Impact Evaluation (IE) Concept Note

Relieving Capital Constraints for Rice Farmers – Warehouse Receipts System in Senegal

[P158266]

April 2017

Keywords: Credit, Rice, Storage, Agricultural markets, Senegal

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IE Profile Indicators

No.	Indicator	Description
1	IE code	IE code (hyperlink to IE portal)
2	IE Title	Relieving Capital Constraints for Rice Farmers – Warehouse Receipts System in Senegal
3	IE TTL	Francisco Campos (GTCDR)
4	IE Contact Person	Guigonan Serge Adjognon (DECIE)
5	Region	AFR
6	Sector Board/Global Practice	T&C/IFC
7	WBG PID (if IE is evaluating a WBG operation)	IFC-00600203
8	WBG Project Name	Warehouse Receipts System Development in Senegal
9	Project TTL (if IE is evaluating a WBG operation)	David Ivanovic
10	Intervention	Warehouse Receipt System
11	Main Outcomes	Access to credit, agricultural income
12	IE Unit of Intervention/Randomization	The main unit of randomization will be the farmers' Common Interest Groups called GIEs.
13	Number of IE Units of Intervention	300 GIEs
14	IE Unit of Analysis	Lowest level of analysis on which outcomes are measured: farmers
15	Number of IE Units of Analysis	1,800 farmers
16	Number of Treatment Arms	3 treatment groups and 1 control group
17	IE Question 1 (Treatment Arm 1)	What is the impact of participating in the WRS on rice producers' access to credit, rice marketing, and agricultural income?
18	Method IE Question 1	Randomized experiment
19	Mechanism tested in IE Question 1	Can WRS release the collateral values of harvests and increase farmers' access to credit?
20	IE Question 2 (Treatment Arm 2)	What is the impact of subsidized transaction costs (such as storage fees) on GIEs' decision to participate in the WRS?
21	Method IE Question 2	Random assignment at the GIEs level
22	Mechanism tested in IE Question 2	The role of transaction costs in participation decision in the WRS
27	Gender analysis (Yes, No)	Yes (oversampling of women farmers)
28	IE Team & Affiliations	Guigonan Serge Adjognon (Economist, DECIE, IE Co TTL); Francisco Campos (Senior Economist, GTCDR, IE Co TTL); Victor Pouliquen (Paris School of Economics, External PI)
29	Estimated Budget (including research time)	590,000 USD
30	CN Review Date	April 2017
31	Estimated Timeframe for IE	06-2017 to 06-2019
32	Main Local Counterpart Institution(s)	Ministry of Commerce

1. Executive Summary

Lack of access to credit and storage infrastructures considerably limits farmers' ability to take advantage of interseasonal variations in commodity prices in rural areas of Sub Saharan Africa (SSA). Farmers generally sell most of their production right after harvests, when prices are the lowest, to satisfy immediate cash needs, only to buy again at high prices later for their own consumption. It has been hypothesized that access to post harvest credit would offer more flexibility to farmers to decide the timing of sales of their products and earn higher revenues from their farming activities. But the credit market in rural SSA suffers critical failures due primarily to information asymmetries and risks. The lack of conventional collateral makes it harder for farmers in rural SSA to have access to formal loans from financial institutions.

Warehousing Receipts Systems (WRS), whereby farmers can use the products stored in a certified warehouse as collateral for the loans, have gained popularity in recent years, as institutional innovation to solve the failure in the rural credit markets. The government of Senegal through the Ministry of Commerce, with technical assistance from the World Bank Group's Trade & Competitiveness GP (IFC AS), is introducing WRS in the country, through a pilot WRS project in the rice sector in the Senegal valley. The overall objective is to support increased access to finance to value chain actors in the agricultural sector of Senegal, favoring the development of better storage facilities and building capacities of private and public stakeholders. The main activities of this pilot project include (i) creating a legal and regulatory environment for WHR, (ii) provision of technical expertise and assistance to the WRS regulatory unit during start-up phase, (iii) sensitization and training of stakeholders on the WRS, (iv) assistance to the warehousing industry, (v) stakeholder engagement for a warehouse receipts trading platform. This pilot is very important for the government as lessons learnt will be used to inform scale up to other grains' value chains and other regions. Therefore, the GoS has requested the support of DIME[1] and T&C (jointly the impact evaluation team), to design an impact evaluation and generate rigorous evidence from the project.

While WRS are becoming increasingly popular in the continent, little is known about their impacts. This study aims at contributing to the emerging literature on WRS in SSA by exploring: (a) the impact of participation in WRS on rice farmers' access to credit, rice sales and storage, and agricultural income; and (b) how the transaction costs of participating in the system, such as storage fees, affect farmers' participation decision. For both these questions, this study will rely on a randomized controlled trial (RCT) at the farmers associations (called GIEs) level. This concept note document presents the main research questions, the design and identification strategy, and plans for data analysis.

2. Background and Key Institutional Features

Nearly 60% of the 13.7 million people in Senegal live in rural areas, and 70% of the rural population depends on agriculture for living. In 2012, the agricultural sector represented 17% of the GDP and employed 60% of the labor force (World Bank, 2013). With more than half the population living in poverty, including 38% living below the international poverty line of US$1.9 a day in 2011, improving agriculture can play a key role on food security and poverty reduction in Senegal (World Bank, 2016). The Government of Senegal's (GoS) "Strategy for Accelerated

[1] DIME=Development Impact Evaluation is a unit of the World Bank Development Research Group (DECRG) which focuses on generating high quality and operationally relevant impact evaluation research to transform development policy, reduce extreme poverty and secure shared prosperity.

Growth" lists agriculture and agro-industries among the five key economic sectors the country should develop further.

Rice is a strategic crop for the country for economic, social and food security reasons. The sector employs more than 1.5 million people (i.e. 10% of the population) and represents 60% of cereal consumption (FAO, 2013). Production has grown steadily from 80,000 MT in 1960 to more than 630,000 MT in 2012, due to improved irrigation infrastructure and the introduction of better varieties and production practices (USAID, 2009; FAO, 2014). However, despite the potential of the country to be competitive in the sub-region if production is scaled-up, imports still cover 60% of the national rice consumption, amounting to a trade deficit valued at more than $450 million (UN Comtrade, 2014).

The main policy issue underlying this project is rice farmers' limited access to credit. Unlocking the collateral value of inventories that farmers and traders manage (i.e. warehouse receipts financing) would potentially clear the first hurdle to relieving access to capital constraints. To advance warehouse receipt financing in Senegal, the country is seeking a systemic solution grounded in a national warehouse receipts regulatory framework. Such framework would aim at building trust and increase credit opportunities for farmers active in the agriculture sector.

The Senegal WRS project

The rice produced in the Senegal valley follows a complex value chain involving several actors with interrelated roles and functions. These include primarily (i) the producers, (ii) the millers, (iii) the traders, (iv) the banks (primarily the CNCAS[2] -Caisse National de Credit Agricole du Senegal), (v) the government (primarily the SAED[3] - Societe Nationale d'Exploitation des Terres du Delta du Fleuve Senegal), and (vi) the consumers.

