AREA PROJECT EXTENSION EXPERIMENT

Executive Summary

This extension experiment tests three models of extension or technology transfer. (1) The Farmer Field School, developed by FAO, is widely employed in Haiti and globally. (2) The Master Farmer approach may be unique to Haiti in the configuration developed during the USAID-funded WINNER Project in Haiti, but it is a version of the farmer-to-farmer approach to technology transfer that USAID, FAO and other international development programs use globally. (3) The input supply model is an outgrowth of the growing international emphasis on the importance of formal and informal input supply systems to successful adoption of innovations. We use the PRECEDE-PROCEED theory of change as the basic conceptual model for the experiment because it incorporates individual, group and macro level factors that can affect the behavior change decisions of individuals. This is a quasi-experiment with post-test only where the unit of analysis if the farmer association. Thirty associations participate in the experiment, ten assigned to each treatment. Two of the ten are female-only associations. The remaining eight are male-only or mixed gender associations. We explicitly explore the role of gender with regard to the outcome variables and to various predictor variables in this study. The level of analysis is the association. We treat individual associations as quasi-replicates in some of the analyses, but caution is required in interpreting differences between associations because these replicates are not randomly assigned. Maintaining some degree of spatial separation between organizations participating in the different models was necessary to help ensure that observed treatment effects are independent. This negated the possibility of random assignment of groups to treatments. We collect most data at the individual household level, but households are embedded within the farmer associations and cannot be treated as statistically independent units of observation. The experiment occurs in the Kenskoff region of Haiti in relatively close proximity to Port-au-Prince. This site was chosen for both logistic reasons like relative ease of transportation, but also because rainfall tends to be abundant and regular in the area. There are several non-experimental factors that we cannot control in the experiment and we did not want to add a major environmental factor to the non-controlled variables. We will select a random sample of 30 households to test for effects on outcome variables, with additional quota sampling in mixed gender associations to permit statistical comparison by gender. The outcome variables

for this study are the rate (by association) of participating in Assisted and Independent Testing of one of five innovations. Assisted Testing refers to initial tests through trainings, demonstrations, and on-farm trials of what we believe are unknown innovations for farmers in the region. Independent Testing means that the farmer chose to implement the innovation without assistant in the following planting season after the introduction. We developed original instruments to assess the outcome variables, previous knowledge of the innovations under test, and traits and characteristics of farmer associations that we hypothesize are critical to the innovation adoption process and that may interact strongly with treatment effects. There are four phases of implementation. Phase 1 provided training for the three agronomists who will implement the models. Phase II is the implementation of the models with the 30 associations. Phase III is the following planting season in which Independent Testing is measured. Phase IV is data analysis and development of publications. Data analysis includes tests for differences between treatments and potentially among different functional types of farmer groups. Tests of association will assess the primary attributes of treatments, association traits and some individual household characteristics that influence Independent Testing.

Background and Problem Statement

People adopt some technologies very quickly. Mobile phones provide an example. According to *The Economist*, between January 2007 and 2016 nearly half of the world's population started using a smartphone, a number expected to reach 80% by 2020 (Feb. 26, 2015, available at https://www.economist.com/news/leaders/21645180-smartphone-ubiquitous-addictive-and-transformative-planet-phones). The economic effects of this single massive technology adoption are staggering. *The Economist* reports that some studies indicate that every ten mobile phone users per 100 population in developing nations increases the rate of growth of GDP-per-person by more than one percentage point. While rural residents often "lag behind" their urban counterparts in adopting new technology, this is not the case for the mobile phone. The e-Agriculture community of practice (http://www.e-agriculture.org/) focuses on the use of information and communication technologies (ICTs) for sustainable agriculture and rural development. This network provides information about dozens of projects and programs using mobile telephony to reach farmers all over the world.

