cost of production in kharif | Expenditures on renting land; purchasing seeds, | ü | |

| Outcome measures | | How measured | Available for | |
|---|---|---|---|---|
| Knowledge & uptake of insurance and credit | | | Main client | Other member |
| | 2022 and rabi 2021 | fertilizers and other agro-chemicals, irrigation, machinery and equipment; hiring labor, and other household labor (INR) | | |
| | Profit from paddy production in kharif 2022 and rabi 2021 | Total revenues per acre, less the cost of production (INR) (excluding cost of own and family labor) | ü | |
| | Return on investment in kharif 2022 and rabi 2021 | Profit per acre divided by cost of production per acre cultivated (excluding cost of own and family labor) | ü | |
| **Gender parity outcomes** | | | | |
| | Contributes to household borrowing decisions | Binary (= 1) if they contribute to household decisions around borrowing | ü | ü |
| | Contributes to household decisions about how to spend borrowed funds | Binary (= 1) if they contribute to household decisions about how to spend borrowed money | ü | ü |
| | Input in livelihood decisions | Binary (= 1) if they contribute to household decisions on livelihood activities | ü | ü |
| | Control over use of income | Binary (= 1) if they exercise control over the uses of income | ü | ü |
| | Asset ownership | Binary (= 1) if they own land and/or any three assets | ü | ü |
| Consumption outcomes | | | Male | Female |
| | Food consumption score | Weighted consumption of food items from different food groups over the preceding seven days (based on the World Food Programme food consumption score methodology) | Household | |
| | Minimum Dietary Diversity for Women Index | Number of food groups consumed by the female household member from 10 possible food groups in the preceding 24 hours | | ü |
| Women's mental health outcomes | | | | |
| | Composite stress score | Average of scores to four questions on perceived stress (below), recoded so that higher scores indicate a higher degree of stress | | ü |
| | Stress 1 | Likert score ranging from 1 (never) to 5 (very often) in response to the question, "How often have you felt that you were unable to control the important things in your life?" | | ü |
| | Stress 2 | Likert score ranging from 1 (never) to 5 (very often) in response to the question, "How often have you felt confident about your ability to handle your personal problems?" | | ü |
| | Stress 3 | Likert score ranging from 1 (never) to 5 (very often) in response to the question, "How often have you felt that things were going your way?" | | ü |
| | Stress 4 | Likert score ranging from 1 (never) to 5 (very often) in response to the question, "How often have you felt that difficulties were piling up so high that you could not overcome them?" | | ü |

Table 8 presents the program's impacts on outcomes pertaining to the knowledge and uptake of insurance, including financial literacy measures (specifically, awareness of crop insurance and some of its terms and conditions), insurance uptake, and insurance renewal over the course of the project.

Focusing on the subsample of 1,621 primary DER clients, we found strong evidence that the program increased uptake and renewal of crop insurance. In Column (2), controlling for baseline insurance coverage as well as a range of other covariates, we see that assignment to treatment increased the likelihood that a respondent took up insurance at least once during the period of study by more than 60 percentage points (from 28% in the control group to 90% in treatment villages).

Further, being assigned to the treatment group increased the likelihood that farmers who had purchased insurance would renew their coverage. We found that farmers in the treatment group who had previously purchased crop insurance were 30 percentage points more likely to renew their coverage than the 40 percent of farmers renewing their coverage in the control group (Column 4).

**Table 8: Treatment effects on insurance uptake and familiarity with insurance**

| | Insurance uptake | | Insurance renewal | | Heard of insurance | | Knowledge score | |
|---|---|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) |
| **Panel A** | | | | | | | | |
| Treatment | 0.622*** | 0.617*** | 0.312*** | 0.282*** | 0.235*** | 0.155*** | 0.705*** | 0.498*** |
| | (0.045) | (0.044) | (0.072) | (0.068) | (0.038) | (0.040) | (0.169) | (0.153) |
| R-squared | 0.399 | 0.407 | 0.087 | 0.111 | 0.057 | 0.159 | 0.076 | 0.185 |
| **Panel B - by gender** | | | | | | | | |
| Treatment | 0.626*** | 0.630*** | 0.083 | 0.073 | 0.069 | 0.023 | 0.572*** | 0.521*** |
| | (0.044) | (0.046) | (0.076) | (0.079) | (0.055) | (0.052) | (0.142) | (0.116) |
| Female | -0.043 | -0.021 | -0.492*** | -0.453*** | -0.212*** | -0.171*** | 0.218 | 0.461 |
| | (0.066) | (0.064) | (0.067) | (0.075) | (0.052) | (0.046) | (0.380) | (0.348) |
| Treatment x female | -0.009 | -0.029 | 0.516*** | 0.497*** | 0.348*** | 0.289*** | 0.162 | -0.063 |
| | (0.073) | (0.074) | (0.082) | (0.089) | (0.082) | (0.072) | (0.411) | (0.372) |
| R-squared | 0.402 | 0.407 | 0.150 | 0.157 | 0.090 | 0.180 | 0.093 | 0.185 |
| Number of observations | 1,621 | 1,621 | 950 | 950 | 1,621 | 1,621 | 687 | 687 |
| Control group mean | 0.280 | 0.280 | 0.394 | 0.394 | 0.308 | 0.308 | 3.047 | 3.047 |
| Controls | No | Yes | No | Yes | No | Yes | No | Yes |

*Notes: Standard errors in parentheses clustered by village. *** p < 0.01, ** p < 0.05, * p < 0.10. Variables controlled for in even columns include dummy variables for age terciles, gender, literacy, caste, pre-existing operations in the village, baseline cultivation in rabi season, credit at baseline, and profits at baseline. All specifications control for a dummy variable indicating block. The model in Columns (1)–(4) controls for baseline insurance uptake.*

Not only did treatment increase the uptake and renewal of insurance, but there is also evidence that the program increased familiarity with crop insurance and an understanding of how it works. The program had an overall positive and statistically significant effect on clients' awareness of crop insurance, with treatment clients 15.5 percentage points more likely than those in the control group to have ever heard of crop insurance in (Column 6).

In terms of awareness about some of the finer nuances of crop insurance, our insurance knowledge score in Column (8) offers a more quantitative metric of financial literacy among respondents who said they were aware of crop insurance. In the control group, these clients answered only about half of the six questions correctly. Respondents from the treatment group were able to correctly answer 0.5 questions more, on average. Thus, the program increased financial literacy not only in terms of increasing the general awareness of respondents about crop insurance, but also increased recognition of some of its specific nuances, many of which may seem counterintuitive to the uninitiated.

Table 9 reports program results on credit uptake. The first column for each outcome variable considers the full sample of 2,915 respondents. The second and third columns estimate impacts separately for the 1,621 primary DER clients and the 1,294 family members who were not the direct clientele of DER, respectively. The latter category's borrowing behavior might still have been affected by the DER client in their household. In the overall sample, households in the treatment group were at least 10 percentage points more likely to have taken a loan than households in the control group (Column 1). We also found very compelling evidence that the program had the beneficial effect of crowding-in uptake of formal credit.

Specifically, in Column (4), we see that the program increased the uptake of loans from formal sources by about 23 percentage points, relative to the control group. Only about 11% of households in the control group borrowed from a formal source, compared to nearly 35% of households in the treatment group. Importantly, only a portion of this effect can be attributed to a substitution of formal loans for informal loans (Column 7). About 13% fewer households in the treatment group borrowed from an informal source compared to households in the control group (approximately 4% and 17% of households, respectively).

Increased borrowing could be detrimental if it leads to increased indebtedness and a pattern of circular borrowing (borrowing from one lender to repay a loan originally taken from another lender). In Column (10), we examine the extent to which respondents indicated that they faced difficulties in repaying their loans. At the outset, it is worth noting that only those respondents who indicated that they had taken a loan from any source were invited to respond to this question.

Households in the treatment group were more than 40 percentage points less likely to report that they faced some difficulty in repaying their loans. Roughly 70 percent of respondents in the control group indicated that they faced some difficulty in repaying their loans, compared with only about 30 percent in the treatment group, suggesting that the loans offered as part of this program had particularly favorable terms.

While not specific to the credit-scoring methodology per se, it should be noted that the loans offered as part of this project required repayments in instalments rather than in a single lump sum (often the terms for agricultural loans) or weekly instalments (often the terms for microfinance loans). Anecdotal evidence suggests that borrowers especially liked this feature of the loans, though some may have had to work off-farm to pay off the first two or three instalments, which were due in the season before the harvest. This did not, however, have a detrimental effect on how they perceived their abilities to repay their loans.