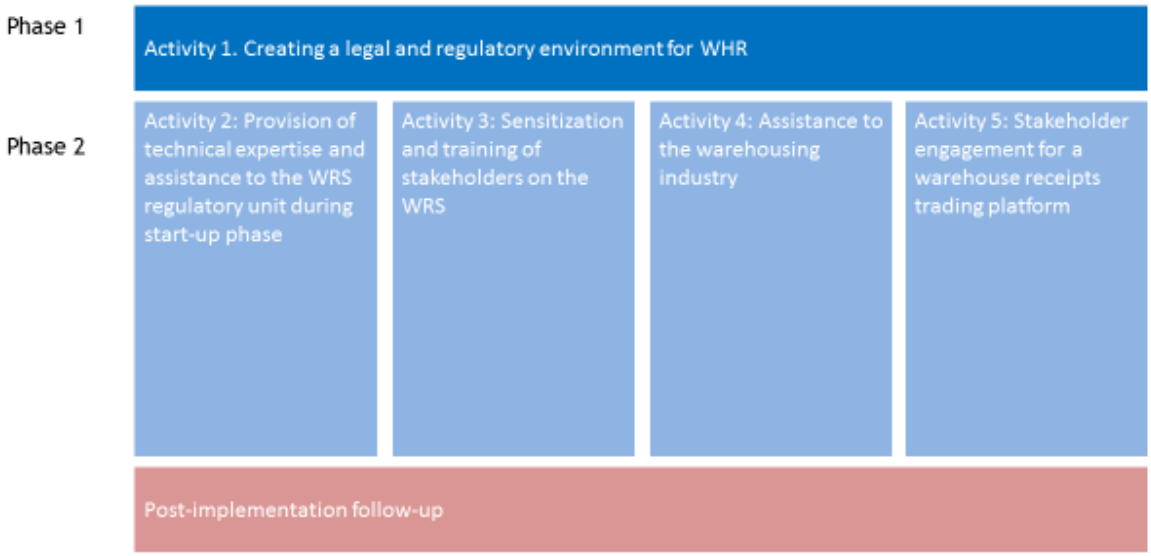
The GoS, through the Ministry of Commerce, Entrepreneurship and the Informal Sector, has asked the IFC to support the implementation of a WRS for the rice industry, accompanied by the development of a legal and regulatory framework, training and sensitization activities and support to the warehousing industry. This pilot will be accompanied by a rigorous impact evaluation (IE), which will be critical for learning about the impact of the intervention, deciding to scale it up to other sub-sectors and regions, and improving its delivery mechanisms.

THE MAIN OBJECTIVE OF THE SENEGAL WRS PROJECT, AS STATED BY THE PROJECT DOCUMENT, IS TO *"SUPPORT INCREASED ACCESS TO FINANCE TO VALUE CHAIN ACTORS IN THE AGRICULTURAL SECTOR OF SENEGAL, FAVORING THE DEVELOPMENT OF BETTER STORAGE FACILITIES AND BUILDING CAPACITIES OF PRIVATE AND PUBLIC STAKEHOLDERS".* THIS INCLUDE, IN A FIRST PHASE, THE CREATION OF A LEGAL AND REGULATORY FRAMEWORK FOR THE WRS, WHICH WILL DEFINE THE RULES OF THE GAME FOR THE POTENTIAL ACTORS IN THE SYSTEM (ACTIVITY 1 IN

Figure 1). Activity 2 includes supporting the setting up of a WRS regulation authority, which will oversee the enforcement of the law, and monitor compliance with quality standards required for warehouses to become certified and be authorized to deliver warehouse receipts. Such regulatory framework is crucial for generating trust amongst actors for the functioning and sustainability of the WRS. The Senegal WRS regulatory framework has been drafted and is now awaiting ratification by the parliament.

[2] Government bank, main financial institution for the agricultural sector
[3] Government agency providing technical support to the agricultural sector in the Senegal valley

FIGURE 1: THE SENEGAL WAREHOUSE RECEIPT SYSTEM



Activity 3 of the project includes sensitization, information, and training campaigns to raise awareness about the WRS and its potential benefits for the various actors in the value chain.

By definition, a WRS needs warehouses that meet the minimum quality and safety standards that qualify them to receive the certification from the regulation authority. To get a sense of the existing warehouse infrastructures in the project area, and their potential for WRS, the project, as part of Activity 4, has implemented a census on all the warehouses in the areas. The study report, available upon request, indicates that:

- there is a total of 268 warehouses larger than 100m2 in the area
- 67% of those warehouses belong to farmers' unions while 27% belongs to private millers
- The general quality of warehouses is very low, but privately owned warehouses have higher standard on average
- There is a high concentration of warehouses infrastructures and quality in the Dagana department followed by Podor, compared to Matam and Bakel.

Given this is the first time the WRS is being introduced in Senegal, the GoS has decided, as part of activity 5, to experiment, at small scale, a WRS trading platform to serve as demonstration for the various actors, and to also learn about the potential impacts and factors of success of such arrangement. The IE for which this concept note is developed will be based on this pilot and allow us to answer some important questions relevant for the WRS development agenda in Senegal and beyond.

3. Literature Review (E)

Failures in agricultural marketing systems in SSA

Agricultural markets in Africa remain underdeveloped and inefficient. The hope that governments' withdrawal from the agricultural sector will prompt the private sector to take over and yield more efficient markets outcomes was

met, to some extent, with disappointment. Huge transactions costs, information asymmetries, and incomplete markets due partly to the lack of public infrastructures and institutions for risks management and contracts enforcement have limited the ability of the private sector to effectively replace government parastatals, and provide agricultural services (Besley, 1994; Doward et al. 1998; Kelly et al., 2003).

Kelsey (2013) described seven markets imperfections that seriously undermine agricultural growth in the developing world. Amongst them, access to credit is one of the most important markets critically lacking for the poor farmers in rural areas of Africa. Limited access to credit and high interest rates faced by poor farmers have not only limited their ability to invest in profitable agricultural inputs, but it has also led them to sell cheap their production right after harvest when prices are the lowest, to earn some cash and satisfy immediate needs for liquidity. This situation illustrates, in part, why access to rural finance is considered a crucial poverty reduction tool (Burke, 2014).

Warehouse receipt systems (WRS) have gained popularity in recent years across SSA as one of the critically needed innovations that may facilitate market exchange (including credit markets), and improve the business environment in the agricultural sector (Coulter et al., 1995; Coulter et al. 2002).

