Household-Level Impacts of *System of Rice Intensification* (SRI) in Haiti:

An SRI intervention with training, insured credit, and coordination by irrigation *bloc*

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ABSTRACT:

Haiti is one of the poorest and most food insecure countries in the world, and improvements in productivity for staple crops such as rice are crucial to improve rural income and food security. The System of Rice Intensification (SRI) is touted as a high-yielding low external input rice cultivation method that can increase rice yields and improve household welfare, but these claims remain controversial and inconsistent with widespread disadoption in some contexts. Evidence of the impact of SRI on household income is mixed because the bundle of practices reduces easily quantified inputs such as seeds and fertilizer but demands more labor, which is difficult to value properly in field trials. Additionally, SRI demands more precise water control, which often raises classic coordination problems with shared local irrigation infrastructure. Addressing these coordination constraints may raise adoption rates and increase the benefits of SRI, but little is known about the magnitude of these constraints and their determinants. In collaboration with Oxfam America as an implementing partner and the *Faculté d'Agronomie et Médecine Vétérinaire* as our research partner, we propose a randomized control trial of SRI to test the household-level impacts of SRI, the effect of coordinated SRI adoption these impacts and the mechanisms behind these coordination effects. The design of this intervention allows us to exploit a dose response approach to rigorously evaluating these effects. Several organizations – including both USAID and Oxfam – are planning to scale up SRI interventions in Haiti in the coming years. Elsewhere in the developing world, hopes are similarly high for massive gains due to SRI. This study aims to inform these programs and supporting policy work by providing a unique evidence basis for these expectations and intervention strategies.

NARRATIVE | Problem Statement

The *System of Rice Intensification* (SRI) is a potentially high-yielding, low external input method for rice cultivation that can generate substantial and persistent increases in yields (Stoop et al., 2002; Sinha and Talati, 2007). SRI has received widespread attention as a pro-poor technological innovation that could help small-scale farmers meet their food needs while lowering expenditures on inputs such as seeds, water, and fertilizer (Berkhout and Glover, 2011). However, adoption has been lower than might be expected given its apparent benefits, and substantial disadoption has been observed in some locations (Moser and Barrett, 2003; Takahashi and Barrett, 2012).

Substantial questions remain regarding household welfare impacts of SRI. Because SRI requires higher labor inputs than traditional methods for land preparation, crop maintenance, and water management, adoption of SRI typically leads to reallocation from other economic activities. The resulting decrease in household income from other activities may offset the income increase from higher SRI yields (Moser and Barrett, 2003; Barrett et al., 2004). Takahashi and Barrett (2012) examine the household welfare impacts of SRI in Indonesia and found that in a setting with high labor market participation, households allocated household labor away from wage work towards SRI to the point where SRI had no significant impact on household incomes. We aim to build on this work to move beyond yield impacts and towards a better understanding of overall household welfare effects of the technology and the reallocation of household resources it induces.

One unexplored area of research is the effect of coordination on adoption decisions and on the ultimate success of SRI. Due to the need for intermittent flooding and draining, SRI requires more regular cleaning and maintenance of shared drainage canals than necessary under traditional methods to enable more precise water management. Because irrigation and drainage canals are shared, coordinated adoption and canal maintenance may yield greater benefits than adoption in isolation. The shared canal system raises questions about coordinated use of public goods, and we can explore whether efforts to coordinate farmers sharing a canal to adopt together increases their likelihood of adoption and whether benefits are greater under such a coordinated approach. Substantial research exists on decentralized common-pool resource management (e.g. Ostrom, 1990), but very little on the role of common-pool resources in technology adoption decisions or the possibilities for coordinated adoption as a way of improving outcomes.

To address these questions, we propose a rigorous evaluation of the household-level impacts of a coordinated SRI intervention being launched by Oxfam America (OA) in Haiti's Artibonite Valley. After piloting several elements of this integrated SRI intervention in recent years, OA is prepared to scale up this program and is eager to understand its impacts on rural households – both to improve its Haiti program and inform its support of SRI initiatives worldwide. Moreover, this evaluation directly complements work by USAID to actively promote SRI elsewhere in Haiti as part of the Feed the Future subprogram Watershed Initiatives for Natural Environmental Resources (WINNER) project. The current WINNER project promotes SRI in a secondary rice growing region east of Port-Au-Prince because institutional constraints prevent it from working in the dominant rice growing region of the Artibonite. The evaluation we have designed will generate insights into how and how much SRI impacts rural livelihoods in these Haitian contexts – as well as providing a basis of evidence for addressing important lingering questions about the efficacy and promise of SRI for rice farmers in other poor countries.

NARRATIVE | Background

System of Rice Intensification

SRI emerged in Madagascar in the 1980s as a set of management practices that includes four primary components: (1) early transplanting of seedlings 8-12 days old; (2) shallow (1-2 cm) planting of seedlings; (3) sparse planting of single seedlings on a 20x20cm grid; and (4) intermittent irrigation. No new seed varieties or external inputs are required; in fact, SRI uses lower levels of seeds, fertilizers, and water. However, careful arranging of transplants and frequent weeding, especially in the early planting stage, increase the labor requirements of SRI compared with traditional methods. Controversy exists on the yield effects of SRI: a number of studies have found substantial increases in yield that persist over time in a range of sites (Uphoff et al., 2002; Sinha and Talati, 2007; Thakur et al., 2010), but these findings have been challenged by crop scientists as untested by conventional agronomic methods (Takahashi and Barrett, 2012). A review of journal articles by McDonald et al. (2006) based mostly on experimental field trials concluded that outside of Madagascar, where the technique was developed, the yield impacts of SRI are negligible or even negative.

As part of the OA SRI pilots, the *Faculté d'Agronomie et Médecine Vétérinaire* (FAMV) conducted SRI trials in 2011 and 2012 in the Artibonite Valley. In the larger 2012 trials, the FAMV team estimated that SRI increased yield per hectare by 67% and rice profit per hectare by 132%. As caveats to these impressive results, first, it is unclear how inputs, in particular labor, were valued in this agronomic study – and more careful economic analysis is necessary to determine the profitability of SRI compared with traditional rice methods. Second, rice profit is an incomplete measure of household-level SRI impacts because the bundle of practices may induce households to make broader adjustments in their livelihood portfolios.