**Table 9: Treatment effects on credit uptake**

| | Took up credit in past 12 months | | | Credit from formal source | | | Credit from informal source | | | Difficulty in repayment |
|---|---|---|---|---|---|---|---|---|---|---|
| | All | Client | Other | All | Client | Other | All | Client | Other | All |
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) |
| **Panel A** | | | | | | | | | | |
| Treatment | 0.107*** | 0.028 | 0.190*** | 0.228*** | 0.209*** | 0.240*** | -0.128*** | -0.189*** | -0.056*** | -0.412*** |
| | (0.029) | (0.035) | (0.033) | (0.025) | (0.032) | (0.029) | (0.021) | (0.027) | (0.020) | (0.046) |
| R-squared | 0.072 | 0.131 | 0.113 | 0.133 | 0.149 | 0.207 | 0.068 | 0.115 | 0.047 | 0.340 |
| **Panel B - by gender** | | | | | | | | | | |
| Treatment | -0.052 | -0.079 | -0.025 | 0.113*** | 0.167*** | 0.019 | -0.174*** | -0.263*** | -0.044* | -0.361*** |
| | (0.036) | (0.050) | (0.041) | (0.033) | (0.046) | (0.036) | (0.026) | (0.042) | (0.024) | (0.059) |
| Female | -0.133*** | -0.188*** | -0.058 | -0.046* | 0.002 | -0.105*** | -0.089*** | -0.206*** | 0.059 | -0.019 |
| | (0.031) | (0.049) | (0.043) | (0.024) | (0.039) | (0.038) | (0.027) | (0.050) | (0.038) | (0.076) |
| Treatment x female | 0.311*** | 0.237*** | 0.372*** | 0.225*** | 0.091 | 0.383*** | 0.090*** | 0.161*** | -0.020 | -0.111 |
| | (0.037) | (0.067) | (0.062) | (0.035) | (0.066) | (0.057) | (0.029) | (0.053) | (0.039) | (0.083) |
| R-squared | 0.098 | 0.145 | 0.155 | 0.151 | 0.152 | 0.262 | 0.128 | 0.128 | 0.047 | 0.342 |
| Number of observations | 2,915 | 1,621 | 1,294 | 2,915 | 1,621 | 1,294 | 2,915 | 1,621 | 1,294 | 987 |
| Control group mean | 0.275 | 0.353 | 0.176 | 0.111 | 0.140 | 0.076 | 0.171 | 0.223 | 0.105 | 0.709 |

*Notes: Standard errors in parentheses clustered by village. *** p < 0.01, ** p < 0.05, * p < 0.10. Variables controlled for in even columns include dummy variables for age terciles, gender, literacy, caste, pre-existing operations in the village, baseline cultivation in rabi season, credit at baseline, and profits at baseline. All specifications control for a dummy variable indicating block. The "difficulty in repayment" variable (Column 10) was collected only for respondents who had indicated that they had taken out a loan; therefore, for this variable, we do not estimate separate models for clients and other family members.*

However, these headline figures only tell a portion of the story. Much of the program's impact on increasing overall credit uptake appears among other household members who were not directly targeted by DER. In particular, the program appears to have increased overall credit uptake by nearly 20 percentage points in this group (Column 3). Among DER clients, there is no evidence that treatment assignment had an appreciable effect on overall credit uptake (Column 2).

There is, however, evidence that treatment assignment affected the sources of borrowed funds. Borrowing from formal sources increased among both the primary client as well as the other family member, and by roughly the same proportion (increases of 21 percentage points and 24 percentage points, respectively, in Columns 5–6). The overall level of credit from formal sources increased to about 35% among clients of DER, and 32% among other household members, as compared to the control group means of 14% and 8%, respectively.

At the same time, members of the treatment group reduced their utilization of informal credit. The biggest reduction in informal borrowing was among the primary clients of DER, with a treatment effect of a nearly 20 percentage point reduction in informal borrowing (Column 8). Among the other household members, the program reduced the likelihood of borrowing from an informal lender only by about 6 percentage points (Column 9). Thus, especially among other household members who were not clients of DER, the reduction in informal borrowing is insufficient to offset the increase in borrowing from formal sources.

In sum, these results present a promising picture for the KhetScore credit scoring methodology to have a potentially transformative effect on rural finance, increasing financial literacy, the ability of farmers to manage agricultural risks, and the inclusivity of credit, and easing the burden of loan repayment.

In Table 10, we present the program's effects on a series of agricultural outcomes, focusing on kharif 2022 in odd columns, and rabi 2021–2022 in even columns. In the first two columns, we consider the effects of the program on the likelihood of farmers cultivating during kharif 2022 (Column 1) and rabi 2021–2022 (Column 2).

Although cultivation during kharif season is nearly ubiquitous (94% in the control group), we find evidence that treatment assignment increased the likelihood that farmers would cultivate during kharif 2022 by about two percentage points. During kharif 2022, revenues per acre in the treatment group were about INR 2,000 (US$27) greater than those in the control group (Column 5), without the treatment affecting the total area of cultivated land (Column 3).

During rabi 2021–2022, treatment households increased their cultivated area by nearly 0.5 acres (Column 4), though the total cost of production per acre fell by INR 3,400 (US$46), perhaps as treatment farmers generated economies of scale (Column 8). Additionally, during rabi season, treatment farmers experienced a 16 percentage-point increase in return on agricultural investments (Column 10). In Columns (11) and (12), there is compelling evidence that treatment households had significantly higher agricultural profits, with kharif profits nearly double those in the control group, and rabi profits offsetting losses experienced by farmers in the control group.

To unpack the mechanisms through which increases in profitability may have come about, Appendix A reports the effects of treatment assignment on various agricultural inputs during kharif 2022 and rabi 2021–2022. The results suggest that there was a positive programmatic effect during both seasons on purchase of seeds and hiring of female labor (the latter statistically significant only for kharif 2022, due to less precise estimates in rabi season). This indicates that respondents used some of their loans to hire labor and free up their time for other activities.

At the same time, in both seasons treatment farmers spent less on renting additional land for cultivation, and in kharif season spent less on hiring machinery. There is also some evidence that households in the treatment group allocated less personal labor to agricultural production during kharif 2022. If we were to include the opportunity cost of DER primary clients' labor in the cost of production, profits, and returns on investments, then this reduction in personal labor supply would manifest as a significant decrease in production costs, a significant increase in investment returns, and an even greater increase in profits during kharif.

**Table 10: Treatment effects on agricultural outcomes**

| | Cultivated paddy | | Area cultivated | | Revenue p/acre (in 10,000 INR) | | Cost per acre (in 10,000 INR) | | Return on investment | | Profit per acre (in 10,000 INR) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Kharif | Rabi | Kharif | Rabi | Kharif | Rabi | Kharif | Rabi | Kharif | Rabi | Kharif | Rabi |
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) | (11) | (12) |
| **Panel A** | | | | | | | | | | | | |
| Treatment | 0.022* | 0.005 | -0.001 | 0.479*** | 0.197*** | 0.043 | -0.020 | -0.340*** | 0.019 | 0.161** | 0.231*** | 1.329*** |
| | (0.013) | (0.040) | (0.066) | (0.094) | (0.066) | (0.113) | (0.070) | (0.065) | (0.069) | (0.062) | (0.068) | (0.237) |
| R-squared | 0.026 | 0.061 | 0.016 | 0.104 | 0.045 | 0.041 | 0.010 | 0.121 | 0.012 | 0.057 | 0.039 | 0.061 |
| **Panel B - by gender** | | | | | | | | | | | | |
| Treatment | 0.027 | -0.015 | 0.047 | 0.407*** | 0.240*** | -0.008 | 0.012 | -0.243*** | -0.078 | 0.155*** | 0.220** | 1.419*** |
| | (0.019) | (0.042) | (0.086) | (0.121) | (0.076) | (0.123) | (0.115) | (0.068) | (0.089) | (0.054) | (0.109) | (0.260) |
| Female | 0.043** | -0.117* | 0.032 | 0.202* | -0.043 | 0.092 | -0.006 | 0.306*** | -0.159 | -0.007 | -0.055 | 0.743* |
| | (0.017) | (0.060) | (0.093) | (0.105) | (0.079) | (0.136) | (0.074) | (0.111) | (0.118) | (0.114) | (0.078) | (0.417) |
| Treatment x female | -0.011 | 0.043 | -0.105 | 0.192 | -0.095 | 0.137 | -0.069 | -0.259** | 0.200 | 0.016 | 0.023 | -0.241 |
| | (0.020) | (0.070) | (0.125) | (0.176) | (0.109) | (0.163) | (0.121) | (0.119) | (0.137) | (0.126) | (0.119) | (0.456) |
| R-squared | 0.027 | 0.062 | 0.017 | 0.106 | 0.045 | 0.042 | 0.010 | 0.126 | 0.014 | 0.057 | 0.039 | 0.061 |
| Number of observations | 1,621 | 1,621 | 1,468 | 992 | 1,468 | 992 | 1,468 | 992 | 1,468 | 992 | 1,468 | 992 |
| Control group mean | 0.944 | 0.729 | 2.084 | 1.916 | 1.248 | 1.299 | 1.146 | 1.329 | 0.364 | 0.069 | 0.237 | -1.284 |

*Notes: Standard errors in parentheses clustered by village. *** p < 0.01, ** p < 0.05, * p < 0.10. Cost per acre, return on investment, and profit per acre are all estimated excluding own labor. Control variables include dummy variables for block, age terciles, gender, literacy, caste, pre-existing operations in the village, baseline cultivation in rabi season, credit at baseline, and profits at baseline.*

In Table 11, we present treatment effects on outcomes related to gender parity. Here, we will briefly introduce the program-wide effects, and later discuss gender differences in these outcomes and gender heterogeneity in the treatment effects, which will shed light on the possibility of empowering women by increasing their contributions to important household decisions and control over both income and assets. These estimates are provided in Panel B and discussed in Section 4.2.3.

At a programmatic level, we found that members of the treatment group reported an increased frequency with which they: (1) contributed to household decisions, (2) contributed to household decisions about how to use borrowed money, (3) provided input on household livelihood activities, (4) exercised control over income, and (5) reported owning land and/or any three assets.

Importantly, there were some differences in how these effects arose, depending on whether the respondents were clients of DER or other household members. In particular, we found that clients of DER in the treatment group reported being able to contribute more to household decisions around borrowing and the use of borrowed funds, while other household members reported an increase in their input into household livelihood activities.