WRS – definition and potential benefits

As described in box 1, a WRS is an institutional arrangement to provide farmers with more flexibility in marketing decisions and serving as a mechanism to access more credits. With this system, farmers can bring agricultural commodities to a certified warehouse and receive receipts certifying the quantity, quality and location of the commodity stored. These receipts provide a secure system whereby stored agricultural commodities can serve as collateral, be sold, traded or used for delivery against financial instruments including futures contracts. There are several variants of WRS according to the commodity, the existing institutional environment, the actors involved, and the relationship between them. Examples are tripartite collateral management agreements, inventory credit systems, and, in some more advanced cases, commodity exchanges. The regulatory system supporting these arrangement is crucial for their sustainability.

Box 1: What are warehouse receipts (WR)

Warehouse receipts (WR) are documents issued by warehouse operators as evidence that specified commodities of stated quantity and quality, have been deposited at particular locations by named depositors.
The depositor may be a producer, farmer group, trader, exporter, processor or indeed any individual or body corporate. The warehouse operator holds the stored commodity by way of safe custody; implying he is legally liable to make good any value lost through theft or damage by fire and other catastrophes but has no legal or beneficial interest in it. The receipts may be transferable, allowing transfer to a new holder—a lender (where the stored commodity is pledged as security for a loan) or a trade counter-party—which entitles the holder to take delivery of the commodity upon presentation of the WR at the warehouse.

Source: Coulter et al. (2002)

WRS have the potential to generate several interrelated benefits to actors along the value chain. They bear the potential to curtail cheating on weights and measures, ease access to finance at all levels in the marketing chain, moderate seasonal price variability and promote instruments to mitigate price risks. They can provide infrastructures and institutions improving efficiencies along the chain, while generating direct welfare gains for the farmers through capital constraint relief, temporal arbitrage, and improved market access. Coulter et al. (2002) discussed these

potential benefits in terms of: (i) trade facilitation, (ii) market efficiency enhancement, (iii) easing access to rural finance, (iv) mitigating price risks, and (v) cost effective management of food reserves.

The main potential challenges to the success of WRS relate to the policy, institutional, and regulatory environment necessary to engender trust from actors involved, especially the banks. Economies of scale may also be an issue for the inclusion of smallholders.

Gap in the literature

Given the potential benefits of WRS for the agricultural value chains, several countries in SSA are implementing WRS for various commodities, and at various scales and degrees of advancement. Examples include Ethiopia, Zambia, South Africa, Zimbabwe, and more recently, Cote d'Ivoire, Kenya, Malawi, Burkina Faso, and Senegal. However, there is surprisingly limited rigorous empirical evidence of the effectiveness and impacts of these schemes beyond case study reports. Therefore, policy makers such as the GoS, implementing WRS interventions, have very limited sources to draw from.

A review of the thin literature on the subject suggests positive association of participation in WRS and agricultural income (Pender, 2008; Tabo et al., 2011); as well as income diversification (Bouquet et al, 2009). But these studies are not experimentally identified and their results cannot be given causal interpretation.

Casaburi et al (2014) used an experimental design to assess the impacts in Sierra Leone of storage support and separately of inventory credit, while allowing farmers to use the oil stored in the community storage as collateral for the loans. The take-up rate was 29.9% for the storage support and 24.9% for the inventory credit. The programs did not have a significant impact on overall storage behavior or on the patterns of oil sales across seasons. The storage within the scheme primarily substituted for other forms of storage. Therefore, in the first year, the two schemes provided limited benefits for the participating communities. The lessons from this study will be used in designing the impact evaluation of the WRS.

The preliminary results from another (still in progress) experimental study, implemented by IPA, in the Tuya and Loba provinces in Burkina Faso, suggests that inventory credit, or *warrantage communautaire*, significantly increased consumption and savings as well as investments in agricultural inputs and education. The take up analysis indicated that 36 percent of the smallholders who were offered the program used the storage facilities, and 39 percent of these took a *warrantage* loan.

These results are not fully informative and clearly points to the needs for more studies around WRS to understand better their impacts and mechanisms and inform policy design.

4. Policy Relevance

Through this IE, the GoS is interested to learn about the impact of the WRS as a tool to improve access to finance in the agricultural sector. The Government has selected the rice sector as a pilot industry. If proven to be successful, the Government's goal is to scale up the WRS to other storable agricultural products (mainly cereal products). The IE is therefore highly policy-relevant and, due to our collaboration with the government, scalability is built into the design right from the start.

WRS have been implemented in several countries in Africa including Ethiopia, Zambia, and South Africa, but to our knowledge, this would be amongst the first IE to provide rigorous evidence of its effectiveness[4]. The T&C Africa program itself has been implementing programs in four countries (Senegal, Cote d'Ivoire, Kenya and Malawi) to support the implementation of warehouse receipt systems. Further, there are demands from many African countries to support the implementation of WRS. This IE will therefore not only help the Government of Senegal to inform its scale-up decision and improving the WRS design, but also provide crucial evidence for other countries testing similar approaches across the developing world.

At the same time, USAID is implementing several activities to structure the agricultural sector of Senegal. The project team has started to coordinate WRS activities with USAID to support increased storage infrastructures and access to credit in the rice sector, so that duplication of efforts is avoided and synergies can be exploited.

5. THEORY OF CHANGE (E)

THE CHART IN

Figure 2 summarizes the theory of change and underlying assumptions motivating the Senegal WRS project. The project activities counting as inputs are expected to lead to take up by the relevant value chain actors. Warehouses operators in the right condition will apply for the warehouse receipt certification, and get the authorization to receive stock of products and deliver warehouse receipts that are valued by other actors of the value chain. Farmers will bring their products to certified warehouses and take the receipts. Banks will trust the system and accept those receipts as collateral.