In contrast, adoption of many agricultural technologies takes years, even decades. No-tillage or no-till farming is an example. The basic practices of no-tillage have been known for many years and the technology needed to use no-till effectively became widely available in the 1970s in the U.S. Yet, despite many economic and environmental advantages, adoption of no-till farming on farmland in corn, soybean, wheat and cotton (four major crops in the U.S.) remains at less than 40% of total acreage (Wade, Claassen & Wallander, 2015) and seems to have been constant for at least 20 years. No-till farming does not reduce yield or the quality of the crop. Perhaps more striking, there are economic incentives in place to encourage farmers to adopt various conservation practices, including no-tillage, and several government agencies including the Natural Resources Conservation Service, the Agricultural Research Service, and the land grant universities and extension service have all conducted extensive, lengthy programs to encourage adoption as have various non-profit organizations.

Unfortunately, protracted process of adoption of no-tillage is not an isolated example of the time involved in moving from discovery to adoption in agriculture. Pardey and Alston (2012: 34) comment that: "The lags between investing in R&D and realizing a return from that investment are long, often spanning decades, not months or years… The dozens of studies done to date indicate that the productivity consequences of public agricultural R&D are distributed over many decades, with a lag of 15-25 years before peak impacts are reached and continuing effects for decades afterwards." Formal extension or technology transfer programs are intended to reduce the lag time between discovery and adoption. This research compares the effects of three different models or frameworks for technology transfer of agricultural technologies in Haiti. We also examine the role of farmer organizations in the technology transfer process and assess whether or not there are gender differences in access to and adoption of five proposed innovations.

Models of Technology Transfer

Informal processes of technology transfer among farmers have undoubtedly taken place for millennia. However, systematic, institutionalized technology transfer to or among farmers appears to date from the early 19th century in many regions of the world. For example, farmers' associations or societies that focused on improving agriculture were abundant in the U.S. and Britain by the 1800s (Hillison & Bryant, 2001; Arnon, 1989). Public agricultural universities were common in many nations by the early 20th century. One example is the China Agricultural University, founded in 1905, which is today a leading agricultural university globally (see http://admissions.cau.edu.cn/en/pages?cid=149&pid=145). Some of these universities included a strong emphasis on research, such as those at Coimbatore established in 1868 and at Poona in 1889 (Ruttan, 1982). The idea of getting farmers to change their practices is present even in the earlier farmers' societies or farmers' improvements. However, formal systems for the dissemination of research results to farmers with a specific intent of getting farmers to change their production practices is newer. The contemporary concept of technology transfer differs from the long-standing concepts of agricultural research and teaching in two ways. First, the technology development process is institutionalized, through research institutes and universities in most cases, speeding the rate of technological innovation. Second, the idea of technology transfer moves beyond research and development to include institutionalized efforts to generate widespread adoption of research products by farmers. The term "extension" originates with the the public system of agricultural and mechanical schools (land grant institutions) developed in the United States in the late 19th century, but has since been widely adopted internationally (Cash, 2001) to describe this transfer process.

Many models of technology transfer or extension are in use globally. Marchesan and Senseman (2010), Choi (2009), Choudhary, Thakur & Suri (2013), Collinson (2000), Barfield & Swisher (1994) provide discussions of the key features of many of these systems, which can be grouped conceptually in several ways. One way is to examine the degree to which the system relies on trained experts to disseminate new technologies. The land grant system developed in the United States is a multi-tiered system in which agricultural professionals disseminate research-based technologies from universities to farmers through state extension specialists and county extension agents. The farmer field school approach is based on the theoretical concepts of adult education and "learning by doing." A trained professional facilitates on-farm demonstrations combined with reflection and group practice. The training and visit system developed by the World Bank as practiced today is conceptually similar to the idea of master farmers who learn about new technologies at a formal facility – often a research station – and then "take the technology home" to their communities. In contrast to these systems in which technical expertise is critical, USAID has used the farmer-to-farmer approach of "horizontal" technology transfer, which relies heavily on volunteer trainers whose expertise is experiential rather than the result of professional training. The farming systems and later offspring of this approach rely more on developing technologies that will "sell themselves" to farmers because they are based on farmers' needs and are developed largely through on-farm experimentation. Typically, trained agricultural researchers play a major role in the design and management of the on-farm trials.