Both DER clients and other household members reported an increase in their ability to exercise control over household income, though the proportional effect was greater among other household members (a 22 percentage-point increase) than among DER clients (a 6 percentage-point increase). Other household members also report an increase in their ownership of assets, though, on average, there was no such effect among DER clients in the treatment group. These two latter effects (or non-effects) could be simply because DER clients already exercise meaningful control over income or own a number of assets, such that being in the KhetScore treatment group did not move the needle to a measurable degree.

As a final set of outcome variables, Table 12 reports the program's effects on two distinct measures of food consumption, namely the World Food Programme's food consumption score and the Minimum Dietary Diversity for Women Index. These modules were completed by the primary female respondent in the household but are taken as household-level measures.

We did not find compelling evidence that the program had a pronounced effect on the level of food consumption (Columns 1–2). The point estimates of the program's effects on the food consumption score are positive, but are measured so imprecisely that the treatment effects estimates are not statistically different from zero at conventional levels. For the Minimum Dietary Diversity for Women Index, the treatment effect point estimates are negative, and statistically different from zero at conventional significance levels. Households in the treatment arm consume, on average, about 0.39 fewer food groups than households in the control group. We will try to explain this in the next section on gender analyses.

## Table 11: Treatment effects on empowerment

| | Contributes to household borrowing decisions | | | Contributes to decisions on how to use borrowed money | | | Input in livelihood decisions | | | Control over use of income | | | Asset ownership | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | All | Client | Other | All | Client | Other | All | Client | Other | All | Client | Other | All | Client | Other |
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) | (11) | (12) | (13) | (14) | (15) |
| **Panel A - full sample** | | | | | | | | | | | | | | | |
| Treatment | 0.073*** | 0.136*** | -0.012 | 0.062*** | 0.120*** | -0.014 | 0.096*** | 0.010 | 0.193*** | 0.137*** | 0.063* | 0.216*** | 0.114*** | 0.035 | 0.211*** |
| | (0.023) | (0.030) | (0.031) | (0.020) | (0.030) | (0.028) | (0.029) | (0.037) | (0.043) | (0.034) | (0.037) | (0.044) | (0.017) | (0.021) | (0.029) |
| R-squared | 0.372 | 0.304 | 0.461 | 0.394 | 0.316 | 0.507 | 0.106 | 0.089 | 0.126 | 0.097 | 0.088 | 0.114 | 0.106 | 0.032 | 0.203 |
| **Panel B - by gender** | | | | | | | | | | | | | | | |
| Treatment | -0.016 | 0.017 | -0.067 | -0.009 | 0.008 | -0.028 | -0.027 | -0.029 | -0.060 | 0.046 | 0.055 | -0.004 | 0.044*** | 0.045** | 0.021 |
| | (0.034) | (0.039) | (0.058) | (0.035) | (0.042) | (0.057) | (0.040) | (0.049) | (0.056) | (0.045) | (0.053) | (0.058) | (0.015) | (0.017) | (0.028) |
| Female | -0.525*** | -0.521*** | -0.521*** | -0.533*** | -0.523*** | -0.516*** | -0.288*** | -0.214*** | -0.391*** | -0.228*** | -0.155*** | -0.346*** | -0.145*** | -0.064* | -0.241*** |
| | (0.025) | (0.035) | (0.043) | (0.025) | (0.041) | (0.043) | (0.032) | (0.044) | (0.054) | (0.028) | (0.053) | (0.050) | (0.019) | (0.032) | (0.036) |
| Treatment x female | 0.174*** | 0.261*** | 0.095 | 0.139** | 0.244*** | 0.024 | 0.242*** | 0.085 | 0.439*** | 0.178*** | 0.016 | 0.381*** | 0.137*** | -0.022 | 0.330*** |
| | (0.050) | (0.071) | (0.065) | (0.053) | (0.083) | (0.060) | (0.042) | (0.064) | (0.068) | (0.039) | (0.070) | (0.067) | (0.024) | (0.041) | (0.040) |
| R-squared | 0.379 | 0.320 | 0.463 | 0.399 | 0.331 | 0.507 | 0.125 | 0.092 | 0.177 | 0.106 | 0.088 | 0.151 | 0.117 | 0.032 | 0.253 |
| Number of observations | 2,915 | 1,621 | 1,294 | 2,915 | 1,621 | 1,294 | 2,915 | 1,621 | 1,294 | 2,915 | 1,621 | 1,294 | 2,915 | 1,621 | 1,294 |
| Control group mean | 0.403 | 0.427 | 0.373 | 0.414 | 0.450 | 0.368 | 0.697 | 0.803 | 1,294 | 0.632 | 0.716 | 0.525 | 0.828 | 0.893 | 0.744 |

*Notes: Standard errors clustered by village. *** p < 0.01, ** p < 0.05, * p < 0.10. Variables controlled for include dummy variables for age, gender, literacy, caste, pre-existing operations in the village, baseline cultivation in rabi season, credit at baseline, and profits at baseline. All specifications control for a dummy variable indicating block.*

**Table 12: Treatment effects on consumption**

| | Food consumption score | | Minimum dietary diversity for women score | |
|---|---|---|---|---|
| | (1) | (2) | (3) | (4) |
| **Panel A** | | | | |
| Treatment | 0.327 | 0.903 | -0.364** | -0.385** |
| | (2.516) | (2.396) | (0.160) | (0.150) |
| R-squared | 0.071 | 0.153 | 0.044 | 0.079 |
| **Panel B - by gender** | | | | |
| Treatment | -3.007 | -1.108 | -0.618** | -0.612*** |
| | (3.362) | (3.453) | (0.246) | (0.225) |
| Female | 13.232*** | 21.379*** | 0.327 | 0.699** |
| | (3.935) | (4.305) | (0.301) | (0.284) |
| Treatment x female | 8.406* | 4.329 | 0.595* | 0.488 |
| | (4.794) | (4.813) | (0.323) | (0.306) |
| R-squared | 0.110 | 0.154 | 0.061 | 0.082 |
| Number of observations | 1,621 | 1,621 | 1,621 | 1,621 |
| Control group mean | 78.757 | 78.757 | 3.934 | 3.934 |
| Controls | No | Yes | No | Yes |

*Notes: Standard errors in parentheses clustered by village. *** p < 0.01, ** p < 0.05, * p < 0.10. In principle, the female respondent completed the consumption module, but if not available, the male respondent answered on her behalf. Variables controlled for in even columns include dummy variables for age terciles, gender, literacy, caste, pre-existing operations in the village, baseline cultivation in rabi season, credit at baseline, and profits at baseline. All specifications control for a dummy variable indicating block, and for the baseline values of the outcome variable.*

### *4.2.3 Gender analyses*

As mentioned in Section 4.2.2, we found evidence that the program had a beneficial impact on financial literacy, increasing insurance uptake and renewal. It expanded access to credit, making it more inclusive, while alleviating the burden of repaying borrowed funds. It also had beneficial impacts on the scale of production and profitability, particularly in the rabi season, and on the ability of respondents to contribute to important decisions within their households.

In Panel B of each table, we introduce interactions between the treatment status and a binary indicator equal to one if the respondent was a female. This allows us to assess whether, and the extent to which, the program had a differential impact on women as compared to men. Evidence suggests that treatment had a differential effect on women, and, in particular, the beneficial effects were magnified among women.

The program-wide results reported above indicated that the program increased uptake, renewal, awareness, and knowledge of crop insurance (Table 8). As seen in Panel B, we found no differential treatment effects by gender in insurance uptake or insurance knowledge, but much of the effect on renewal and awareness was driven by a substantial increase among women in the treatment group. In Column (4), which includes a comprehensive set of controls, we see that there is essentially no effect on

insurance renewal among men, though women in the treatment group are nearly 50 percentage points more likely to renew insurance coverage.

Similarly, in Column (6), men's familiarity with crop insurance is not affected by treatment. Surprisingly, despite women being considerably less familiar with crop insurance overall, the proportion of women in the treatment group who reported being aware of crop insurance increased by roughly 29 percentage points. This highlights the extent to which the program has disproportionately improved women's renewal of and familiarity with crop insurance.

There is also compelling evidence that the program's impact on crowding-in formal credit was magnified among women. In the full sample, women in the treatment group were about 26 percentage points more likely to take credit from any source than women in the control group (Column 1), about 34 percentage points more likely to take a loan from a formal lender (Column 4), and about 8 percentage points less likely to take a loan from an informal lender (Column 7).

On average, roughly 9 percent of women in the control group reported borrowing from a formal source, compared with more than 43 percent of women in the treatment group. This is nearly three times the effect observed among men (an 11 percentage-point increase, also Column 4). Much of the increase in formal credit appears to be among other household members that were not direct clients of DER.

In particular, we observe a 38 percentage-point increase in the likelihood that a female non-client would take a loan from a formal source (Column 6). Here, too, we found that much of this overall increase in formal borrowing is not fully explained by a mere substitution of formal borrowing for informal borrowing. Among DER clients, women in the treatment group were about 16 percentage points more likely to take loans from informal sources than men in the treatment group, but still less likely to take loans from informal sources than women in the control group.

Table 11 reports the effects of the program on gender parity outcomes, particularly contributions to household decisions regarding borrowing, the use of borrowed funds, livelihood activities, control over income, and ownership of assets. As mentioned in Section 4.2.2, the overall program impacts were positive, suggesting that the program increased the likelihood that individuals would make valuable contributions to household decision making, or would exert some control over income or take ownership of land or other assets.