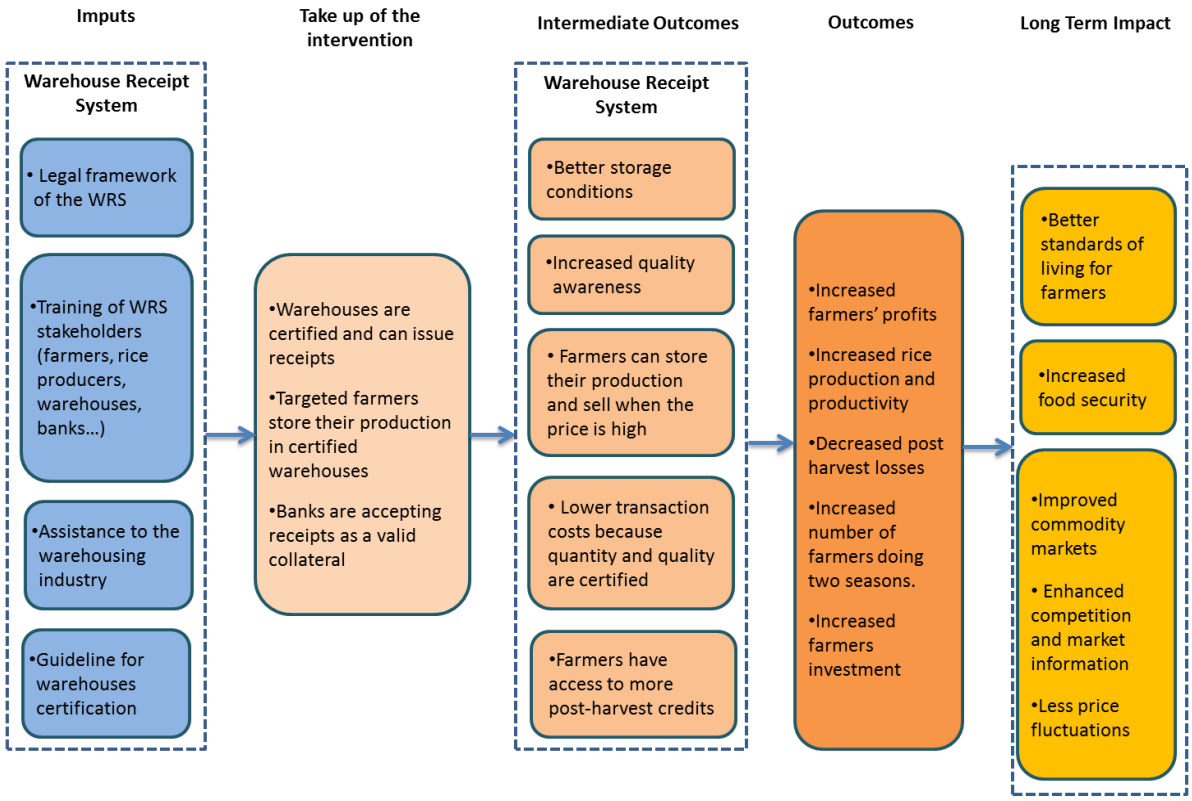
Under those conditions, the WRS is expected to yield the following intermediate and final outcomes and impacts:

- Mobilization of credit to agriculture by creating secure collaterals for the farmer, processor, and trader;
- provide surplus-producing farmers (including smallholders) with a market window, which can help them, secure the best possible deal, allowing them to deal directly with downstream buyers and financiers, and overcome asymmetric power relationships within the market chain.
- Smoothing of market prices by facilitating sales throughout the year rather than just after harvests;
- Upgrading the standards and transparency of the storage industry since it requires better regulation and inspection;
- Creating commodity markets which enhance competition, market information and trade;
- Contributing to lower post-harvest losses due to better storage conditions (i.e. induces farmers to store in more appropriate warehouses);

[4] The RCT studies in Sierra Leone (Casaburi et al, 2014) and in Burkina Faso (IPA) have focused on *warrantage* which is slightly different from the standard WRS. The *warrantage* does not offer improved storage infrastructure to the beneficiaries.

- Lowered transaction costs by guaranteeing quantity and quality and allowing trade of receipts instead of physical commodities;
- Increased quality awareness as the production stored is systematically evaluated (allowing for grading of crop quality)
- The WRS can help farmers store more food for their local consumption requirements, protecting farmers from "overselling" crops, which are shipped out to urban centers, only to be shipped back as either grain or meal, and at much higher prices in the lean season.
- Increased investments in warehouses (third party warehousing becoming a more attractive business) and processing (lower cost of financing working capital, i.e. stored paddy rice).

FIGURE 2: PROGRAM THEORY OF CHANGE



Source: Project Document - Senegal Warehouse Receipt Program

6. HYPOTHESES/EVALUATION QUESTIONS (E,R)

This impact evaluation will focus on the following two main research questions:

Q1- What is the impact of participating in the WRS on rice producers' access to credit, rice sales and storage patterns, and agricultural income?

Q2 – What is the effect of providing subsidies offsetting the transaction costs of participation in the WRS on take up of the system by farmers' associations?

7. Main Outcomes of Interest (E,R)

Table 1 summarizes the main outcomes of interest in this impact evaluation analysis, and their definition as well as measurement level. The pilot WRS in Senegal will target farmers' groups called GIEs (from French acronym). Outcomes will be measured at both the group level and the farmers' household level. This will help shed the light on potential distributional and equity issues that may affect program impacts within the group.

TABLE 1. MAIN OUTCOMES OF INTEREST

Outcome Type	Outcome Name	Definition	Measurement Level
Primary	Income	Value of rice production. Sales of rice. Household level income, consumption and other welfare.	Farmer's Household
Primary	Access to post harvest credit	Indicator variable for whether, or not, the GIE/farmer took a loan during the post-harvest If yes, what is the source? What is the amount? Conditions of credit? What is the objective?	GIE Farmer's Household
Primary	Take up of WRS usage	Indicator variable for whether the GIE/farmer stored part of the harvest in the program warehouses. This is an indicator of take-up	GIE Farmer's Household
secondary	Rice storage and inventories	Quantities of Paddy in storage at various points in time during post-harvest period	GIE Farmer's Household
Secondary	Marketed surplus	Total share of rice production sold by the following season	Farmer's Household
Secondary	Rice paddy selling prices	Average price at which farmers sell their paddy	Farmer's Household
Secondary	Quality of rice paddy sold	Grade score of paddy rice at time of destorage	Farmer's Household
Secondary	Post-harvest losses during storage	Quantity of rice paddy lost (not sold and not consumed)	Farmer's Household

8. Evaluation Design and Sampling Strategy (E,R)

8.1 Design

To answer the questions presented above, we will rely on an experimental WRS involving farmers' groups (GIEs), private millers with up-to-standard warehouses, and the CNCAS (Caisse Nationale de Credit Agricole), which is the primary financial institutions for the rice value chains actors in the Senegal valley. The CNCAS will be the sole financial institution partner in this experimental WRS. Therefore, we will work only with farmers' groups and private millers in the catchment of the CNCAS. This implies that our sample of focus is not necessarily representative of the whole valley, but would still certainly offer important insights for the scale up of the WRS project.

Amongst all the private millers already working with the CNCAS as part of their collateral management program[5], 5 to 10 millers, with good infrastructures and willing to participate, will be chosen to support this pilot program[6]. They will therefore receive exclusive rights from the CNCAS to deliver warehouse receipts to farmers' groups who will deposit their stocks of rice in their warehouses. Given that the WRS regulatory authority will not be in place by the time this experiment is conducted, the trust of the CNCAS will come from the fact that the collateral manager sitting in each of the chosen warehouses will represent the interests of the Bank and monitor the stocks of paddy against which the bank will be giving credit to farmers. This experimental WRS will be conducted in the Dagana department were warehouses, especially private millers with better infrastructures, are most concentrated.

Q1: Impact of participating in the WRS

A POPULATION OF 300 GIES, GROUPED INTO 28 FARMERS UNIONS, AND ALREADY WORKING WITH THE CNCAS WILL BE RANDOMLY DIVIDED BETWEEN 150 GIES IN A TREATMENT GROUP AND 150 IN THE CONTROL GROUP (

Figure 3). The treatment GIEs will be offered the opportunity to deposit their stock of rice in the designated warehouses and receive warehouse receipts that the CNCAS will accept as collateral for credit. The receipt will indicate the quantity, quality, grade, and value of the rice deposited by the GIEs in the warehouses. The quantity and quality measurement tools at the chosen warehouses will allow a good appreciation of the value of the paddy. The CNCAS will give a credit of up to 75 percent of the value of the stored products. The collateral manager will deliver the warehouse receipts when farmers bring their stocks, and monitor the products while in storage. Then, they will release the products when farmers or buyers show up with the receipts attached to specific stocks of products.