How SRI induces households to change these portfolios can have a significant effect on overall household impacts. In Indonesia, Takahashi and Barrett (2012) found that SRI increased yields by 64%, but that SRI users reallocated labor from off-farm work to farm work such that no net household income gains were observed. In the FAMV field trials, labor requirements for preparation and maintenance were found to be 55% and 39% higher, respectively, for SRI, while nursery labor requirements were nearly three times higher for traditional rice methods. To understand the household welfare impacts of SRI in Haiti, we need to understand local labor markets and study how adopting households reallocate labor. The effect of higher labor requirements for SRI will depend on local wage labor opportunities and the shadow price of labor.

Poverty & Low Agricultural Productivity in Haiti

In recent years, SRI has generated high hopes among several development agencies and organization in Haiti because improving agricultural productivity is fundamental to relieving poverty and improving food security among rural Haitians. As the poorest country in the western hemisphere and one of the most food insecure countries on earth, Haiti has a desperately poor rural population: Nearly 90% of rural Haitians live in poverty (<$2/day) and two thirds are considered extremely poor (<$1/day). Agriculture was once the backbone of the Haitian economy, accounting for 50% of the country's GDP in the 1960s. Today, that percentage is 28%, which is more indicative of a decline in productivity and profitability than it is of the critical role agriculture still plays in the lives of a majority of Haiti's population. More than 75% of low-income Haitians are employed in agriculture, and in rural Haiti farming is often the only source of income and food. Annual food demand is growing by approximately two percent per year, but food supply is growing only by 0.4 percent, leading to a decrease in per capita food consumption and an increase in dependence on food imports. Haiti imports more than half of its food needs, and the average Haitian caloric intake is 73% of the minimum recommended by the World Health Organization.

Rice is a staple food for Haitians and a critical source of income and employment. The rice value chain employs about 5% of the country's total population, and if family members are factored in, roughly a million people are directly affected by the productivity and profitability of the sector. National rice production has been stagnant for the past 40 years: while it once met all consumption needs, local rice production now accounts for less than 20% of consumption. To achieve sustainable poverty reduction and food security in both rural and urban Haiti, emphasis must be placed on overcoming the various obstacles that have impeded agricultural development for the last half century. These include a history of inattention from government and international donors, detrimental trade policies the flood the market with cheap rice imports, lack of research and extension services, technological stagnation, and natural resource degradation.

Fortunately, there are some positive signs. Between 2006 and 2008, donor investments in agricultural development doubled. The Haitian government and development agencies such as USAID are increasingly investing in agriculture. In May 2010, the government launched an ambitious, seven-year, $772-million agricultural reconstruction plan focused on infrastructure improvements, sustainable production increases, value chain development, and rural service delivery. As such efforts move forward, steps must be taken to ensure the government and the donor community live up to their commitments and that rural communities play an active role in decision-making processes.

Oxfam America's Rice and Livelihoods Program in the Artibonite Valley

In late 2010, as immediate earthquake relief efforts began to wind down, OA began exploring ways to leverage the resources, staff, and infrastructure now in place to best address Haiti's long-term development needs. It was clear that improving rural livelihoods would need to be central to this effort, and studies were commissioned to examine the coffee, rice, and salt value chains to determine where OA could offer the most benefit. OA offers a unique combination of advantages that ultimately led to their decision to engage in the rice sector. Given its central role in Haitian rice production, established relationships with government actors and other organizations in the region, and a lack of other major programs there, the Artibonite Valley was the logical choice for this engagement.

The overall program goal established for Oxfam's *Artibonite Valley Livelihoods Program* is that by 2015, farmers and producers of rice in the Artibonite Valley will have improved their livelihoods and lessened their vulnerability to shocks because they actively influence, and are supported by, improvements in the system of production, processing, and marketing in the national rice value chain, and improved local, national, and international policies and practices. The approach and theory of change for the *Artibonite Valley Livelihoods Program* were designed to leverage each of these advantages at multiple levels to capitalize on emerging opportunities in the rice and broader agricultural sector, and to address the various issues that have hampered the productivity and profitability of Haiti's rice value chain.

The impact of an improved rice value chain would be especially important for the Artibonite Valley. Between 75% and 80% of the country's rice along with a variety of other crops are grown in the Artibonite, which contains the country's largest river and an extensive irrigation system. Despite this potential, nearly all of the Artibonite's 1.6 million people are currently affected by hunger and 43.1% face serious food insecurity. The decline of the rice value chain, especially in the Artibonite valley, can be attributed to low production resulting from poor infrastructure; limited access to agricultural technologies and inputs; inadequate drying, harvesting, and storage facilities resulting in losses exceeding 50%; and poorly managed, inefficient marketing systems.

Despite the myriad problems throughout the rice value chain, both in the Artibonite and throughout Haiti, there are also a number of emerging opportunities, including a growing discourse among the broader population, government, and donor community about the importance of growing and consuming local rice; expanding markets for rice, including for export varieties; improved cultivation techniques (including SRI); and a farming community that is ready and eager to participate in improving their productivity.

Oxfam has focused efforts on improving the production, processing, marketing, and management capacities of RACPABA, a comparatively large cooperative association of small-scale rice farmers and several smaller rice cooperatives and associations, including AILA and MAFLPV. 99% of the members of these partner organizations live on less than $2 per day. The program is concentrated in six municipalities in the lower Artibonite Valley (Desdunes, L'Estère, Grande Saline, Marchand Dessalines, Petite Rivière, and Verrettes), and complementary research and advocacy activities at the national and international level are also supported. OA's work has included establishing nearly 100 demonstration plots to showcase SRI and related improved cultivation techniques; supporting trainings for both organization leadership; rehabilitating or constructing training and processing facilities; introducing tools such as rotary weeders and composting units; helping partners coordinate with each other and with external stakeholders; supporting irrigation system rehabilitation; and training cooperative members to assess agricultural damage and analyze risks associated with climate variability.