As seen in Panel B, however, these effects were largely driven by improvements among women in the treatment group, with small and, in most cases, statistically insignificant treatment effects for men. Among the full sample, there was no effect on men's contributions to household borrowing decisions (Columns 1–3), decisions on how to use borrowed funds (Columns 4–6), decisions regarding household livelihood (Columns 7–9), nor in their control over the uses of income (Columns 10–12). Yet, women in the treatment group, especially DER clients, reported an increase in their level of empowerment across all of these domains.

Overall, women in the treatment group were 17 percentage points more likely to report making contributions to household decisions regarding borrowing, 14 percentage points

more likely to make contributions to household decisions about how to use borrowed money, 24 percentage points more likely to report providing input into household livelihood decisions, and nearly 18 percentage points more likely to report having control over the use of income.

Among the clients of DER, the most pronounced treatment effects pertain to gains in women's contributions to household decision-making around borrowing and the uses of borrowed funds. Female DER clients in the treatment group were 26 percentage points more likely to report contributing to household decisions around borrowing and 24 percentage points more likely to report contributing to household decisions around the uses of borrowed funds.

Other female household members who were not DER clients benefited from the treatment as well, as they were 44 percentage points more likely to report having input into household livelihood activities, 38 percentage points more likely to report having control over income, and 33 percent more likely to report owning land, or three or more assets, than women in the control group.

These results suggest that the KhetScore credit scoring methodology had a profound effect on increasing women's empowerment, voice, and stature within the household. By reducing the documentation requirements for loan qualification, the program has the ability to expand access to credit to population groups (e.g., women and other marginalized groups) that have historically been ignored by financial institutions. This enhanced credit access and utilization seems to improve women's standing within the household and strengthen their ability to voice opinions and help steer household decisions.

By and large, we did not find that the program had a differential effect among women in the treatment group, as it pertained to agricultural outcomes (Table 10, Panel B). The only exceptions are in productivity and the cost of production per acre during the rabi season. During this season, women in the control had higher productivity than men, perhaps due to higher investments that manifested in higher production cost per acre. However, the treatment offsets these gender gaps in productivity and production cost. For women in the treatment group, the cost of production was nearly INR 5,000 (US$67) lower than the average cost of production among women in the control group.

As mentioned in Section 4.2.2, we did not find any evidence that the program affected either measure of food consumption, although we did observe a reduction in the diversity of food consumed (Table 12). These findings remained when we considered the gender dimension of food consumption. As was the case when we examined program-wide impacts on the food consumption score, the program's effect on the score among women in the treatment group was positive, but not statistically different from zero at conventional levels, especially once we controlled for a set of variables to account for respondent demographics and household characteristics that were imbalanced at baseline.

The negative effect of the program on the Minimum Dietary Diversity Index was primarily concentrated among households with a male client. Among women, we noted that the treatment effect was not statistically different from zero.

Finally, we consider the program's effect on several women's mental health outcomes, which are measures of individuals' perceived stress levels. Table 13 presents different measures of perceived stress. The "treatment" row refers to women in the treatment group, though we also differentiate between the effects on female DER clients versus other surveyed family members by incorporating the interaction term, "treatment x other family member."

It is worth noting that, in general, other family members reported higher levels of stress, suggesting more mental health problems among this sample. In Column (1), we consider the program's effects on the composite stress measure described above. We found that it had a beneficial effect on reducing stress levels, but only among other female household members not directly targeted by DER. Compared to a control group mean of 2.785, the composite stress score of other female household members was reduced by 0.5 points, indicating a significantly lower overall stress level.

We also found that the program had beneficial impacts on stress reduction in two of the four indicators considered, though these effects were limited to the other female household members and did not materialize among the female DER clients. In particular, we found that the program decreased the frequency with which women felt unable to control the important things in their lives (Column 2) and the frequency with which they felt that difficulties were piling up so high that they could not overcome them (Column 5).

In the case of the former outcome, the measured effect is greater than 10% of the average score among women in the control group. In the case of the latter, the effect is even more pronounced: its 1.3-point reduction in this measure is greater than 40% of the average score among the control group, signifying a substantial reduction in women feeling overwhelmed. The treatment effects on the other two indicators are not statistically different from zero at conventional levels, but the signs are consistent with the program having a beneficial effect on reducing stress levels.

In sum, the results from the program are highly encouraging. They suggest that the program has wide-ranging beneficial impacts for women in terms of increasing access to and use of credit, improving their ability to contribute to household decision-making as well as their control over income and assets, and reducing their overall stress levels, thereby improving well-being.

**Table 13: Treatment effects on mental health outcomes**

| | Composite stress score | Frequency of inability to control important things | Frequency of confidence in ability to handle personal problems | Frequency of confidence that things were going her way | Frequency of feeling that difficulties were piling up |
|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) |
| Treatment | -0.028 | 0.095 | 0.187 | 0.101 | 0.121 |
| | (0.079) | (0.149) | (0.153) | (0.136) | (0.159) |
| Other family member | 0.262** | 0.373** | -0.193 | -0.345* | 0.435** |
| | (0.101) | (0.143) | (0.181) | (0.184) | (0.185) |
| Treatment x other family member | -0.525*** | -0.401** | 0.291 | 0.049 | -1.327*** |
| | (0.116) | (0.159) | (0.201) | (0.195) | (0.194) |

| | Composite stress score | Frequency of inability to control important things | Frequency of confidence in ability to handle personal problems | Frequency of confidence that things were going her way | Frequency of feeling that difficulties were piling up |
|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) |
| R-squared | 0.146 | 0.073 | 0.084 | 0.073 | 0.151 |
| Total effect \| other family member | -0.525 | -0.401 | 0.291 | 0.049 | -1.327 |
| p-value | 0.000 | 0.015 | 0.154 | 0.803 | 0.000 |
| Number of observations | 1,512 | 1,512 | 1,512 | 1,512 | 1,512 |
| Control group mean | 2.785 | 3.126 | 3.659 | 3.332 | 3.007 |

*Notes: Standard errors in parentheses clustered by village. Control variables include dummy variables for block, age terciles, gender, literacy, caste, pre-existing operations in the village, baseline cultivation in the R rabi season, credit at baseline, and profits at baseline.*

## 5. Cost analysis

To determine the cost of the intervention, we focused on the expense of implementing loans and insurance using KhetScore, relative to conventional methods for providing financial services, but holding the distribution channel constant since DER leverages the existing lending and insurance operations of financial service providers. We distinguished between the fixed costs of the research and development around KhetScore, and the marginal costs of providing the digital credit and insurance products. DER is still finalizing its estimates of implementation costs, but the best available estimates are based on baseline projections and provided in Table 14.

The total, one-off research and development costs associated with launching the KhetScore program were close to US$60,000. The fixed cost of operating the loan operations—including project management, staff travel, field office costs, app maintenance, and communication material—were approximately another US$20,000.

These costs would not be sustainable in a program with 450 farmers taking loans. Even when enrolling a similar number of farmers in the control group, the cost of US$ 21.07 would be too high for a sustainable operation, as they would significantly increase interest rates if factored into the projected interest that farmers pay. The presence of a field office would become more sustainable if DER could expand into more blocks, and additional villages within these blocks, and provide loans to more farmers in targeted communities.

Moreover, the variable costs that DER incurs in every agricultural season per farmer (costs that are increasing according to the number of farmers it is trying to reach) are currently too high for the intervention to be sustainable, but these figures could improve as the program reaches scale. Currently, these costs are close to US$100, 43.5% of which is borne by the farmer. DER field staff constitute the main cost driver in this category, and it will be important for DER to identify ways in which these costs can be reduced. Some of these costs are likely of a fixed nature, and as the program goes to scale each field agent would cover a larger number of farmers, reducing the per-farmer cost.

For the impact evaluation, we had to limit the scale to keep operations focused on targeted clients in the treatment group, and avoid contamination of the control group. However, as the impact evaluation comes to an end, DER can grow in scale and reduce both average fixed costs and variable costs to generate a more financially viable and impactful intervention. DER is updating the projections for what the intervention costs at a larger scale, in order to inform the cost-effectiveness analyses that we will be using in future stakeholder engagement and policy dialogues with the Odisha state government.

**Table 14: Implementation cost**

| | Cost per unit | No. of unit | Total cost | |
|---|---|---|---|---|
| | | | INR | US$ |
| **Research & development (one-off cost)** | | | | |
| Personnel | | | 1,463,060 | 19,665 |
| Office/facilities | | | 690,000 | 9,274 |
| IT services | | | 243,994 | 3,279 |
| Data collection/licensing | | | 1,670,086 | 22,447 |
| Guarantee fund for initial de-risking of KhetScore | 10% per INR 28,850 loan | 104 farmers | 300,000 | 4,032 |
| Other overheads | | | 225,000 | 3,024 |
| ***Total one-off research & development cost*** | | | ***4,367,140*** | ***58,697*** |
| **Fixed cost per season** | | | | |
| Project management | | | 367,481 | 4,939 |
| Staff travel | | | 36,627 | 492 |
| Field office costs | | | 690,000 | 9,274 |
| App/portal maintenance | | | 248,400 | 3,339 |
| Communication material | | | 68,626 | 922 |
| ***Total cost*** | | | ***1,411,135*** | ***18,966*** |
| **Variable cost per farmer** | | | | |
| Interest for 6-month loan | 9% of loan | 26,129 | 2,352 | 31.61 |
| Insurance | 3% of loan | 26,129 | 784 | 10.54 |
| KhetScore reports | n/a | n/a | 500 | 6.72 |
| DER field staff | n/a | n/a | 3,173 | 42.65 |
| Staff transport, allowance | n/a | n/a | 308 | 4.14 |
| Printing, stationery | n/a | n/a | 96 | 1.29 |
| ***Total cost per farmer*** | | | ***7,213*** | ***96.95*** |

***1 US$ = INR 74.40***

# 6. Discussion

## 6.1 Introduction

Many small and marginal farmers in developing countries lack the liquidity necessary to purchase inputs that could increase their productivity. They are often further limited in their ability to access credit because they lack the necessary collateral or documented land rights. In addition, through their reliance on agriculture, their livelihoods are inextricably linked to an increasingly variable natural environment.