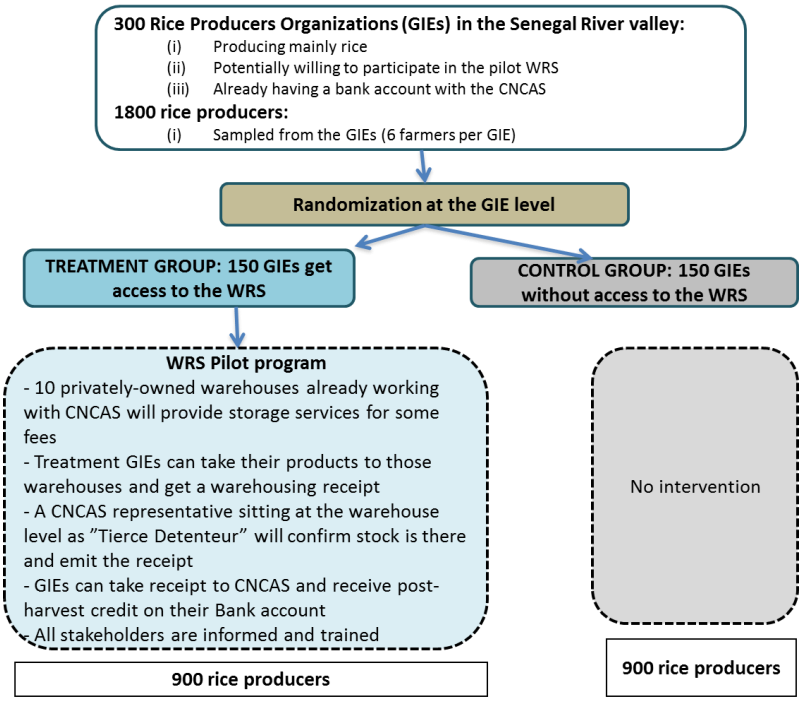
[5] The collateral management program is a program through which the CNCAS provides credit to private millers to buy enough paddy rice to run their milling industry until the following season. But to enforce the repayment, the CNCAS appoints someone (the collateral manager) who sits at the milling facility and takes hold of the milled rice, ensuring that the miller repays before he can access the product and sell to buyers.

[6] Private millers have expressed great interest in participating in this program during our preliminary field visits

The controlled GIEs will do business as usual, whereby they can store their products in any warehouses they have access to, or sell off their paddy rice right after harvest as mostly common currently. The key difference between the treatment and the control groups is that the treatment GIEs will get a CNCAS certified receipt if they deposit their products in the chosen warehouses and have access to better storage conditions in those warehouses. The control GIEs, on contrary, will not get any CNCAS approved receipts, and will only have their usual storage facilities available.

The random selection insures that the GIEs that end up in treatment and those that end up in control are like each other, and would have evolved in a similar manner had the program not been implemented. The comparison of the treatment and control groups after the implementation of the program will therefore provide unbiased estimates of the impacts of WRS participation on farmers' outcome.

FIGURE 3: EXPERIMENTAL DESIGN FOR TESTING THE IMPACT OF WRS PARTICIPATION ON FARMERS OUTCOMES



To improve the precision of our estimates, the randomization will be stratified by farmers unions, among other characteristics of interest. In addition, we will explore the possibility of randomizing the unions involved in the study to measure spillover effects. To this effect, we would compare the control group within the treated unions with a pure control group in other unions.

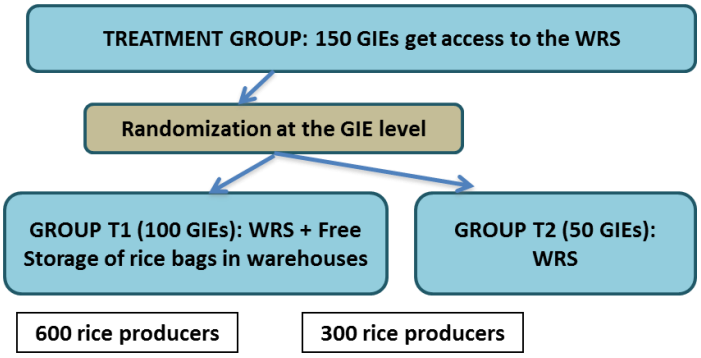
Q2: Factors affecting take up of the WRS

The second research question will test the importance of transaction costs on farmers' decision to participate in the WRS. Despite the information, sensitization, and training provided to all the actors by the GoS, the transaction costs

of participating in the system may still affect greatly the take up. In this regard, the GoS would like to test the extent to which the warehousing fees would reduce take up amongst the GIEs in the treatment groups. For this purpose, we will use the following randomized design (

Figure 4).

FIGURE 4: EXPERIMENTAL DESIGN FOR TESTING THE EFFECTS OF WAREHOUSING FEES ON TAKE UP OF THE WRS



In this design, the 150 GIEs who are offered access to the WRS will also be randomly allocated into 2 experimental groups[7]. In group T1, 100 GIEs will get access to the system free of charge. In group T2, 50 GIEs will have to pay some determined fees to get access to the system. We keep more GIEs in T1 (free storage) to avoid loss of power due to potential take up issues.

8.2 Sample Size Calculations

In statistical inference, power is the probability of detecting a causal impact of the treatment intervention on key outcomes, if such an impact truly exists. Sampling and power analysis allow us to evaluate the sample size needed in each treatment arm to have sufficient power to detect a reasonable effect size from the project. Statistical power is primarily a function of sample size; effect size; desired power-level and confidence level; standard deviation of key outcome variables; explanatory power of available covariates; and correlation of outcomes between baseline and end-line. The goal of this section is to evaluate the minimum number of GIEs and sample size required per GIE to minimize research costs.