NARRATIVE | Study Design

Based on lessons learned in the first few years of its *Artibonite Valley Livelihoods Program*, OA recently formulated an ambitious coordinated SRI intervention that targets entire irrigation blocs. [1] This

[1] These local irrigation areas are referred to as '*blocs'*, a French term we use throughout this proposal to denote the irrigation areas defined by a local network of canals and drains.

coordinated approach aims to incentivize full SRI adoption on all the plots within selected irrigation blocs, which are delimited by a network of shared canals and drains. Recent efforts by the Ministry of Agriculture have organized all the farmers with plots in an identified collection of blocs into a water users association in order to facilitate coordination. The SRI intervention we propose to study is similarly motivated: poorly maintained canals and (especially) drains may prevent some farmers from being able to adopt SRI on their own. Coordinating at the bloc level allows the initiative to leverage program investments in repairing and maintaining this shared irrigation network. Other benefits of coordination may arise from synchronized flooding cycles and production phrases, agronomic monitoring, and social learning within the bloc.

OA is currently launching a coordinated bloc-level SRI intervention in two blocs and is planning an expansion of this intervention in the coming years. The research design we propose evaluates the household-level impacts of this SRI intervention. The fact that this coordinated approach is – by design – concentrated in a relatively small geographic area raises unique research opportunities. As the primary opportunity, this intervention will yield a wide range of SRI adoption intensities (i.e., share of rice land in SRI) across households, some with 100% in SRI, depending on a household's distribution of land in and out of the treatment blocs.

The study design we describe in this section aims to address three guiding questions:

1. **What impact does this coordinated SRI intervention have on rural households?** We will explore both income and food security measures of household impact.
2. **How much of this impact is attributable to coordination at the bloc-level?** By comparing a coordinated treatment with an uncoordinated treatment, we will learn about the importance of coordination in both adoption decisions and the performance of SRI.
3. **What is the mechanism behind these coordination benefits, if any?** We will consider several potential mechanisms, including how coordination affects individual adoption decisions, learning and adjustment, and the agronomic potential of SRI for plots in different within-bloc locations relative to canals and drains.

Dose Response Design

We exploit the unique bloc-level coordination in this SRI intervention using a dose response design in which we use different levels of SRI intensity by household to estimate household-level impacts as a continuous function of SRI intensity. To illustrate the basic idea behind this approach, consider the map of the two blocs – Ylette and Balanyen – where OA is currently launching the intervention (Figure 1). These two blocs encompass roughly 400 plots cultivated by 370 different farmers, many of whom pool production and consumption decisions as part of a single household (e.g., as adult children, spouses, or siblings). In many cases, these individual farmers and the household to which they belong also cultivate other plots in other blocs. While 100% of the cultivated land for some households may be in a single bloc, the land cultivated by other households may be spread across multiple blocs.

Crucial to our research design is an exogeneity assumption: For any given bloc, the share of total household land that is contained within that bloc is effectively exogenous to household characteristics. Land transfers are quite rare, so plots ownership is as good as exogenously determined for a given households. While households may move dwellings, self-selecting into villages or settlements, they do not typically buy or sell land, and rather hold on to their parcels for generations. As a result, the distribution of a household's land is not necessarily related to where the household lives, so households in a given village may have parcels of land scattered in many different blocs. For a given household, plots of land are not necessarily located near one another, so the percent of a household's land that happens to be in the bloc selected for the intervention is exogenous to characteristics that directly shape productivity through ability, access to inputs or market, etc.

Treatment Arms

The research design we envision relies on random assignment of blocs to four different treatment arms:

A Blocs – Coordinated SRI with subsidized credit: The intervention in these blocs will be launched in summer 2013 by OA and local partners. Households with plots in these blocs will receive (1) SRI training