The various models or approaches to technology transfer can also be grouped based on the broad theoretical perspectives underlying them. Three broad theoretical frameworks underlie most approaches to technology transfer in agriculture and rural development, although there are other frameworks less represented in practice. The three common frameworks are rational actor theory, diffusion theory, and social network theory, within which we include actor network theory.

Rational actor theories treat behavioral change as a rational decision, emphasizing the role of the decision-makers assessment of potential costs or risks and potential benefits of a given change in behavior or practice in the decision. The framework treats decision-making largely as an individual mental exercise and includes little emphasis on the role of larger social structures and networks on the decision-making process. However, it does incorporate some external factors, particularly an individual's perceptions of how significant reference groups like other farmers perceive of the proposed change in behavior and how important these groups are in an individual's decision-making process. Knowledge and self-efficacy or confidence in one's ability to engage in a behavior are important concepts in these theories. The theory of planned behavior (Ajzen, 1991), and its predecessor the theory of reasoned action (Fishbein & Ajzen, 1975) are good examples. The land grant model and Haitian ministry of agriculture model both rely heavily on rational choice theory. In the U.S., the land grant model particularly emphasizes the importance of knowledge in the behavior change process, while the Haitian model focuses on availability of inputs as well, including the use of input subsidies. The farming systems approach differs from traditional rational actor theories in its focus on the research that produces new technologies, emphasizing the development of innovations that are appropriate to the specific needs and constraints of farmers and conducting research on-farm rather than on research stations (Hildebrand 1985, 1986). This approach was widely employed in the US and internationally in the latter 20th century (Harrington, 1995; Flora, 1992). It has influenced agricultural research and extension in several ways, including attracting social scientists to agricultural research, emphasizing on-farm research and understanding women's needs and role in farming (Collinson, Michael P., 2000).

Diffusion theories that grow from the work of Rogers (Rogers, 1963a, 1963b, 1995) differ from the strictly rational actor theories in two main regards. Like rational actor theories, diffusion theories consider the individual's internal, mental decision-making process based on cost-benefit considerations, but they also take into account attributes of the technology that can enhance or retard adoption. While rational actor theories focus on adoption as a decision at a single point in time, diffusion theory treats adoption as the outcome of a process. Widely employed to understand adoption of agricultural technologies and health behaviors, diffusion theory sees behavior change as the final step in which individuals or groups accept, adapt or reject an innovation as it spreads through a population (Straub, 2009). The original “naïve diffusion” theory in which the spread of an innovation was treated as a rather simple process of exposure has evolved into more robust models today. Contemporary diffusion theory incorporates social and contextual factors to some degree, but pays scant attention to other factors like the hierarchy of formal and informal institutions, organizations, networks and policy in which individuals make decisions (Lindberg & Palmas, 2013; Long et al., 2014; Marra, Pannell & Ghadim, 2003).

The intertwined social network and action network theories of technology transfer emphasize the effects of membership in social networks on decision-making and behavior of individuals.

These networks range from the global to local. Moore (2011) makes three key points about networks and behavior. First, people create definitions of desirable outcomes through their relationships with others and those relationships define “appropriate” behavior for network members. Second, networks, especially those that affect decision-making, are composed of components or “sub-networks” that may be relatively autonomous of or dependent on each other. These “sub-networks” often compete in various ways, and there are winners and losers in the competition. Third, local networks of farmers are highly influenced by global networks of information exchange, technological innovation, and commerce. Few, if any, local farmer networks are autonomous in the options available to them or in how they can define “desirable outcomes”. Coughenour’s (2003) early use of actor network theory to understand the adoption of no-tillage cropping points to the emergence of new definitions of desirable outcomes and appropriate behaviors produced by new networks of farmers, farm advisors and input suppliers with a shared paradigm of ecological farming. This “sub-network” then compete with the conventional agricultural networks for members, and members in the new network see no-till cropping as more appropriate than conventional tillage. Carolan (2005) discusses the importance of contesting social fields or networks in the development of the “sustainable agriculture movement in the U.S. and draws attention to the importance of trust in social networks, including trust in the validity of concepts and information (Carolan, 2006). These approaches have been used more to explain patterns of behavioral change than to plan interventions in agriculture (Coomes et al, 2015; Daloglu et al, 2014; Wood et al, 2014), particularly in industrial and post-industrial nations. However, extension models that incorporate key aspects of social network theories have emerged in developing nations. The farmer field school, farmer-to-farmer, and master farmer models of technology transfer draw on key concepts of action and social network theories. They point to the importance of farmer-to-farmer transfer of technology and the role of social networks in the diffusion of knowledge. They emphasize the role of modeling, seeing and copying the behavior of others “like oneself” in testing and learning a new behavior. They also take into account the role of context in technology transfer, particularly with reference to conditions that constrain or foster the efficacy of a technology in a giving setting – the global to local linkages that facilitate or constrain behaviors (Choudhary, Thakur & Suri, 2013; Diaz-Jose et al, 2016; Friis-Hansen & Duveskog, 2012; Thorburn, 2014).