For question 1: Impact of WRS participation

The primary outcome for this impact evaluation is access to post-harvest credit. We do not have empirical data on the current situation but discussions with farmers during field visits suggest that post-harvest credit is close to zero. This justifies why most people sell off their production right after harvest at low prices. We assume the following:

- 5 percent of the farmers have access to post harvest credit in control group,
- Take-up rate: at least 25% of farmers will store some of their product in a program warehouse. (we think that it is a conservative assumption since all the GIEs in treatment group 1 will be allowed to store their product for free)
- Number of GIE in each arm: 150
- 5 farmers sampled in each GIE[8]
- Intra cluster correlation is 0.2
- Correlation between baseline measurement of outcome (and other covariates) and outcome: 0.2
- Desired power 80%,

[7] Depending on power, we may consider later the possibility of implementing 3 groups with 3 levels of warehousing fees

[8] We are considering 5 farmers per GIE in the power calculations to anticipate potential farmer attrition

- Significance level 5%

Based on the above assumption and using the "*clustersampsi*"[9] command in *STATA*, the IE is sufficiently powered to detect an "*intention-to-treat*" effect of 5 percentage points (so from 5% to 10% of farmers accessing post-harvest credit). Assuming that the program take up rate will be 25%, we can detect a 20 percentage point increase in access to credit on those who use the WRS system (*treatment-on-the-treated*). We think that this minimum detectable effect is of economically meaningful size. Furthermore, it is even lower than the size seen in another study currently implemented in Burkina-Faso[10] which found that 36% of those offered access to a "Warrantage" program providing access to storage facilities took up and 39% of them took a loan (so an "*intention-to-treat"* effect of 14 percentage points on access to credit).

To improve our statistical power, we will use matching techniques to do the randomization. Using baseline survey data, we will use GIEs and farmers characteristics to create pairs of GIEs with similar characteristics and conduct the randomization inside each pair.

As we acknowledge and discuss below, it is possible that we cannot measure the outcome of some farmers at endline (due to attrition).

For question 2: Effect of relieving transaction costs on take up

The primary outcome is take-up of the WRS by the GIE. We rely on the following assumptions:

- In T1 (GIEs with access to WRS but paying the usual fee): 15 percent of the farmers will store some of their product in a WRS warehouse.
- Number of GIE in each arm: 50
- 5 farmers sampled in each GIE
- Intra cluster correlation is 0.2
- Correlation between baseline measurement of outcome (and other covariates) and outcome: 0.2
- Desired power 80%,
- Significance level 5%

Using *Stata* and the *clustersampsi* command, we get a minimum detectable effect of 14 percentage points (from 15% to 29% of people using the system). Given the cost implication of this treatment (paying for farmers' storage fees), we consider this minimum detectable effect as reasonable from a policy point of view.

9. DATA COLLECTION (E,R)

9.1 QUANTITATIVE INSTRUMENTS

This impact evaluation will rely on several complementary data collection efforts.

[9] clustersampsi, binomial detectabledifference p1(0.05) m(5) k(150) rho(0.2) base_correl(0.2)

[10] See project description on: http://www.poverty-action.org/study/impact-inventory-credit-food-security-and-rural-livelihoods-burkina-faso

1. First, the main outcomes as described in section 7 will be measured through primary data collection surveys at the level of the GIEs and farmers, members of those GIEs. From the list of members of each GIEs, we will select randomly 6 households to be included in our sample. We will conduct two waves of data collection. First, a baseline survey will be implemented before the pilot WRS which should coincide with the beginning of the smaller rice production season. This ensures that information about sales and management of storage from the harvest of the main agricultural season are already available. The endline survey will be conducted one year later, around the same time, to avoid variations due to seasonality. Both baseline and endline surveys will be conducted using a well-structured survey questionnaire, at GIE and farmer households' levels, and will cover a wide range of topics from general socio economic characteristics, to access to credit, to production, storage, and sales, etc. Conditional on funding, we will consider additional follow-ups in further seasons to understand long-term effects.
2. Our study will also use administrative data, such as the data kept by warehouses, by the CNCAS as well as the USAID project Naatal Bay on the GIEs and farmers' unions operating in the area. These data contain historical information on credit and savings behavior of those GIEs (CNCAS), as well as production and marketing of rice (Naatal bay).
3. During implementation of the pilot program, we will collect high frequency (weekly) detailed information on the storage and sales of rice at the GIEs and the individual farmers' levels. This will be done through frequent visits or phone calls. We will explore with the survey firm which approach is more appropriate. The preliminary warehouse census implemented so far seems to indicate that access to cell phone is widespread and might be the more practical. Diaries to be filled by farmers and GIEs leaders is also an option, though this approach had limited success in the case of Casaburi et al (2014) in Sierra Leone.
4. Market price information will also be collected weekly, in the local and major markets in the study area, using crowd sourcing approaches, or phone interviews of selected rice sellers in the markets.
5. Finally, to compute the cost-effectiveness of the program, cost data on program implementation will be collected.

9.2 Management of Data Quality

The evaluation team has extensive experience conducting high-quality surveys in West Africa. An experienced survey firm will be hired to implement the data collection activities. To ensure high quality of program and survey monitoring, a full-time field coordinator will be hired on the project. His or her main task will be to supervise the survey company in charge of data collection and to work in close coordination with implementing partners to ensure that the study protocol is respected. Survey protocols will be developed by the research team in collaboration with the survey company and will ensure that the following rules are respected:

- High level of qualification of the surveyors and supervisors.
- High level of remuneration for the survey team with incentives for high data quality.
- High level of survey preparation, including intensive field piloting of survey instruments, and proper training of field staffs. Training of field staff will be conducted jointly by the survey company and the WBG field coordinator.
- High level of monitoring during the survey conducted by both the survey company and the WBG field coordinator. It will involve high level of field supervision and back checking of at least 5% of the surveys.
- Electronic data collection using dedicated softwares such as *SurveySolutions*, *surveyCTO* or *CSPro*.
- High quality survey interfaces that allow survey monitoring and high frequency checks of the data in real time during the survey implementation.

Finally, to limit potential bias, and ensure that surveys are conducted in the exact same way for farmers in treatment and control groups, surveyors will not be informed of the treatment status of the farmers they will survey.

9.3 Ethical Issues

The study is not targeting any population usually considered as particularly at risk like children or people with health issues. Moreover, no sensitive information on study participation will be collected during the project. However, strict protocols will be enforced to guarantee informed consent of study participants and to ensure that the anonymity of respondent is respected and that study data are properly stored. We will ensure the research principal investigators all have up to date NIH Certificate for Human Subjects Research. Enumerators will be chosen from a pool of experienced surveyors with a background in conducting surveys in the region, and will receive intensive training on informed consent and confidentiality procedures.

For the study, we will require ethical approval from the Paris School of Economic Institutional Review Board (IRB) for Protection of Human Subject.

Consent

Consent will be obtained from all participants prior to the start of the interview. Household and GIE respondents will first be informed of the purpose of the study—to learn about the effectiveness and impacts of WRS—and subsequently made aware of any risks or benefits they may accrue from their participation. We will then ask participants to provide oral consent, and offer them written copies of the consent forms. Some people sampled for this survey may be illiterate or feel embarrassed if asked to sign a document. Therefore, oral consent will be requested. All participants will be informed that they need not participate in the survey if they are uncomfortable, and that they may stop the survey at any time. Enumerators will be trained on how best to ensure informed consent. Participants will be provided with a phone number to contact in case they have any questions following the study.

Privacy and Confidentiality

Confidentiality of a respondent will be ensured by removing all identifying information from the data prior to encryption (and post assignment of a unique ID number.) Only authorized staff will have access to identifying information.