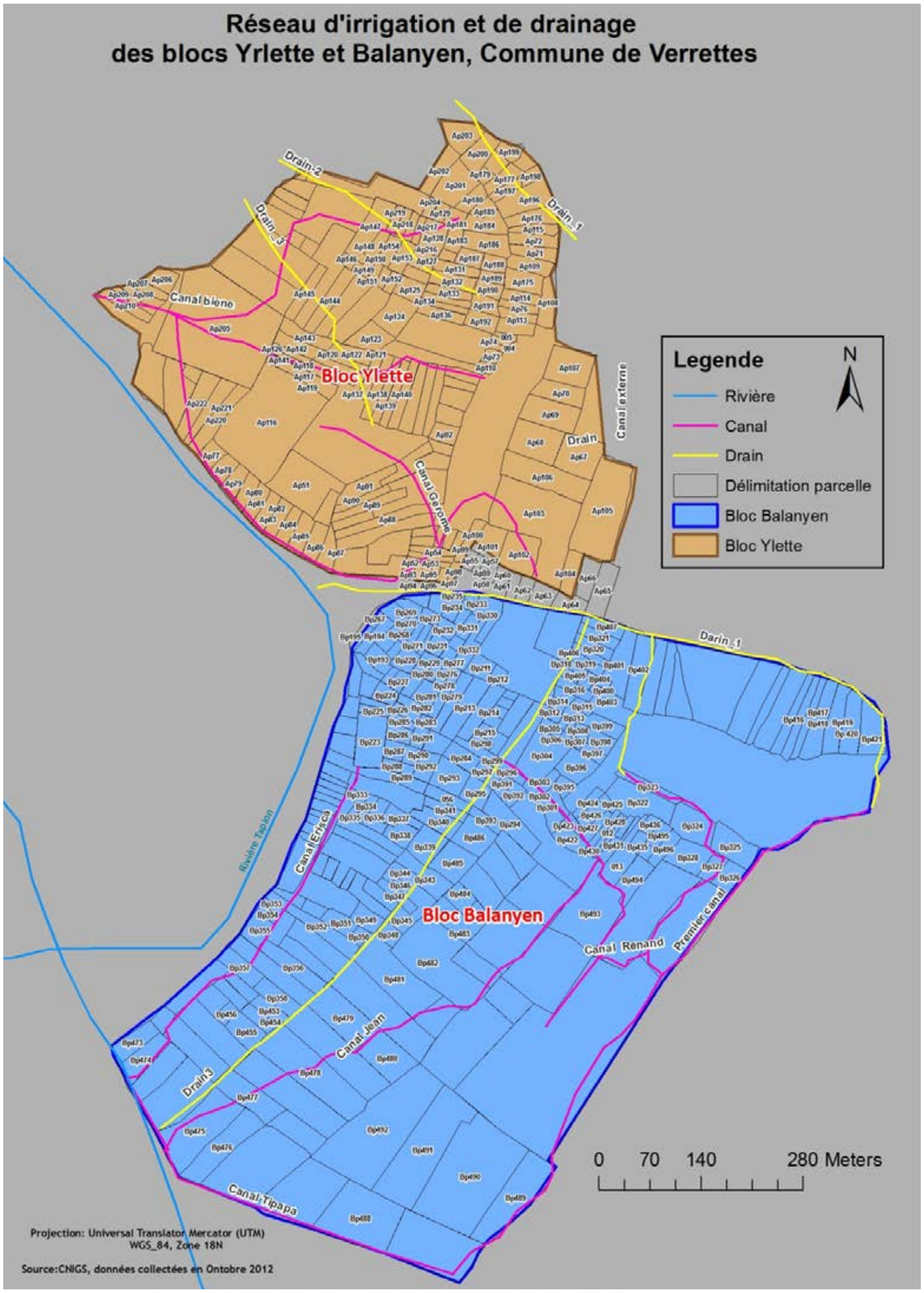

Figure 1 Map of individual plots and irrigation network (canals and drains) in the two A blocs

before planting and continued monitoring and training throughout the growing season, (2a) 'service credit'[2] to cover production inputs and plot preparation for adopting SRI subsidized at 50% in the initial

[2] Service credit is the term used by local associations in the Artibonite Valley to describe a form of credit that enables farmers to make the upfront investments necessary to launch a season of production. Such farmers pay

season, and (3) bloc-level coordination and investment in the irrigation network of canals and drains. Based on recent experiences with SRI training and trials, we expect that these households will only adopt SRI on plots inside the treated blocs (i.e., where they receive (2a) and (3)).

B Blocs – Coordinated SRI with insured credit: The treatment in this arm will begin in 2014. Households with plots in these blocs will receive (1) and (3) as before. Instead of being offered heavily subsidized service credit as above, they will receive (2b) service credit that is implicitly insured with a money back guarantee (MBG) for services rendered on SRI plots within 'treated' blocs. This MBG service credit will use the yield data we will collect A blocs in the first year to design conditional subsidies of the form: *"If average SRI yields are not at least 35% higher than average non-SRI yields in your association, you will receive a service credit subsidy at harvest in proportion to how small this yield advantage is. If SRI yields are more than 35% higher, you will pay back the full value of your service credit at harvest as usual."* We will calibrate this MBG based on initial data collected in the A blocs and pretest the design and communication of this MBG offer to ensure comprehension and transparency. Based on focus group discussions, we are confident that such a MBG offer may be effective at substantially reducing the uncertainty entailed with adopting SRI.

C Blocs – Uncoordinated SRI with insured credit: Again, the treatment in this arm will begin in 2014. Households with plots in these blocs will receive (1) and (2b), but not (3). These uncoordinated intervention households will enable us to estimate the magnitude of the coordination benefit, if any, and to explore the mechanism driving the coordination benefit. As in the full coordination blocs, only plots located in the blocs assigned to the uncoordinated SRI treatment will qualify for the MBG service credit and for technical assistance throughout the season.

X Blocs – Control: Households with only plots in control blocs will continue to have access to service credit for agricultural inputs and plot preparation through their association, but will receive no SRI

back the value of these services in cash or in kind within a month of the harvest. The equipment used to plow and prepare the land is sometimes managed by the association itself, which is why this is referred to as *service* credit.

training/monitoring and will not be offered the MBG credit to encourage the adoption of SRI. These households will populate the 0% SRI point on the dose response profile.

We will use these four treatment arms to address the three guiding questions above:

(1) Household-Level Impacts of Coordinated SRI: OA is launching the intervention in the A blocs. We will collaborate with OA to evaluate the impacts of this full intervention using the dose response approach described above applied to both the A and X blocs. While this evaluation is potentially insightful, subsidizing 50% of the service credit offered to farmers is unlikely to be financially sustainable as an intervention. Bloc B treatment represents a more sustainable version of a coordinated SRI intervention and the comparison of B and X blocs will therefore provide an evaluation of impact that is most useful for shaping plans to scale up the intervention beyond this project. The bloc A treatment may nevertheless play a key role in catalyzing SRI adoption on bloc B plots the: part of the SRI training in the B blocs will include field visits to A blocs as a 'proof of concept' for coordinated SRI adoption (scheduled for Aug-Sep 2013).

(2) Magnitude of SRI Effect due to Coordination: To estimate the magnitude of the coordination benefit, if any, we will compare blocs B and C. As described below, we can conceptualize this in our context as a comparison of the slope of two dose response lines: one estimated using blocs B and X and the other using blocs C and X. Since the adoption decision may be qualitatively different in the uncoordinated C blocs than in the coordinated B blocs, we will also use an 'intent to treat' approach that uses the share of land area cultivated by a given household in a C bloc as an instrumental variable for the share of land the household devotes to SRI. We can estimate the magnitude of the coordination effect by using such an instrumental variable approach to generate an unbiased estimate of the slope of the relationship shown in Figure 2 (discussed below) for bloc C households as compared to the same relationship for bloc B households.