Impact of Extension or Technology Transfer on Farmer Behavior

The overall effects of extension programs on farmer adoption behavior are not clearly established. The research designs often fail to meet the criteria needed to test direct causal effects. Few or none of the studies employ true experiments although some, like our proposed research, do use quasi-experiments. Few of the study designs permit hypothesis testing regarding treatment effects because there are no comparison groups. While many of the studies are used for evaluation purposes, the absence of reasonably matched participant and non-participant groups greatly limits ability to reach reliable or valid conclusions about both direct and indirect effects of program participation. Few provide any type of counterfactual evidence. These weaknesses in the evaluations that of the efficacy of purposive technology transfer efforts provide practitioners with little guidance in selecting which of the many approaches, including the three widely used approaches that are the subject of this research, are most effective. Improving the impact of technology transfer is critical to reducing the lengthy lag time between scientific discovery and widespread adoption of new technology or between problem identification and the application of even well tested solutions.

There does exist a massive body of essentially descriptive literature about technology transfer, particularly models based on rational actor theories like the theory of planned behavior, on diffusion of innovations theory, and to a lesser degree the social and action network theories. We restrict this review to a narrower body of literature based on more robust research designs and that focuses more explicitly on the three models of interest to our study. These are the master farmer, farmer field school, and Ministry of Agriculture models which is similar to that of the land grant institutions in the US, but also directly intervenes to make critical inputs available because of their role as enabling factors in adoption. The body of literature is particularly robust for farmer field schools, as a few more recent publications illustrate (Irshad et al, 2016; Khan & Khan, 2015; Khatam , Muhammad & Ashraf, 2014; Lalani et al, 2016; Larsen & Lilleor, 2014; MacMillan & Benton, 2014; Mariyono et al, 2013; Masset & Haddad, 2015; Paltasingh et al, 2017; Siddiqui, Siddiqui and Knox, 2012; Siregar & Crane, 2011; Thorburn, 2012).

The contradictory results and conclusions regarding the efficacy of farmer field schools provide good examples of the general quality of the body of knowledge about the efficacy of technology transfer more generally. Davis et al (2012) provide an excellent summary of the reported effects of farmer field schools in their literature review. They assessed the results with regard to three types of outcome variables, (1) yield, income, productivity and pesticide use, (2) adoption or dissemination beyond the farmers who hosted the schools, and (3) empowerment measured as greater well-being, higher knowledge or skills (including leadership), knowledge retention, and improved collaboration or cohesiveness among farmers. Not all studies measured all three types of outcomes and the specific indicators in studies varied greatly. Overall, the results reported in the literature they reviewed are highly variable for all three types of indicators. Feder, Murgai and Quizon (2004) review the assessment literature about farmer field schools with a focus on the empirical regarding the magnitude of diffusion from farmer trainers to others in their communities, the key driver for widespread technology adoption in this model, and find inconsistent results regarding the impact. These authors also conducted their own study using panel data to assess diffusion of knowledge about integrated pest management in farmer field schools in Indonesia. They conclude that: “The results confirm that better knowledge leads indeed to reduced pesticide use, and that trained farmers make a modest gain in knowledge. However, there is no significant diffusion of knowledge to other farmers who reside in the same villages as the trained farmers.”