9.4 Qualitative Instruments

Qualitative data will be collected at different times during the project implementation. There will be three main objectives of the qualitative work:

(i) Understand if the study protocol is respected and if all stakeholders understood properly all components of the program. This will be done with semi-structured interviews with stakeholders in the treatment group including farmers, group of producers, warehouses and CNCAS staffs. This work will start few weeks after the pilot program launch and will be conducted frequently during the whole duration of the study. If important discrepancies between the study protocol and what is implemented are found, we may revise the program protocol to ensure the evaluation design is respected. This may involve doing additional information campaigns or to train again some implementing staffs.

(ii) Understand potential program effect to feed quantitative surveys. Few months before the follow up survey, in-depth semi-structured interviews will be conducted with stakeholders in the treatment group to identify the potential effects of the program and make sure this will be measured in quantitative surveys.

(iii) Understand potential program externalities. Qualitative interviews with farmers not benefiting from the program in both treatment and control group areas will be conducted. GIEs in the control group will be also interviewed. These interviews will help to identify eventual spillovers of the program or reactive behaviors by the control group (i.e. John Henry effect)

(iv) Qualitative surveys at the GIE level will also be conducted to understand the experience of farmers with the pilot WRS and get feedback on what they will have found most useful, and understand the mechanism through which the pilot program may have affected the targeted groups. Since the treatment is at the group level, these will also help understand group dynamics and explore the extent to which these affects program take up and impacts.

(v) We will also implement experimental games at farmers' level for a subset of farmers, to measure risk preference and time preferences as these are likely important factors in farmers' willingness to participate in a WRS.

10. Data Processing and Analysis

10.1 Data coding, entry and editing

Data will be collected using electronic tablets. Surveys will be programmed in Open Data Kit and automatically uploaded and stored online via the surveyCTO platform for immediate access by the IE team. To ensure reliability, back checks will take place for at least 5% of the collected data. DIME will hire a team of research assistants to edit the raw data before analysis phase.

10.2 Model specifications for quantitative data analysis

Estimation specification:

To evaluate the impact of participating in the WRS, our estimation will be at the farmer level, and involve the following general specification for farmer *i* in GIE *j*:

$$Y_{i,j,t=1} = f(\beta_0 + \beta_1 WRS_j + \pi Y_{i,j,t=0} + \gamma M_{i,j,t=0} + X'_{k,i,j} + \varepsilon_{i,j,t=1}) \quad (1)$$

Where $Y_{i,j,t=1}$ is the given outcome variable measured post-treatment, $Y_{i,j,t=0}$ is its baseline value and $M_{i,j,t=0}$ a dummy variable indicating whether or not this baseline value is missing, WRS_j is an indicator for GIE *j* being assigned to the WRS program. X_k is a vector of strata dummies (one variable for each pair used for the randomization). $\varepsilon_{i,j,t}$ is the error term. β_1 will provide the intent-to-treat effect of been assigned to the WRS program as opposed to being assigned to the control group. **Standard errors will be clustered at the GIE level**. Heterogeneous treatment effects will be estimated by interacting treatment status and the lagged dependent variable in equation (1) with the variable of interest Z. We will specifically explore heterogeneous effects based on baseline access to quality warehouses, risk preferences, and time preferences.

Appropriate consideration will be given to functional form based on the nature of the dependent variable. The impact on binary variables such as access to post harvest credit will be analyzed using probit estimation, whereby the function f(.) corresponds to the standard normal density function.

The impact on storage behavior will use duration analysis where, the function f(.) could be assumed linear or following a cox proportional hazards model (Wooldridge 2010), to determine how participation in the WRS affect the length of time during which the farmers still have some positive storage.

Take up analysis will focus on the difference in participation rates between groups receiving the free storage treatment and those not receiving it, controlling for strata (pairs) dummies (equation2).

$$\text{Participation}_j = G(\alpha_0 + \alpha_1 \text{FreeStorage}_j + \delta M_{i,j,t=0} + X'_{k,i,j} + \mu_{i,j,t=1}) \qquad (2)$$

This equation can also be estimated at the individual farmers' level to include within group variations in decision to participate.

Balance checks and survey attrition:

Detailed baseline data on study outcomes and on potential farmer and GIEs characteristics that could explain take up on all program components will be collected before the program implementation. This will include (in addition to baseline values of study outcomes) information on GIE characteristics such as size, access to storage infrastructures, sales, gender and education of leader; and farmer characteristics such as gender, level of education, financial literacy, baseline access to other type of loans, and distance to the closest accredited warehouse and to the closest bank.

We will then perform balance tests by regressing baseline value of these variables on treatment dummies, controlling for strata dummies and clustering standard errors at the GIE level. These balance checks will be performed after the randomization on the whole study population to show that the sample is well balanced.

If attrition during the endline survey is differential between treatment and control groups, this could bias our estimation of the impact of the program. To check that, we will follow the same methodology and regress attrition on treatment dummies (also controlling for strata dummies and clustering standard errors at the warehouse level). If treatment status is found not to significantly affect attrition at the 5 percent significance level in general and in any treatment group, then all estimation will proceed without any adjustment for attrition. If attrition is found to be related to treatment status, we postulate that attrition will be higher for the control group. We will then employ two bounding approaches to test robustness to attrition:

(i) Lee bounds: the group with lower attrition will have either the top or the bottom tail of responses trimming following the Lee method. For continuous outcomes robustness to assuming that the attrited observations were at the 95th, 90th, and 75th percentiles will be used for the lower bound, and 5th, 10th, 25th percentiles for the upper bound.

(ii) Behaghel et al bounds: we will use the number of attempts it took to contact respondents to form bounds following the approach set out in their paper.

RCT registry and multiple hypothesis testing:

This study will be registered in the AEA RCT Registry (https://www.socialscienceregistry.org/). A pre-analysis plan describing in details how the data will be analyzed will be uploaded on this website before the implementation of the follow up survey.

As described in section 7, we have a relatively rich set of outcome measures. To deal with multiple hypothesis testing we will employ several approaches.

1) We will specify in the pre-analysis plan a set of primary outcomes which we see as the main outcomes of the study, and distinguish these from impacts on the other outcomes.
2) Whenever possible, we will look at standardized treatment effects within domains where it makes sense to combine measures into a single aggregate. To do this we follow the approach of Kling, Katz and Liebman (2007) to create a standardized treatment effect via the following steps: i) sign all outcomes in the domain so the hypothesized effects go in the same direction; ii) standardize each variable as a z-score by subtracting the control group mean and dividing by the control group standard deviation; and then iii) averaging these z-scores.
3) To control for multiple hypothesis testing with respect to the heterogeneity of treatment effects, we will follow the recommendations of Fink, McConnell and Vollmer (2010) and employ the Benjamini and Hochberg (1995) method to minimize the false non-discovery rate (FNR). We will also limit our examination of treatment effect heterogeneity to select outcomes identified in the pre-analysis plan.