(3) Mechanisms Behind SRI Coordination Effects: We can take advantage of the spatial distribution of plots along canals (see Figure 1) to examine which mechanisms drive any benefits to coordination that we observe. Coordination may increase the benefits of SRI through multiple mechanisms, including learning from neighbors and better management of shared irrigation and drainage infrastructure. Further, if farmers understand these coordination benefits, we are likely to see higher adoption among farmers in the coordinated treatment group in response to higher expected benefits of adoption.

Physical benefits of coordination are driven by access to water and drainage canals, which varies along a canal: plots towards the top of a canal may have more or more consistent water access, while plots closer to drainage canals are likely to have better drainage abilities. Namara et al. (2003) found that farmers at the head end of a canal and those relying on rain-fed farming were more likely to adopt SRI than those at the middle and tail end of the irrigation canal. They proposed that the repeated drying and wetting of the fields required by SRI were behind this finding. If water availability over the course of the season is in question, which is more likely for downstream plots than upstream plots, farmers may be hesitant to drain their fields if there is uncertainty about their ability to re-wet them.

Coordination benefits resulting from learning or synchronized production cycles, on the other hand, should affect farmers equally regardless of their placement along a canal. Farmers learn from their neighbors and social networks, which do not necessarily correspond with who farms the neighboring plot, particularly when dwelling location is not well correlated with farming location. With information about each plot's placement along the canals, we can compare both adoption rates and SRI yields by location to study whether the coordination effect varies based on placement on the canal. We can also compare the effects of decisions made by farmers in neighboring plots to the effects of decisions made by farmers who claim each other as information neighbors as the basis for separately identifying physical coordination effects with social or learning effects. In the scenario described by Namara et al., for example, coordinated adoption could affect farmers further down the irrigation canal more than those at the top, who are more likely to adopt in the uncoordinated intervention.

Power Calculations

While a number of previous studies have found significant increases in yields when rice is grown using SRI methods, the connection between higher rice yields and higher incomes is still unclear. In initial field trials, data on both yields and profits were calculated. Profits are not a perfect measure upon which to base power calculations, as our outcome of interest is household income. However, profit measures account for increases in both yields and input (especially labor) costs, so using profit rather than yield as a predictor of effects on household income is a more conservative measure that at least partially accounts for the labor reallocation effects that may dampen the impact on household income. While we have some concerns about how profit was calculated (especially how labor was valued), the data provides a baseline for power calculations to estimate the necessary sample size for our study.

A methodological innovation in our project is the dose response approach to testing the marginal effect of increasing the amount of land put into SRI by generating exogenous variation in the amount of land households have in blocs treated with SRI. Households included in the intervention group will be exposed to different levels of treatment because most households own several plots of land, and many will likely own plots of land in multiple blocs. According to baseline data from the region, households own between one and 14 plots, with a mean of 2.1. Households with land both in and outside of the treatment bloc will receive an SRI dosage equal to the percentage of their land in the treatment bloc. As a result, standard power calculation methods based on a binary treatment are not relevant here. Instead, we use a power calculation method designed to detect a regression slope, i.e. the marginal effect of increasing the level of exposure to the treatment on the outcome of interest (Dupont and Plummer, 1998). Figure 2 provides a conceptual depiction of minimum detectable slope (MDS), where the distribution of households' plots across blocs provides exogenous variation in the intensity of SRI adoption (*x* axis) depicted as a histogram across five intensity bins.[3] This figure is relevant for evaluating the overall effect of coordinated SRI by combining data from blocs B and X. A sample size that is sufficient to pick up a particular MDS (e.g., dashed line) has the statistical power to detect a relationship characterized by a yet larger slope.

[3] This non-uniform distribution emerges from the pattern of plot ownership as described below.

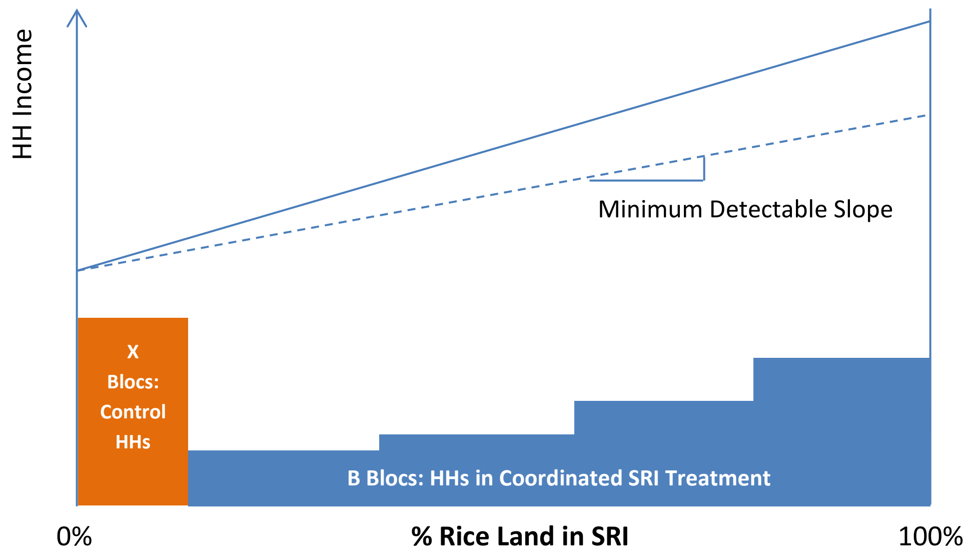

Figure 2 Conceptual depiction of SRI dose response profile and minimum detectable slope

More explicitly, if we treat *n* households, where household *j* is exposed to treatment level (i.e. the percent of their land that is in the treatment bloc) x_j and has a response level y_j, the expected value of y_j given x_j is $\gamma_0 + \gamma_1 x_j$. In this case, x_j is the proportion of their land under treatment and y_j is household income. We want to test the null hypothesis that $\gamma_1=0$ against a type I error level α and a power level (1-β). The power of a test depends on the standard deviation of the independent variable, in this case rice yield (σ_x), the slope of the regression line (γ_1), and the standard deviation of the regression errors (σ). Given these parameter estimates, we can determine the necessary sample size necessary to detect a regression slope for given levels of significance and power. We can draw on estimates from the FAMV trial for these parameter estimates:

- SRI profits per hectare were 134% higher than rice profits under traditional methods. Because these were controlled, monitored field trials, rice profit increases in our treatment may be lower. Moreover, we are also unsure about the accuracy of profit calculations. In order to be conservative in our calculations, we therefore divide this estimate by half and use $\gamma_1=0.67$.
- The dispersion of the independent variable, σ_x, is determined by the number of people at each level of treatment. The dose-response power calculation method uses discrete treatment levels,

which we can approximate by dividing up our sample into ranges. Because treatment level is equivalent to the proportion of a household's land in the treatment bloc, we can estimate the distribution across treatment levels based on baseline data about the number of parcels owned by each household.