Similar contradictory evidence emerges in assessments of rational actor and diffusion approaches to technology. Carlisle’s (2016) examination of how well the factors traditionally included in rational actor and diffusion theories account for U.S. farmers’ adoption of soil health practices. She concludes that these factors are not adequate to explain farmer decision-making decisions and provides five key conclusions that are salient to our proposed research in Haiti. (1) Farmers who occupy different positions on the diffusion adoption continuum have different motivations for or barriers to adoption of soil health practices. She points out that the research designs used – particularly the failure to include non-adopters in evaluations – mean that we know much more about adopters than non-adopters, which would further weaken the conclusions that can be drawn. (2) Farmers consider many decisions at the same time, and there are complex interactions among different practices, including different practices of the same general genre, like soil health. (3) Many findings suggest that adoption is not an incremental process. Incremental change seems to have more to do with the fit of a specific practice into the farmer’s management system whereas transformative change requires a radical change in the farmers’ mental models that leads farmers to reject a whole set of past practices. (4) Farmers have many noneconomic motivations and economic factors appeared to be of secondary predictive value. (5) Individual farmers are actors in a larger food and agricultural system that plays an enormous role in determining behavior. Farmers occupy different positions in the system. Generalizing individual decision-making considerations to the farm population as a whole in any setting is therefore fraught with threats.

Farmer Associations and Technology Transfer

Farmer associations of various sorts play a key roles in agricultural change in many places, perhaps most. Producer associations in the United States, for example, play a role in developing federal and state policy, sometimes formally through mechanisms like Senate hearings and even more often informally through their role in political elections and public decision-making. US producer associations often fund research through funds generated by their own members. They interact directly with researchers in the land grant institutions, state agencies, and the Agricultural Research Service. The "segmentation" of social networks described earlier (Moore, 2011) is clearly evident in the origins of federal funding for sustainable agriculture. The Sustainable Agriculture Research and Extension (SARE) Program funded by USDA grew out of the self-organization of an initially small group of farmers, nonprofit organizations representing both farmers and consumers, and some agricultural scientists largely working outside the land grant and federal USDA system. They called for the kind of transformational change in paradigm that Carlisle (2016) discusses and ultimately won support in the federal government for the SARE program. Farmers' organizations have also been important in direct technology transfer. These associations also play direct roles in technology transfer. Early farmers' clubs or self-improvement associations, for example, played key roles in disseminating new technologies prior to the development of agricultural sciences in universities in England and the United States (Cash, 2001). Associations today continue to play this role. Farmer associations and their members are very active in professional societies, for example, like the Crop Science Society of America and the Caribbean Fruit Crops Society. In addition, various forms of producer associations have become important actors in direct technology transfer to farmers, particularly in developing nations. The farmer field schools and predecessor training and visit system of extension and farmer-to-farmer programs funded by international donors including USAID, are examples. The master farmer model used by the USAID WINNER Project in Haiti relied very heavily on Haitian farmer associations for outreach and technology transfer.

To some extent, these farmer organizations are hidden components in the technology transfer process in the research literature. Surprising given the enormous body of literature, particularly evaluation literature, about technology transfer, relatively little few contributions focus on understanding how farmer organizations facilitate or create barriers to technology transfer and even fewer assess how traits of the organizations affect their impact on the transfer process. The rather modest body of empirical evidence shows that farmer organizations take many forms and play many different kinds of roles in the change process.

Trebbin (2014), for example, studied the role farmer producer companies play in India in linking small farmers to the emerging retail food sector in the country. His study of 181 farmer producer companies registered with the Indian government show that they can play a key role in providing small producers with access to the growing retail market sector where large, often international corporations determine policies and standards that can limit participation in the sector. He found that: "Their way of membership organization and participation is similar to that of a cooperative, while the integration into corporate law allows greater professionalism and flexibility in their business activities…" (2014:39). He concludes that while only a few of the organizations he studied have succeeded in becoming part of the retail value chains, they should receive greater support from government, including finances for start-up, training, and more opportunities to share lessons learned. Latynskiy & Berger (2016) also examined the effects of rural producer organizations on mechanisms for reducing transaction costs, improving market access, and providing access to inputs and capital for smallholders in Uganda. Their findings show positive impacts of these organizations. However, they also highlight key limitations, including limited access to inputs, competition between the organization and middlemen, limited capital, and organizational limitations largely having to do with leadership, transparency, and trust. Overall, they conclude that the rapid growth of rural producer organizations shows that they can play an important role in improving farmer access to both inputs and markets, enhancing diffusion of practices, and providing resources to farmers, but that the need assistance from development organizations and extension to improve functioning (2016:585).