Together, these liquidity, credit, and risk constraints make it difficult for them to cope with frequent weather shocks, but also prevent potentially profitable investments in their farms that could lift them out of poverty traps. Reducing risk and promoting investments that increase agricultural productivity are therefore important strategies to reduce hunger and poverty, enhance incomes and food security, and strengthen the resilience of the world's poor.

This report describes the design and endline survey findings of an impact evaluation of KhetScore, an innovative tool developed by DER, which uses digital technologies, including satellite remote sensing combined with ground reference data, to unlock credit and insurance for small and marginal farmers in Odisha state.

This impact evaluation serves as a case study to provide insights on how digital technologies can help to improve agricultural risk management. The project evaluated this novel financial product that has the potential to ameliorate credit constraints by eliminating the need for documented land rights and burdensome collateral, while simultaneously allowing farmers to manage weather-related agricultural risks.

In particular, KhetScore leverages emergent digital technologies such as satellite imagery and other remote sensing, coupled with machine learning and crop analytics, to generate farm-specific credit scores even in the absence of land titles, thereby expanding and increasing the inclusivity of rural credit. At the same time, loans are coupled with a crop insurance product that can compensate the lender in the event of adverse conditions, thereby alleviating collateral requirements and helping farmers decouple agricultural investments.

We implemented a cluster randomized trial with approximately 1,800 potential KhetScore clients from 58 villages in the district of Jajpur. These villages were randomized into a treatment arm, where farmers were offered a digital credit product bundled with insurance to protect them from the risk of crop failure. Both financial services relied on satellite imagery and smartphone pictures for crop monitoring.

Through this randomized trial, we analyzed how recent advances in remote sensing and crop analytics can reduce transaction costs and overcome information asymmetries and documentation requirements in the provision of financial instruments for marginal farmers. We also examined the extent to which this improves famers' access to credit and insurance, investments in agriculture, incomes, food security, and well-being.

The evaluation was designed to pay particular attention to gender and other dimensions of social inclusion. Specifically, we operated under the assumption that women and other marginalized farmers are less likely to hold documented land rights, thereby restricting their access to credit and insurance. KhetScore aims to address precisely these barriers.

At baseline, we found evidence supporting this hypothesis. While women expressed lower demand for credit, and were also less likely to take credit, baseline findings suggested that the intervention may well have larger effects for female clients. Women reported more often than men that the introduction of KhetScore, and bundling with insurance, would make them more likely to apply for loans, and that they would be interested in borrowing larger amounts.

Over the course of this impact evaluation, we found beneficial impacts across a wide range of agricultural, gender parity, and mental health outcomes. In particular, the evaluation demonstrated the potential transformative effects on the rural economy that can occur through increasing financial literacy, credit and insurance uptake and farm profits, enhancing women's empowerment, and easing some of the mental health stresses that so often accompany near-subsistence agriculture.

## 6.2 Challenges and lessons

Our results are promising, and, overall, we consider this to be a highly successful impact evaluation. However, we also experienced a number of challenges.

First, during the baseline phase of the evaluation, we learned how difficult it is to finance lending operations. Initially, we started working with Vector Finance, a microfinance institution that was planning a large scale-up of their loans, around which we would be able to build our impact evaluation. However, during the pandemic, funding for Vector Finance and other microfinance institutions was drying up, which prevented this scale-up. We therefore organized the impact evaluation around an expansion of Dvara's own lending operations, but accessing finance was a challenge for those operations as well.

From the second season onwards, Dvara was able to offer credit and insurance to all 900 farmers in the treatment arm, with an expectation that about 50 percent (450 farmers) in the treatment arm would sign up. However, in the first season, loans were available only for a limited number of farmers because the pandemic had made financial institutions more risk averse, and they required a proof of concept based on the first season. Since then, DER has been able to secure financing on a larger scale, but access to financing is a risk and challenge that is important to note.

Second, due to the ongoing pandemic, baseline surveys were administered by phone, which meant that the different survey components had to be split across three separate rounds. Although response rates for primary clients were relatively high in the first round, we faced more attrition over time, especially in terms of whether a household completed all three survey rounds.

Moreover, we could not always ensure that respondents were surveyed in private, as they sometimes kept their phones on speaker, or were working in the fields (especially in the case of male clients) with other farmers around them. This meant that enumerators had to skip questions on sensitive topics. At endline, we were able to administer surveys in person, which helped to increase response rates, particularly among other family members who were not the targeted DER clients, amongst whom baseline response rates had been low.

Third, at baseline, we revised our power calculations and concluded that effect sizes must be large—often a magnitude of 0.5 standard deviations, assuming 100 percent uptake—in order to be detectable with sufficient power. This is because we could not obtain our targeted number of clusters (90 villages) working with Vector Finance, and instead increased lending operations with loans financed by the Dvara Trust (parent company of DER). Although the decision to scale up DER's operations provided us with the targeted sample size, it also resulted in a smaller number of clusters (58 villages), thus reducing statistical power.

Moreover, the intra-cluster correlation for targeted impact variables was higher than anticipated, based on earlier survey data available to us during our initial power calculations. To maximize our statistical power given these constraints, we coordinated closely with DER throughout the duration of the study to ensure that they were focused on achieving high levels of intervention uptake.

A final challenge we faced was our limited ability to disentangle impacts related to resolving credit constraints versus reducing production risk, or to address the effects of the bundled loan and insurance product on household resilience. Since the study period coincided with fortuitous weather conditions, households were not exposed to serious shocks, and the insurance policy rarely paid out. In the absence of shocks and an insurance safety net, there is little that can be learned regarding the impact of the product on resilience, or the role that the insurance product played as an addition to KhetScore loans.

In future work, we will use additional subgroup analyses to explore the extent to which treatment effects could be driven by investment risk versus credit constraints. We are starting a follow-up study on the current impact evaluation, expanding into new villages in Odisha as well as Maharashtra to look at the impacts of credit versus credit bundled with insurance, offered as separate treatment arms.

## 6.3 Conclusions and recommendations

This impact evaluation shows that KhetScore loans provided by our implementing partner, DER, have had strong and meaningful impacts on our study participants. We suggest that the KhetScore credit-scoring methodology ameliorates credit rationing, and expands and increases the inclusivity of rural finance, particularly through its reduction of transaction costs for both borrowers and lenders.

The fact that KhetScore eliminates paperwork requirements (specifically land titles) opens up formal credit to a whole new class of potential borrowers who have previously been excluded by formal lenders. In addition, crop insurance may help to alleviate collateral requirements, which may help to overcome both risk and quantity rationing in formal borrowing. These findings will offer important entry points for conversations with policymakers in Odisha, where there is great interest in expanding access to credit and insurance for sharecroppers and tenant farmers who do not have documented land rights.

# Appendix A: Treatment effects on investments in kharif and rabi

| | Seed | | Fertilizer | | Irrigation | | Machinery | | Rent | | Male labor | | Female labor | | Family labor - own | | Family labor - other male | | Family labor - other female | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Kharif | Rabi | Kharif | Rabi | Kharif | Rabi | Kharif | Rabi | Kharif | Rabi | Kharif | Rabi | Kharif | Rabi | Kharif | Rabi | Kharif | Rabi | Kharif | Rabi |
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) | (11) | (12) | (13) | (14) | (15) | (16) | (17) | (18) | (19) | (20) |
| **Panel A - full sample** | | | | | | | | | | | | | | | | | | | | |
| Treatment | 0.035*** | 0.051** | -0.042 | -0.075* | -0.002 | -0.017 | -0.057* | 0.582 | -0.053*** | -0.179* | 0.005 | 0.592 | 0.077*** | 0.116 | -9.037*** | 3.935 | 1.512 | -2.760 | 1.525 | -1.817 |
| | (0.008) | (0.020) | (0.040) | (0.039) | (0.012) | (0.019) | (0.032) | (0.549) | (0.016) | (0.106) | (0.038) | (0.567) | (0.015) | (0.221) | (2.387) | (3.261) | (1.965) | (2.292) | (2.009) | (1.770) |
| R-squared | 0.115 | 0.033 | 0.033 | 0.166 | 0.025 | 0.068 | 0.064 | 0.178 | 0.072 | 0.058 | 0.038 | 0.116 | 0.044 | 0.058 | 0.165 | 0.072 | 0.029 | 0.042 | 0.182 | 0.103 |
| **Panel B - by gender** | | | | | | | | | | | | | | | | | | | | |
| Treatment | 0.059*** | 0.074*** | -0.015 | 0.084 | 0.004 | -0.043* | -0.023 | 1.218* | -0.027 | -0.266* | 0.001 | -0.722 | 0.132*** | -0.106 | -15.547*** | -1.854 | 1.168 | -8.253*** | 0.437 | -5.420** |
| | (0.012) | (0.027) | (0.056) | (0.054) | (0.020) | (0.022) | (0.049) | (0.673) | (0.019) | (0.139) | (0.054) | (0.639) | (0.022) | (0.278) | (2.727) | (3.692) | (2.498) | (2.939) | (2.742) | (2.316) |
| Female | -0.006 | 0.022 | 0.027 | 0.501*** | -0.047** | -0.079*** | 0.155*** | 3.888*** | 0.035 | -0.349** | -0.076 | -2.032*** | 0.019 | -0.104 | -29.267*** | -17.132*** | 1.916 | -3.764 | -13.771*** | -7.035*** |
| | (0.014) | (0.030) | (0.032) | (0.077) | (0.023) | (0.023) | (0.046) | (0.749) | (0.026) | (0.149) | (0.055) | (0.660) | (0.023) | (0.207) | (4.476) | (3.881) | (2.447) | (3.485) | (2.037) | (1.636) |
| Treatment x female | -0.052*** | -0.062 | -0.061 | -0.424*** | -0.014 | 0.071** | -0.075 | -1.696* | -0.059* | 0.233 | 0.008 | 3.498*** | -0.122*** | 0.590* | 14.309*** | 15.418*** | 0.756 | 14.631*** | 2.388 | 9.597*** |
| | (0.020) | (0.041) | (0.055) | (0.092) | (0.025) | (0.031) | (0.063) | (1.002) | (0.030) | (0.182) | (0.068) | (0.911) | (0.029) | (0.333) | (5.079) | (4.828) | (3.557) | (4.437) | (3.059) | (2.505) |
| R-squared | 0.123 | 0.038 | 0.034 | 0.200 | 0.025 | 0.077 | 0.066 | 0.184 | 0.078 | 0.061 | 0.038 | 0.142 | 0.062 | 0.062 | 0.177 | 0.088 | 0.029 | 0.068 | 0.182 | 0.127 |
| Number of observations | 1,468 | 992 | 1,468 | 992 | 1,468 | 992 | 1,468 | 992 | 1,468 | 992 | 1,468 | 992 | 1,468 | 992 | 1,468 | 992 | 1,468 | 992 | 1,468 | 992 |
| Mean control group | 0.230 | 0.275 | 0.516 | 0.540 | 0.147 | 0.163 | 0.433 | 4.530 | 0.136 | 0.569 | 0.552 | 7.126 | 0.171 | 1.275 | 48.574 | 41.090 | 25.085 | 16.655 | 12.760 | 7.737 |