- Trials were conducted in pairs, with one SRI plot and one traditionally managed plot for each household. For an estimate of standard deviation of rice profit for a household, σ_y, we can use the standard deviation of total profit at the household level from the trial data, which was 39,866 gourdes per hectare, or 54% of the mean profit across all test households, 72,821 gourdes per hectare.

Power calculations are obtained by using the Power and Sample Size Calculation computer program. Setting the significance level 0.05 and power level 0.8, the program calculates optimal sample size for a given minimum detectable slope based on the parameters discussed above, using methodology developed by Dupont et al. (1998).[4]

As a base case, we can divide our sample into five treatment levels: 0 (control), 25%, 50%, 75%, and 100%. Because one quarter of the households in our baseline survey have only one plot, and another quarter have only two, the distribution of the treated households will not be uniform. Based on the distribution of household landholdings discussed above, and assuming we assign 25% to the control group, we estimate the following distribution across treatment levels:

SRI Treatment Level	0	0.25	0.5	0.75	1
Percent of Sample	25%	10%	15%	25%	25%

With this sample distribution, a sample size of 400 is necessary to detect a 17% increase in profit with 80% power. Figure 3 shows a plot of the minimum detectable slope (MDS) against sample size.[5]

[4] Software available at http://biostat.mc.vanderbilt.edu/twiki/bin/view/.../PowerSampleSize

[5] Note that these power calculations are robust to the number of treatment levels assumed. To approximate a continuous treatment, it may be more accurate to divide the sample into a large number of treatment levels, so defining the treatment levels as 0, 10%, 20%, etc. Doing so and assuming a similar distribution of treatment levels as above results in nearly identical sample size results.

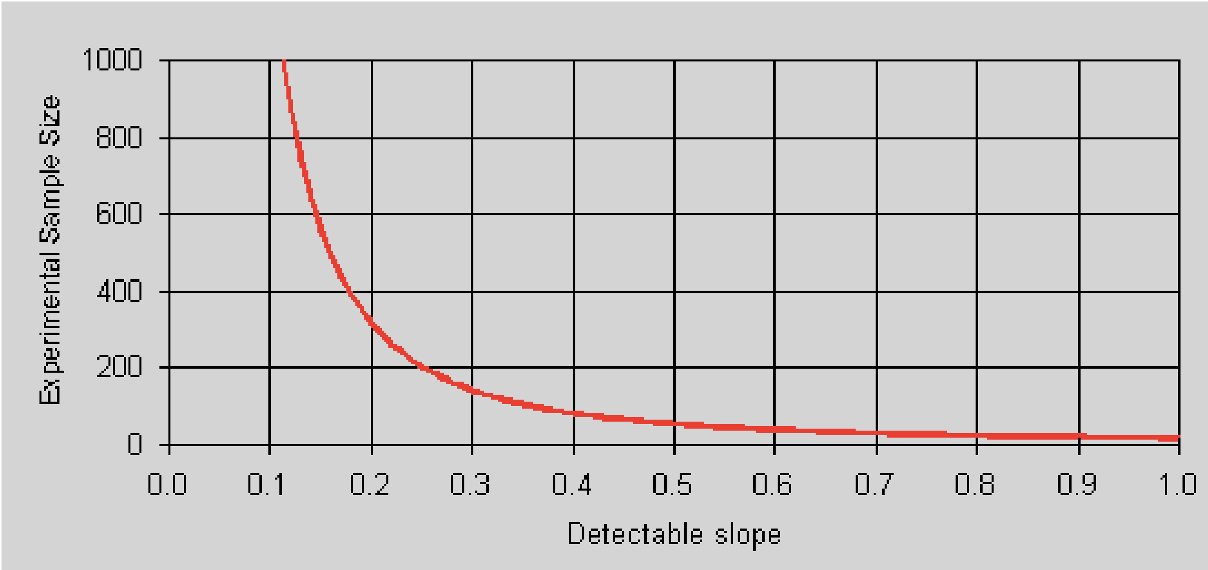

Figure 3 Minimum detectable slope (MDS) versus sample size for five treatment levels

To estimate this dose response function of rice profit with respect to SRI intensity includes households in both X blocs (0%) and B blocs (>0%). We envision a target sample size from these two arms of 150 and 350 households, respectively, which provide an MDS under these assumptions of 16%. Based on trial evidence, we believe this would provide a robust basis for testing the broader livelihood effects of SRI, but note that – depending on how the intervention plays out in practice – we may be able to include households in A blocs (150 household target) and C blocs (350 household target), which would further decrease the MDS to 12%.

We also want to be able to detect a difference in outcomes between the coordinated intervention group and the group receiving training and credit but no bloc-level coordination. A difference in profits may result from two effects: the technical benefit of coordination, which increases profits conditional on a level of adoption, and the effect of higher adoption rates under the coordinated intervention. Although dose response power calculation formulas exist for computing minimum detectable *difference* in slope between two regression lines, these rely on assumptions that seem tenuous in this case.[6] Instead of this

[6] When making these assumptions and computing these power calculations, the target sample size by treatment arm we propose has sufficient power to detect a difference in slope of about 20%. We do not report these full calculations because we are uncomfortable with the assumptions they require.

comparison of two dose response slopes, we propose a pooled intent-to-treat approach that combines sampled households in B, C and X blocs (and, possibly, A blocs) and uses the share of household rice land in a given treatment as an instrumental variable for predicting the share of land in SRI. Finally, note that even if the profit difference between coordinated and uncoordinated SRI is small, modeling adoption decisions in these two different treatments could be insightful. We are confident that our target sample size is sufficient to detect even a small change in adoption patterns. A clear effect of the full treatment, combined with evidence that the full coordination treatment leads to higher adoption than does the uncoordinated treatment will be strong evidence in support of the coordinated intervention.