11. Study Limitations and Risks (E)

Threat to internal validity:

Unbiased estimation of program impacts requires control and treatment groups to be comparable ex-ante and randomization ensures this comparability in expectation. To support this comparability in practice on important observable GIEs and farmer characteristics, we will stratify the sample by making pairs of GIEs with similar characteristics (in particular geographical location), and conduct the randomization inside these pairs. In addition, the stratification will improve the statistical power of the study as treated GIEs/farmers and their controls will be drawn out of same pairs ensuring high comparability.

Attrition is one of the biggest challenges to impact evaluation. To keep it to a minimum, we will use the following methods:

- Tracking of the study population: the evaluation team will collect a maximum of information on farmers to be sure that we can find them in the future. Though, this issue is less of a concern here because the farmers included in our samples will be members of GIEs and unions which makes it easier to find them even if there is movement between surveys.
- Minimize response refusal rates: we will consider offering small gifts to respondents to encourage response to the survey.
- Monitoring differential attrition: since the farmers in the control group will not receive any treatment, they may have lower incentives to answer the follow-up surveys. To monitor this problem, we will carefully follow the attrition rate in each group during each survey. If there is significant differential attrition during one survey, additional means will be dedicated to track farmers or to incentivize them to answer the survey.
- As described in the power calculation section, we will also increase the sample size and sample 6 farmers inside each GIE instead of 5. This will ensure that we will have a sufficient number of farmers in total and also reduce the likelihood that we find no farmer in some GIEs (and so that we lose some clusters).

Another potential threat to internal validity occurs if the implementing agencies, and the actors involved, do not respect the randomized assignment design. This could be the case for example if some GIEs selected in the control group get access to the chosen warehouses, or if farmers in the control GIEs get access to the treatment by pooling their products with the treatment groups' stocks of rice. To limit this risk, the IE field coordinator will carefully monitor this in close collaboration with the chosen partner millers, and the tiers detenteur representing the bank at those milling facilities. Moreover, we think that we should be able to monitor properly this risk given the small number of warehouses (around 10) that will participate in the program.

Finally, spillovers due to externalities and general equilibrium effects could also bias the results of the evaluation. Here for the main intervention, the randomization will be done at the GIEs level, so we should not expect much risks of externalities. Even if we fear displacement effects given that the intervention will alter the demand and supply of paddy rice right after harvest, our study involves only a small subset of the GIEs in the area which reduces the chances that their exogenously induced change in behavior might transmit to the whole market. While we do not have enough information on the structure of the market as of now, we plan to collect enough data during baseline to inform the extent to which such displacement might happen, and to take corrective measures as necessary.

Take up issues

If take up at GIE level is particularly low, the ITT parameter might no longer be valuable, and 2SLS approaches might be warranted so we get at the average treatment effects. But then we might run into power issues. To reduce the potential for such problem, we will ensure that sensitization and information campaigns as part of activity 2 of the project are intensified for the 300 GIEs involved in this impact evaluation. In addition to this, 100 out of the 150 treatment GIEs will access the WRS free of charges. This is expected to generate high participation rate overall.

External validity:

One important implication of our sampling strategy is that the external validity of the results will be limited to the 300 GIEs included in this study. These GIEs are not necessarily representative of the whole area because they were sampled purposively from the GIEs already working with the CNCAS. However, the conclusions generated from this sample can provide useful insights for the scale up of the WRS, as this study will be the only available evidence on the effectiveness of WRS in the country, and beyond. The focus on GIEs working with the CNCAS is crucial for ensuring the buy in of the CNCAS, without which this demonstration will not be possible.

12. IE MANAGEMENT (E,R)

12.1 EVALUATION TEAM AND MAIN COUNTERPARTS

TABLE 2. IE TEAM AND MAIN COUNTERPARTS

Name	Role	Organization/Unit
Francisco Campos	Principal investigators (Lead Researcher and IE TTL)	Senior Economist, GTCDR, World Bank
Victor Pouliquen	Principal investigator	Paris School of Economics and JPAL-Europe

Serge Adjognon	Principal investigator	Economist, DECIE, World Bank
To be determined	Field Coordinator	World Bank
David Ivanovic	Project TTL	GTCDR
Rashmi Shankar	Practice manager, West Africa	GTCDR
Syed Estem Dadul Islam	Operational Officer	IFC
Makhtar Lakh	Secretary-General of the Ministry of Commerce	Ministry of Commerce of Senegal
Magate Ndoye	Focal point on warehouse receipts	Ministry of Commerce of Senegal

12.2 Work Plan and Deliverables

TABLE 3: MILESTONES, DELIVERABLES, AND ESTIMATED TIMELINE

Milestones	Deliverables	Completion Date
Peer-reviewed Concept Note	Methodology note	April 30, 2017
Data collection plan and pilot	TORs Questionnaires	July 1st,2017
Data collection (Baseline)	Cleaned data Dictionaries	October 1st, 2017
First data analysis	Presentation Data file Do files Baseline report	February 1st, 2018
Implementation of intervention aligned to evaluation	Rollout plan Monitoring reports verifying treatment and control status	January 30th, 2018 June 1st, 2018
Follow-up 1 data collection plan	TORs Questionnaire	July 1st, 2018
Data collection (Follow-up)	Cleaned data Dictionaries	October 1st, 2018
Final report and policy notes	Technical note Policy note Data file Do files	April 1st, 2019
Dissemination of findings	Presentations	June 1st, 2019

12.3 Budget

Table 4 summarizes the budget for this Impact Evaluation. The total estimated cost over the 2-year period is US$590,000. This covers mostly data collection costs (about 60 percent), as well as travels, consultants, and staff time needed to coordinate the project.

TABLE 4: TOTAL BUDGET PER CATEGORY

Category	FY17/FY18	FY19	Total	%
Staff	50,000.00	50,000.00	100,000.00	16.95
STC Field Coordinator	30,000.00	30,000.00	60,000.00	10.17
STC Research assistant	15,000.00	15,000.00	30,000.00	5.08
Data Collection	200,000.00	150,000.00	350,000.00	59.32
Travels	25,000.00	25,000.00	50,000.00	8.47
Total	320,000.00	270,000.00	590,000.00	100.00

13. Plan for Using Data and Evidence from the Study

After each survey, a report will be written and presented to the Government of Senegal:

- The baseline report will be used to enrich the program characteristics and how it will be implemented. Indeed, providing the administration in charge of designing the program with detailed characteristics of the farmers that will benefit from the program will help them refine program details. Moreover, baseline data on GIEs and farmers will also help to target specific intervention that could be conducted before the randomization to improve take up of the intervention.
- The report on short term impact one year after the program launch.
- The final results will be presented to the Government of Senegal will provide important information not only on the research questions but also on how the program was implemented and on whether some improvement is possible
- A working paper will be written and presented in academic seminars.
- During the whole duration of the study, qualitative information will be collected and share with the Government of Senegal and other implementing partners to improve the way the intervention is delivered and to ensure the study design is respected.

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