*Notes: Standard errors clustered by village. *** p < 0.01, ** p < 0.05, * p < 0.10. Variables controlled for include dummy variables for block, age, gender, literacy, caste, pre-existing operations in the village, baseline cultivation in rabi season, whether took credit at baseline, and profits at baseline. Dependent variables in Columns (1)–(14) are reported in INR 10,000, whereas those in Columns (15)–(20) are reported in the number of days.*

# Appendix B: Endline survey instruments

### IFPRI & DER: Impact evaluation of KhetScore loans. Endline questionnaire

| Sl. No | Label: English | |
|---|---|---|
| | Start time | |
| 1 | Please select your name - enumerator | Preloaded (select from the list) |
| 2 | In which village is this farmer? | Preloaded (select from the list) |
| 3 | Which farmer are you calling? | Preloaded (select from the list) |
| 4 | Enter respondent ID for a check | Enter manually from the sheet provided to you |
| 5 | [Question for enumerator] Can you start the interview? | 1. Yes = Main farmer is available.<br>2. Yes = But main farmer is no longer available. Replace main farmer and continue.<br>3. No = Farmer died<br>4. No = Farmer moved away<br>5. No = Not farming anymore<br>-888 = Other (specify) |

CONSENT FORM

[Enumerators read out:] Good morning/afternoon. I am _____ from Dvara E-Registry, an organization based in Hyderabad. We aim to improve the financial services available to farmers here in Odisha. Together with the International Food Policy Research Institute (IFPRI)— a research organization that aims to reduce hunger and poverty — we are doing a study with farmers in Odisha.

The goal of this study is to analyze how access to agricultural credit can be improved for farmers like you here in Odisha. I would like to ask you some general questions about your sources of income, cropping pattern, and about your role in the family. We expect the interview to take approximately two hours to complete.

There will be no risks from participating in the study. If you agree to participate, the information you provide will be used for research purposes. Any information we obtain during the research will be kept strictly confidential; your answers will be shared only with researchers. This study is conducted anonymously; you will only be identified through a code. Your name and address will not be stored with any other information we collect about you.

We value your opinion. There are no wrong answers to any of the questions we will be asking. Your participation is completely voluntary. You are free to skip any questions that may make you feel uncomfortable, refuse to participate, or withdraw your consent at any time.

Your participation will be highly appreciated. Your answers can help researchers and policymakers identify how we can help improve farmers' access to credit. Before we continue, do you have any questions about this?

I agree to take part in this study. I understand that I am free to discontinue participation at any time if I so choose, and that the researchers will gladly answer any question that arise during the study.

In case you have any questions about this study, please contact Subhransu Pattnaik, the study coordinator from IFPRI, at [S.pattnaik@cgiar.org]. In case you have any questions about your rights as a participant in this research, please contact Olivette Burton, at [IFPRI-IRB@cgiar.org].

| | | |
|---|---|---|
| 7 | Do you agree to take part in this survey? | 1 = Yes<br>0 = No, see Q8 |
| 8 | [If farmer refuses consent, Q7 is “0”] Why is the household not willing to be interviewed? | 1 = No time<br>2 = Not interested\no specific reason<br>3 = Other (specify) |
| 9 | What is your age? (in years)<br>[Write .98 if don’t know] | Enter the age manually |
| 10 | Marital status | 1 = Married<br>2 = Separated/divorced<br>3 = Widowed<br>4 = Single/never married |
| 11 | To which caste do you belong? | 1 = General caste<br>2 = Scheduled caste<br>3 = Scheduled tribes<br>4 = Other backward classes |
| 12 | Can you read and/or write? | 1 = Yes, I can read and write<br>2 = Yes, my own name<br>3 = Yes, I can only read<br>4 = No |
| 13 | What is your highest level of schooling? | 1 = No formal schooling<br>2 = Some primary level (< class 5)<br>3 = Completed primary level (class 5)<br>4 = Some secondary level (> class 5 but < 10)<br>6 = Completed secondary level (class 10)<br>7 = Greater than secondary level (> class 10)<br>98 = Don’t know |

| **Module 1: Household income and financial Inclusion** | | |
|---|---|---|
| 18 | What is your annual household income | 1 = INR 0–30,000<br>2 = INR 30,001–60,000<br>3 = INR 60,001–90,000<br>4 = INR 90,001–120,000<br>5 = INR 120,001–240,000<br>6 = More than INR 240,000 |
| 19 | Do you, either by yourself or together with someone else, currently have an account at a bank or another type of formal financial institution? | 1 = Yes, solely<br>2 = Yes, jointly<br>3 = No, skip to Q16 |

| | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 | 32 | 33 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | In order to finance produc-tion did you …<br><br>1 = Yes<br>0 = No | Who provided this loan? | When did you take the loan? ***(month & year)*** | If yes, how much finance (in INR) did you get from this source? | What was the interest rate of this loan? **(Put "0" if don't know)** | Balance still to be repaid in INR. | In how many months is this amount typic-ally repaid to the source? | Do you struggle to repay the loan on time?<br><br>1 = Yes<br>0 = No | ***If "YES to 27"*** How do you plan to repay the loan?<br><br>1 = From crop income<br>2 = By selling assets<br>3 = Help from family and friends<br>4 = By working extra time in other jobs | Are there any conse-quences for not repaying the loan by the given time?<br><br>1 = Yes<br>0 = No | What is the consequence?<br><br>1 = Must pay penalty<br>2 = No loan for the next season<br>3 = Don't know<br>4 = Get reported to credit bureau | ***If selected "No" for "Take out any formal loans /Purchase any inputs or services on formal credit":***<br><br>What are the main reasons for why you and your household members did not take out any loans in the last 12 months?<br><br>1 = Loan amount insufficient<br>2 = Lack of creditworthiness<br>3 = Insufficient collateral<br>4 = Fear of losing collateral<br>5 = Loan term not flexible<br>6 = Application cost too high<br>7 = High interest rate<br>8 = Distance to bank is too far<br>9 = We did not need a loan | Do you take the decision to borrow most of the time? | Do you make the decision about what to do with the money or item borrowed most of the time? |

| | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Withdraw any savings? | | | | | | | | | | | | | | |
| Sell any assets? | | | | | | | | | | | | | | |
| Receive cash/inputs in kind from landowner ? | | | | | | | | | | | | | | |
| Take out any informal loans? | | 1 = Informal moneylender or pawn broker<br>2 = Commission agent/trader<br>3 = Landowner or malik<br>4 = Other trader, contractor or employer<br>5 = Friends or relatives<br>6 = Informal credit or savings groups (e.g., chit funds) | | | | | | | | | | | | |
| Take out any formal loans ? | | 1 = Cooperative society/kisan credit card<br>2 = Public /private bank/ lending institution<br>3 = MFI<br>4 = Farmer- | | | | | | | | | | | | |

| | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | producer org/self-help group | | | | | | | | | | | | |
| Purchase any inputs or services on informal credit? | | | | | | | | | | | | | | |
| Purchase any inputs or services on formal credit? | | | | | | | | | | | | | | |
| Access any other source of financing (specify)? | | | | | | | | | | | | | | |