Bloc Selection

The A blocs (Figure 1) were selected in 2012 by OA based on several criteria, including (in order of importance) the potential of the irrigation network to provide sufficient water control for SRI adoption with only modest investments in cleaning and basic repairs, physical suitability for SRI (slope, soil, etc.), and the functionality of the associated water users associations. We have worked with the technicians who selected these two initial blocs to construct a list of all the blocs covered by the same two associations that could have also been selected based on these same criteria. This list of 16 blocs – each with 300-400 plots cultivated by 250-350 different households – will provide the sample frame for this study. We will randomly assign blocs from this list to the treatment arms described above.

Implementation & Research Risks

Based on two field visits to the Artibonite Valley and the extensive OA and FAMV connections to local officials, agencies and organizations we are confident that there are no implementing or research partners who could better execute this intense coordinated intervention and the research design outlined above. Still, there are important risks associated with this research design. A few are worth noting. First, the initial A bloc intervention may fail to achieve full adoption or have limited success due to logistical or administrative constraints. Although the risk of such an outcome is small, we are in constant dialogue with our implementing partners to track progress and learn from these experiences. Second, there is a possibility that the MBG offer included in the bloc B and C treatment may not incentivize widespread SRI adoption in these blocs. We intend to carefully and completely pre-test the design of this MBG offer to reduce this risk, but have discussed with OA the possibility of extending the subsidized service credit to these blocs if necessary. Finally, if social learning is particularly rapid and the SRI effects in these rural households are striking, there is a possibility of control area contamination – as bloc X households choose to adopt SRI with no direct intervention support. We do not envision this to be a problem in a relatively short duration study due to prevailing liquidity, uncertainty, or coordination constraints, but are prepared to exploit such an occurrence as part of the study should it happen.

NARRATIVE | Research Themes & Policy Relevance

This project will address multiple barriers to technology adoption – knowledge and training, coordination, public goods management, and risk – to evaluate an intervention that addresses all barriers simultaneously and to test the importance in particular of the barriers related to coordination and the mechanisms through which coordination may affect adoption rates and household welfare.

The primary research themes of this proposal correspond to the three guiding questions above: (1) the household-level impacts of a coordinated SRI intervention, (2) the magnitude of the coordination benefit, if any, and (3) the mechanisms behind any coordination benefit. These research themes raise a number of important and interesting research questions:

- What are the household benefits of SRI when the technology is introduced as part of a coordinated intervention? How do benefits here compare with prior studies, namely the findings in Indonesia (Takahashi and Barrett, 2012) of no net benefits, in a setting with different wage labor opportunities and market access? Based on the structural approach we propose that seeks to establish mechanisms behind impact, what can we learn about where SRI is most likely to lead to income benefits for farmers?

- How important is cooperation over water resources and the associated infrastructure in adoption decisions and in the success of SRI? There is evidence suggesting that water-sharing issues may be important (Namara et al., 2003), but no studies have specifically examined the connections between water management and SRI adoption.
- Are there differential returns to SRI or differential propensities to adopt that depend on access to public goods such as water resources or drainage canals? Which farmers can benefit the most from the new technology, and does this distribution of benefits change when adoption is coordinated at the bloc level?
- How effective will coordination initiated by the intervention be in guaranteeing long-run coordination? Existing research on decentralized public goods management tends to focus on user-initiated, often longstanding cooperative systems. Given the need for local-level management of public goods in many settings, understanding whether and when such coordination can successfully be initiated by an external actor such as Oxfam is particularly important for informing agricultural development policies and programs.

Oxfam in particular is hoping to use this evaluation project to inform its future strategies for SRI promotion activities in Haiti, so there is much to be learned that will have immediate impacts on Oxfam's current development activities.

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ANTICIPATED OUTPUTS: Results, Dissemination & Outreach

We anticipate several results emerging from this study that will be of interest to stakeholders in Haiti, to agricultural development specialists worldwide, and to a variety of academic and other researchers. Specifically, we anticipate impact evaluation results that correspond to three questions describe in the narrative above. We envision several means of disseminating these results to relevant audiences.

First, our local partners in this project – FAMV and Oxfam America – have local networks that stretch across many sectors and are particularly strong in the agricultural development milieu. These existing relationships with local government officials, the NGO community, policy makers and researchers will provide a key platform for discussing and disseminating the results of this project. While we envision this as a fluid and organic process that often happens as coordination and collaboration in this network emerges, we plan to convene a formal stakeholder and policy maker meeting in year three of the project as a structured platform for distilling, discussing and debating lessons learned from the project and their broader implications. This meeting will be organized by FAMV in Haiti. Given the complementarities between this work and the USAID WINNER project, we expect to collaborate closely with USAID to plan and conduct this meeting. The budget for this meeting includes support for representatives from farmer and water users associations in rice growing regions of Haiti to attend, along with traders, agro-input dealers, and local NGOs.

Second, our collaboration with FAMV will involve several students in rural economics. Many students will be employed as enumerators and field managers. The project will directly support the thesis research of three FAMV students. These theses will tackle specific questions within the broader scope of the project and the data collected. This support will be an important contribution to the training of these students and their theses will provide another angle of dissemination.

Finally, we envision several academic publications emerging from this project. Some of these publications will stem from the work of PhD students in Agricultural & Resource Economics at UC Davis. Other publications will arise more directly from the collaboration with the FAMV co-PI and students. In the early stages of these publications – as evidence emerges – we will tap the local stakeholder networks to circulate policy briefs and project bulletins. We also look forward to using the BASIS network as a platform for sharing this evidence.