34. Do you currently have any loan outstanding to repay apart from your agricultural loan from DER? Yes/No

35. If "***Yes",*** What is the total amount of the outstanding loan that you have to repay? _____INR

| KhetScore awareness | | |
|---|---|---|
| 36 | Have you been offered a KhetScore loan by DER in the last 12 months? | 1 = Yes<br>0 = No |
| 37 | *If "Yes" in Q36*, have you applied for a KhetScore loan? | 1 = Yes<br>0 = No |
| 38 | *If "No" in Q36*, why did not you apply for a KhetScore loan? | 1 = I don't need it<br>2 = Too much documentation<br>3 = My neighbors/friends did not apply<br>4 = I am not comfortable with remote monitoring<br>5 = Don't know how to enroll<br>6 = Repayment method is not suitable (pay at once)<br>7 = Worried I won't be able to repay the loan<br>-888 = Others (*specify)* |
| 39 | ***If responded to 38 "7* = Worried I won't be able to repay the loan*"***<br>Why are you worried about not being able to repay the loan? | 1 = Possibilities of the crop getting damaged<br>2 = Possibilities that the loan amount will be used for other purposes<br>3 = Possibilities that my spouse may misuse the loan amount |
| **Khetscore perception** | | |
| 40 | What are the main reasons you apply for KhetScore? | 1 = Somebody offered me KhetScore<br>2 = I understand how it works<br>3 = I need it<br>4 = Cheap<br>5 = I trust DER<br>6 = I trust the field staff of DER<br>7 = Other, specify |
| 41 | Do you agree...<br>1. KhetScore is reliable | 1 = Strongly agree<br>2 = Agree<br>3 = Undecided<br>4 = Disagree<br>5 = Strongly disagree<br>9 = Don't know |
| 42 | Do you prefer KhetScore to other traditional credit products? | 1 = Yes<br>0 = No |
| 43 | Would you apply for KhetScore in future years? | 1 = Yes<br>0 = No |

| Module 2: CROP INCOME (for main farmer only) | | | |
|---|---|---|---|
| **Season** | Did you cultivate [crop] in this season?<br>1 = Yes<br>0 = No | Have you already harvested the crop?<br>1 = Yes<br>0 = No | Have you sold your harvested crop?<br>1 = Yes<br>0 = No |
| **Rabi 2021–2022** | | | |
| **Kharif 2022** | | | |

**For seasons marked “yes”**

| | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | *If (2.01) = 1* | | *If (2.01) = 1* | | | | | *If (2.07) > 1* | *If (2.08) > 1* | *If (2.01) = 1* | | | | |
| | what is the total … | | How much of the harvested [crop] … | | | | | | | To produce [crop], how much did you spend … | | | | |
| (2.01) Which crops did you produce?<br><br>1 = Yes<br>0 = No | (2.02) … land area on which you culti-vated [crop]? | (2.03) … quantity of [crop] that you harvested? | (2.04) … did or will you keep for home consumption ? | (2.05) … was lost post-harvest? (due to e.g., rain, water exposure, abnormal ripening, fungi, pests) | (2.06) … was paid to the landowner? (for sharecroppers) | (2.07) … do you expect to sell? | (2.08) … did you sell? | (2.09) What price do you expect to receive per quintal of [crop] sold? | (2.10) What price did you receive per quintal of [crop] sold? | (2.11) … on seeds ? | (2.12) … on fertilizer and other chemicals (e.g., pesticide, herbicide, fungicide) ? | (2.13) … on irrigation (rent for hiring the diesel pump and the cost of diesel used)? | (2.14) … on hiring machinery/ equipment (e.g., tractors, combine harvester, thresher)? | (2.15) How much did you spend on leasing / renting land? (only in cash, not in kind) |
| | In acres | Specify in total quintals | | | | | | In INR | | Specify total amount spent in INR | | | | |
| Paddy | | | | | | | | | | | | | | |
| Black gram | | | | | | | | | | | | | | |
| Green gram | | | | | | | | | | | | | | |
| Tomato | | | | | | | | | | | | | | |
| Onion | | | | | | | | | | | | | | |
| Cauliflower | | | | | | | | | | | | | | |
| Other (specify) | | | | | | | | | | | | | | |

**For crops marked "yes" in previous table**

| **Module 3: COST OF LABOR USED FOR CROP (for main farmer only)** | | | | | |
|---|---|---|---|---|---|
| | **Hired male labor** | **Hired female labor** | **Own labor** | **Own other male labor** | **Own other female labor** |
| Product/crop | (3.01) In total, how much did you spend on *male* hired labor to produce [crop] during the [season] season? | (3.02) In total, how much did you spend on *female* hired labor to produce [crop] during the [season] season? | (3.03) In total, how many days did you work on [crop] production during the [season] season? *Make sure that length of day is a full 8-hour laborer day* | (3.04) In total, how many days did other *male* members of your household work on your [crop] production during the [season] season? *Make sure that length of day is a full 8-hour laborer day* | (3.05) In total, how many days did other *female* members of your household work on your [crop] production during the [season] season? *Make sure that length of day is a full 8-hour laborer day* |
| a. Paddy | | | | | |
| b. Black gram | | | | | |
| c. Green gram | | | | | |
| d. Tomato | | | | | |
| e. Onion | | | | | |
| f. Cauliflower | | | | | |
| g. Other (specify) | | | | | |

(3.06) On average, how much did you pay for a day of male hired labor during last 12 months? (in INR) _____ INR per day

(3.07) On average, how much did you pay for a day of female hired labor during last 12 months? (in INR) _____ INR per day

| **Role in household decision-making around production and income [PRO-WEAI Module G2]** | | | | | | | |
|---|---|---|---|---|---|---|---|
| | | (G2.01) Did you [NAME] participate in [ACTIVITY] in the past 12 months (that is, during the last [one/two] cropping | (G2.02) When decisions are made regarding [ACTIVITY], who normally makes the decision? 1 = Myself, solely 2 = Myself, jointly with female/male | (G2.03) How much input did you have in making decisions about [ACTIVITY]? **USE CODE G2↓** 1 = Little to no input in decisions 2 = Input into some | (G2.04) To what extent do you feel you can participate in decisions regarding [ACTIVITY] if you want(ed) to? **CIRCLE ONE** | (G2.06) How much input did you have in decisions about how much of the outputs of [ACTIVITY] to keep for consumption at home rather than selling? **USE CODE G2↓** 1 = Little to no input in | (G2.07) How much input did you have in decisions about how to use income generated from [ACTIVITY]? **USE CODE G2↓** 1 = Little to no input |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | | seasons), from [PRESENT MONTH] last year to [PRESENT MONTH] this year? | respondent<br>3 = Myself, jointly with someone else from household<br>4 = Others from the household | decisions<br>3 = Input into most or all decisions<br>98 = Not applicable /no decision made | 1 = Not at all<br>2 = Small extent<br>3 = Medium extent<br>4 = To a high extent | decisions<br>2 = Input into some decisions<br>3 = Input into most or all decisions<br>98 = Not applicable /no decision made | in decisions<br>2 = Input into some decisions<br>3 = Input into most or all decisions<br>98 = Not applicable / no decision made |
| A | Staple grain farming and processing of the harvest: grains that are grown primarily for food consumption (rice, maize, wheat, millet) | YES……1<br>NO…….2 → ***ACTIVITY B*** | | | | | |
| B | Horticultural (gardens) or high-value crop farming and processing of the harvest | YES……1<br>NO…….2 → ***ACTIVITY C*** | | | | | |
| C | Raising large livestock (cattle, buffaloes) and processing of milk and/or meat | YES……1<br>NO…….2 → ***ACTIVITY D*** | | | | | |
| D | Raising small livestock (sheep, goats, pigs) and processing of milk and/or meat | YES……1<br>NO…….2 → ***ACTIVITY E*** | | | | | |
| E | Raising poultry and other small animals (chickens, ducks, turkeys) and processing of eggs and/or meat | YES……1<br>NO…….2 → ***ACTIVITY F*** | | | | | |
| G | Fishpond culture | | | | | | |
| H | Non-farm economic activities (running a small business, self-employment, buy-and-sell) | | | | | | |
| I | Wage and salary employment (work that is paid for in cash or in-kind, including both agriculture and other wage work) | | | | | | |
| J | Large, occasional household purchases (bicycles, land, transport vehicles) | | | | | | |
| K | Routine household purchases (food for daily consumption or other household needs) | | | | | | |

| Module 5: RISK (for main farmer) | | |
|---|---|---|
| 5.01 | Did your crop get damaged by any natural hazard while in the field during….<br>1. Rabi 2020–2021<br>2. Kharif 2021<br>3. Rabi 2021–2022<br>4. Kharif 2022 | 1 = Yes<br>0 = No |
| 5.02 | *If 5.01 = 1*<br>What damaged the crop? Select the main cause | 1 = Pests and diseases<br>2 = Excess/unseasonal rains<br>3 = Hail<br>4 = Strong winds<br>5 = Too much fog<br>6 = Temperatures too high<br>7 = Flood<br>8 = Drought<br>9 = Fire<br>10 = Other, specify |
| 5.03 | *If 5.01 = 1*<br>What proportion of the cultivated area was affected by the damage? | 1 = Limited damage – 1/4<br>2 = Moderate damage – 1/2<br>3 = Severe damage – 3/4<br>4 = Full loss – full |
| 5.04 | *If 5.01 = 1*<br>Of the proportion of cultivated area, what percentage of the crop was damaged/lost? | 1 = Limited damage – 1/4<br>2 = Moderate damage – 1/2<br>3 = Severe damage – 3/4<br>4 = Full loss – full |
| 5.05 | If 5.01 = 1<br>How did your household cope with the damage? [Select all that apply] | 1 = Borrowed loans from informal sources (friends/family, local moneylenders)<br>2 = Borrowed loans from formal sources (e.g., bank, MFI)<br>3 = Received gifts (cash or in-kind) from friends/family<br>4 = Received compensation from government scheme<br>5 = Used household savings or sold non-productive assets (such as jewelry, consumer goods)<br>6 = Sold productive assets (used for business or agriculture)<br>7 = Reduced day-to-day expenditure<br>8 = Postponed large expenditures (e.g., school fee payment)<br>9 = Took up additional job or worked longer hours outside of the farm<br>10 = Reduced inputs used in the affected season<br>11 = Reduced investments in farm in subsequent seasons<br>12 = Modified cropping pattern or practices in the subsequent seasons<br>13 = Did nothing<br>14 = Others, specify_____ |
| 5.06 | Did you suffer any of the following shocks to your health because of this damage? | 1 = Illness (specify)<br>2 = Injury (specify)<br>3 = Depression<br>4 = Anxiety<br>5 = Panic attacks<br>6 = Other (specify)<br>7 = None of the above |
| 5.07 | *If 5.01 = 1*<br>In order to avoid such damage in future, what measures are you taking currently? | 1 = Additional savings<br>2 = Using technology to forecast contingency<br>3 = Taking up insurance<br>4 = Changing the cropping pattern<br>5 = No plans<br>6 = Others, specify_____ |

| Module 6: AWARENESS OF INSURANCE PRODUCTS (for main farmer only) | | |
|---|---|---|
| 6.01 | Have you heard of crop insurance? | 1 = Yes<br>0 = No |
| 6.02 | Which of the following statements about crop insurance are true?<br>1. I have to pay (a premium) to be covered by crop insurance<br>2. The premium amount is typically much smaller than the compensation amount I could get back from the insurance<br>3. Crop insurance promises to pay compensation every season<br>4. Crop insurance promises to pay compensation for any amount of loss I may face for any reason<br>5. If I don't have any crop damage, the insurance company gives back my premium<br>6. Crop insurance promises to pay compensation to me even if the price for my crop falls | 1 = True<br>2 = False |
| 6.03 | Are you aware of the existence of the following types of crop insurance in your village?<br>1. The PMFBY scheme Yes/No<br>2. National Weather Index Based Insurance (Restructured Weather-based Crop Insurance Scheme) Yes/No<br>3. Picture-based crop insurance Yes/No<br>4. Other (specify) Yes/No | 1 = Yes<br>0 = No |
| 6.04 | Which risks are covered by this insurance? Select all that apply | 1 = Pests and diseases<br>2 = Excess/unseasonal rain<br>3 = Late onset of monsoon<br>4 = Hail<br>5 = Strong winds/lodging<br>6 = Frost/low temperatures<br>7 = Temperatures too high<br>8 = Drought/dry spell<br>9 = Price fluctuations |

| **Season** | What are the main crops that you cultivated in this season? | a. Did you have crop insurance for [crop] in this season? | b. [If a is "Yes"] Which insurance policy did you have?<br><br>1. The PMFBY scheme<br>2. Picture-based crop insurance<br>3. Others | Was this insurance policy tied to any loan that you took? | c. How much area did you insure (in acres) | d. [If a is "Yes"] What was the premium you paid (in INR per acre) | e. [If a is "Yes"] What was the total sum insured? (in INS per acre)<br><br>Hint: This is the maximum you can receive from the insurer on suffering 100% damage | f. [If a is "Yes"] Did you receive a payout in this season?<br><br>Yes/No | g. [If a is "Yes"] What is the payout you received? | h. [If a is "Yes"] Were you satisfied with this payout?<br><br>1 = Satisfied<br>2 = Somewhat satisfied<br>3 = Not satisfied | i. [If a. is "No"] what was the main reason for not enrolling in any crop insurance?<br><br>1 = Did not know how to enroll<br>2 = I don't understand how it works<br>3 = I don't need it<br>4 = Too expensive<br>5 = I didn't have the money at that time<br>6 = I don't trust getting paid<br>7 = Coverage too low/payments don't cover my losses<br>8 = I have a personal experience in the past where it didn't work<br>9 = It didn't work for my neighbor/friend<br>-888 = Other (specify) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Rabi 2020–2021** | | | | | | | | | | | |
| **Kharif 2021** | | | | | | | | | | | |
| **Rabi 2021–2022** | | | | | | | | | | | |
| **Kharif 2022** | | | | | | | | | | | |

| Module 8: ACCESS TO PRODUCTIVE CAPITAL | | | | |
|---|---|---|---|---|
| | a. | b. | c. | d. |
| | Productive Capital | **Does anyone in your household currently own any [ITEM]?**<br>1 = Yes, one<br>2 = Yes, more than one<br>0 = No | **Do you own any [ITEM]? [PROWEAI]**<br>1 = Yes, solely<br>2 = Yes, jointly with female/male respondent<br>3 = Yes, jointly with someone else from household<br>4 = No | **How many do you or your household own?** |
| 1 | Agricultural land (pieces/plots) | | | In acres |
| 2 | Other land not used for agricultural purposes (pieces/plots, residential or commercial land) | | | In acres |
| 3 | Large livestock (cows, buffaloes, bullocks, horses, donkeys, mules) | | | Separately for<br>(1) Cows<br>(2) Buffalos<br>(3) Bullocks<br>(4) Horses, donkeys or mules |
| 4 | Small livestock (goats, sheep, pigs) | | | Separately for<br>(1) Goats<br>(2) Sheep<br>(3) Pigs |
| 5 | Chickens, ducks, turkey, pigeons | | | |
| 6 | Fishpond or fishing equipment | | | |
| 7 | Farm equipment (non-mechanized: hand tools, animal-drawn plows, non-mechanized irrigation tools) | | | |
| 8 | Farm equipment (mechanized: electric pump- | | | |

| | | | | |
|---|---|---|---|---|
| | set, diesel pump-set, diesel generator for pumping water, polyhouse, tractor, seed-cum-fertilizer-drill machine, power-tiller, rotavator, zero-till drill, happy-seeder, thresher, straw reaper, combine harvester, laser land leveler) | | | |
| 9 | Nonfarm business equipment (solar panels used for recharging, sewing machine) | | | |
| 10 | House or other structures | | | |
| 11 | Large consumer durables (refrigerator, TV, sofa, dining table, chair, mattress, cot or bed, computer, washing machine) | | | |
| 12 | Small consumer durables (radio or transistor, pressure cooker, inverter, electric fan, watch or clock, landline phone) | | | |
| 13 | Regular mobile phone | | | |
| 14 | Smartphone | | | |
| 15 | Means of transportation (bicycle, motorcycle, car, animal-drawn cart) | | | |
| 16 | Valuable items such as gold, jewelry | | | |

## Module 9: STRESS – (respondent female)

The next set of questions ask you about your feelings and thoughts during the last month. In each case, you will be asked to indicate your response by telling me how often you felt or thought a certain way.

1 = Never
2 = Almost never
3 = Sometimes
4 = Fairly often
5 = Very often

| | | |
|---|---|---|
| 6.01 | How often have you felt that you were unable to control the important things in your life? | |
| 6.02 | How often have you felt confident about your ability to handle your personal problems? | |
| 6.03 | How often have you felt that things were going your way? | |
| 6.04 | How often have you felt that difficulties were piling up so high that you could not overcome them? | |

## Module 10 - Consumption module (respondent: female)

| | **Food group** | **Examples** | (7.01) In the last 7 days, on how many days did your household consume [food]? | (7.02) If (7.01) ≥ P1: Did anyone in the household consume [food] yesterday during day or night? 1 = Yes 0 = No | (7.03) If (7.02) = P1: Did you yourself consume [food] yesterday during day or night? 1 = Yes 0 = No |
|---|---|---|---|---|---|
| 1 | Cereals/grains | Rice, wheat, beaten rice, puffed rice, maize, semolina, bread | | | |
| 2 | White tubers and roots | White potatoes, white yams, white cassava | | | |
| 3 | Vitamin a rich tubers and roots | Sweet potatoes, beet, turnip | | | |
| 4 | Vitamin A-rich vegetables | Pumpkin, carrots, squash | | | |
| 5 | Dark green leafy vegetables | Spinach, mustard leaves, *palanga*, fenugreek leaves, coriander leaves | | | |
| 6 | Other vegetables | Tomato, onion, brinjal/eggplant, gourd, pointed gourd (*parwal*), radish, pumpkin, bitter gourd (*karela*), cauliflower, cabbage, okra (*blindi*), French beans (*barbati*), green chillis, sponge gourd (*ton*) | | | |
| 7 | Vitamin A-rich fruits | Ripe mangoes, cantaloupe, apricots (fresh or dried), ripe papaya, dried peaches, and other locally available vitamin-A rich fruits | | | |
| 8 | Other fruits | Other fruits, including wild fruits | | | |
| 9 | Organ meat | Liver, kidney of goat or chicken | | | |

| | | | | | |
|---|---|---|---|---|---|
| | (iron-rich) | | | | |
| 10 | Flesh meats | Lamb, goat, chicken, duck | | | |
| 11 | Eggs | Chicken, duck, guinea hen or any other egg | | | |
| 12 | Fish | Fresh or dried fish or shellfish | | | |
| 13 | Legumes | Beans, peas, lentils | | | |
| 14 | Nuts and seeds | Nuts, seeds or foods made from these | | | |
| 15 | Milk and milk products | Milk, cheese, yogurt or other milk products | | | |
| 16 | Oils and fats | Oil, fats or butter added to food or used for cooking | | | |
| 17 | Sweets | Sugar, honey, sweetened soda or sugary foods such as chocolates, candies, cookies, and cakes | | | |
| 18 | Spices, condiments, beverages | Spices (black pepper, salt), condiments (soy sauce, hot sauce), coffee, tea, alcoholic beverages, OR local examples | | | |

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