ANTICIPATED IMPACTS: Informed SRI Scale-Up, Collaboration, & Research Capacity

Through collaboration with FAMV, Oxfam, and local farmers' associations, we have the opportunity to influence future agricultural development policies and research in a region in Haiti where improving agricultural incomes is crucial for alleviating poverty and food insecurity. This project will inform future roll-out of agricultural development projects on a larger scale and build research and extension capacity of our partners in Haiti.

(1) Strategies for program scale-up: Oxfam and its partners will continue promotion of SRI and associated efforts to improve production, processing, and marketing through the *Artibonite Valley Livelihoods Program* after this specific project concludes. Findings from this study will provide insight into the benefits of a concentrated intervention for targeted farmers and inform the feasibility of scaling up a similar intervention throughout the Artibonite Valley or in other regions of the country. The lessons learned and experience gained through this project will also be used to influence the activities and leverage the resources and experience of other development organizations, the government, private sector, and other applicable stakeholders. The complementary USAID WINNER project – which is promoting SRI in other regions of Haiti – is a likely beneficiary of this study in this regard. We are confident that results from the evaluation we propose will be of direct relevance to the WINNER project.

This project's activities are already closely aligned with the goals of the Ministry of Agriculture's sectorial plan for developing the rice value chain, increasing productivity, and modernizing rice production processes. By demonstrating the effectiveness of the proposed interventions, the government could enact similar interventions backed by the $770+ million it has planned for agricultural reconstruction. Other development actors could apply these methods, as could actors like RACPABA. Equally, if not more, important though, will be efforts to involve such actors (especially the government) in the project throughout so that they have a say in program design, develop ownership of the activities, and learn from them first hand.

Finally, in part, our research design aims to elucidate mechanisms behind SRI impacts. Based on what we learn about these mechanisms, there may be broader validity of these results beyond the Haitian context. For example, Oxfam America has a portfolio of SRI initiatives worldwide and is eager to learn how and where to modify these initiatives to improve the impact on rural household welfare. We anticipate this project spawning wide discussions within Oxfam on this topic. Moreover, given that the rigorous research design of this project stands in contrast to much of the SRI literature – which often reads more like advocacy than research – we believe the work will have an important impact on SRI initiatives more generally by contributing to a solid evidence base.

(2) Local research collaboration and capacity building: Implementation of the intervention will take place in conjunction with several local partners, including RACPABA, AILA, and MAFLPV. A direct impact of the intervention will be the strengthening of these associations. In addition, the project builds a collaborative research relationship with faculty from FAMV, who will be in a position to continue such research on agricultural development in Haiti and incorporate impact evaluation into agricultural programs in the future. By working with the premier university in Haiti and Oxfam, who has substantial contacts and experience on the ground, this project builds a foundation for future research and development collaboration for SRI promotion and other agricultural development programs.

TIMELINE

The intervention in the A blocs is being implemented currently, and the selection, mapping and initial surveys of the remaining blocs will begin in summer 2013. This process will be informed by findings from the early stages of the intervention in the A blocs. Training in SRI methods will take place in early 2014, before the first rice season for the year, for both the B and C blocs, as well as drain and canal cleaning in the B blocs. A full timeline is laid out below.

2013												
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
A *Blocs*: Coordinated SRI with subsidized credit				**SRI Training Pre-survey**			SRI. 1	SRI. 1	SRI. 1	SRI. 2	SRI. 2	SRI. 2
B *Blocs*: Coordinated SRI with insured credit							R.1	R.1	R.1	R.2	R.2	R.2
C *Blocs*: Uncoordinated SRI with insured credit							R.1	R.1	R.1	R.2	R.2	R.2
X *Blocs*: Credit only (control)							R.1	R.1	R.1	R.2	R.2	R.2
						Map plots			**Survey.1**			
2014												
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
A *Blocs*: Coordinated SRI with subsidized credit							SRI. 1	SRI. 1	SRI. 1	SRI. 2	SRI. 2	SRI. 2
B *Blocs*: Coordinated SRI with insured credit		**Clean canal/ drains**		**SRI Training**			SRI. 1	SRI. 1	SRI. 1	SRI. 2	SRI. 2	SRI. 2
C *Blocs*: Uncoordinated SRI with insured credit				**SRI Training**			SRI. 1	SRI. 1	SRI. 1	SRI. 2	SRI. 2	SRI. 2
X *Blocs*: Credit only (control)							R.1	R.1	R.1	R.2	R.2	R.2
							Survey.2					
2015												
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
A *Blocs*: Coordinated SRI with subsidized credit							SRI. 1	SRI. 1	SRI. 1	SRI. 2	SRI. 2	SRI. 2
B *Blocs*: Coordinated SRI with insured credit							SRI. 1	SRI. 1	SRI. 1	SRI. 2	SRI. 2	SRI. 2
C *Blocs*: Uncoordinated SRI with insured credit							SRI. 1	SRI. 1	SRI. 1	SRI. 2	SRI. 2	SRI. 2
X *Blocs*: Credit only (control)							R.1	R.1	R.1	R.2	R.2	R.2
							Survey.3					
2016												
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
A *Blocs*: Coordinated SRI with subsidized credit							SRI. 1	SRI. 1	SRI. 1	SRI. 2	SRI. 2	SRI. 2
B *Blocs*: Coordinated SRI with insured credit							SRI. 1	SRI. 1	SRI. 1	SRI. 2	SRI. 2	SRI. 2
C *Blocs*: Uncoordinated SRI with insured credit							SRI. 1	SRI. 1	SRI. 1	SRI. 2	SRI. 2	SRI. 2
X *Blocs*: Credit only (control)		**Clean canal/ drains**		**SRI Training**			SRI. 1	SRI. 1	SRI. 1	SRI. 2	SRI. 2	SRI. 2
		Possible delayed intervention				**Survey.4**						