In contrast, others have examined how farmer organizations affect farmers' access to resources. Liverpool-Tasie (2014) examined how farmer groups affect access to inputs, comparing two approaches for a fertilizer distribution program in Nigeria. In one case, a farmer group was responsible for distribution to individual farmers. In the other government agents directly provided vouchers to individuals. Distribution through the farmer groups resulted in elite capture in which relatives of the group presidents obtained more fertilizer than other group members. While the program increased access to fertilizer, the author found that: "…fertilizer was still received late by farmers and no evidence was found that the program improved the quality of fertilizer received" (2014:47) He recommends using groups to identify farmers and coordinate participation in such programs, but that individuals should receive and redeem their own vouchers. Coomes et al (2015) challenge four misconceptions about farmer seed networks, that they are (1) inefficient for seed dissemination, (2) closed, conservative systems, (3) foster egalitarian access to seeds, and (4) will be overtaken by commercial systems. They argue that the informal systems: "…make a vital contribution to agriculture because they are an effective means of moving seed not only farmer-to-farmer, but also from nature, local markets, national seed agencies, research stations, agro-dealers, and agribusiness to farmers throughout the countryside (2015:47). They point out that these systems can and do reinforce social relations, including inequalities in status, identity and wealth. Lopes et al (2015) examined how farmer organizations affect seed supply. They found that community-based seed production groups were effective in multiplying and disseminating high-yielding corn seed in Timor-Leste, but that the closeness of social relationships with growers who already knew and used the new seed strongly influenced group efficacy. Organizational traits were also important, including frequency of meetings, number of positive leadership traits, group trust, and group management.

Other researchers have examined the more traditional role of farmer groups as conduits for information. Llewellyn (2007) examined the role of farmer groups in Australia, where such groups are large, well organized and managed for the most part, and have fiscal and human resources at their command. He found that farmers highly value local information, and particularly local information generated through farmer-led research or research on local farms. He concludes that: "… there is evidence that engaging with farmer groups can be a path to delivering more effective information for more rapid adoption decisions. Greater integration of farm advisors and information service providers into technology development and delivery is another possible approach to addressing information-related demands of technology adoption. In the cases of some more complex information-intensive technologies, widespread adoption will be significantly less likely unless local advisory services are available to overcome information and learning-related constraints" (2007:155). Sangole et al (2014) explored another key aspect of effective technology transfer, monitoring and evaluation. This is a rarely explored aspect of farmer organizations, although long experience with public and private extension and technology transfer organizations of other types show the importance of effective monitoring and evaluation on organizational development and efficacy. These authors compared groups that used community-based participatory monitoring and evaluation with groups that did not. They found that groups that used community-based participatory monitoring and evaluation show greater cohesion, more satisfaction among members, and better performance as change agents. Accountability did not differ between groups with and without participatory monitoring and evaluation. This work suggests that strengthening the monitoring and evaluation aspects of farmers' organizations can be important in improving their role as change facilitators. Wood et al (2014) examined traits of farmer networks, although not necessarily networks embodied in formal farmer organizations. They identified three common themes of importance in understanding how farmers share knowledge. (1) Farmers tend to value knowledge based on their familiarity with and trust in the person who delivers the knowledge, not his/her technical role or expertise. (2) They trust knowledge gained through direct experience with farming and (3) are more apt to rely on knowledge based on empirical observations than generalizations derived from theory. Perhaps more important, they also learned that farmers engage in intense discussions about observable experimentation (e.g., field plots or on-farm experiments), but do so more intensely in relatively homogeneous groups.

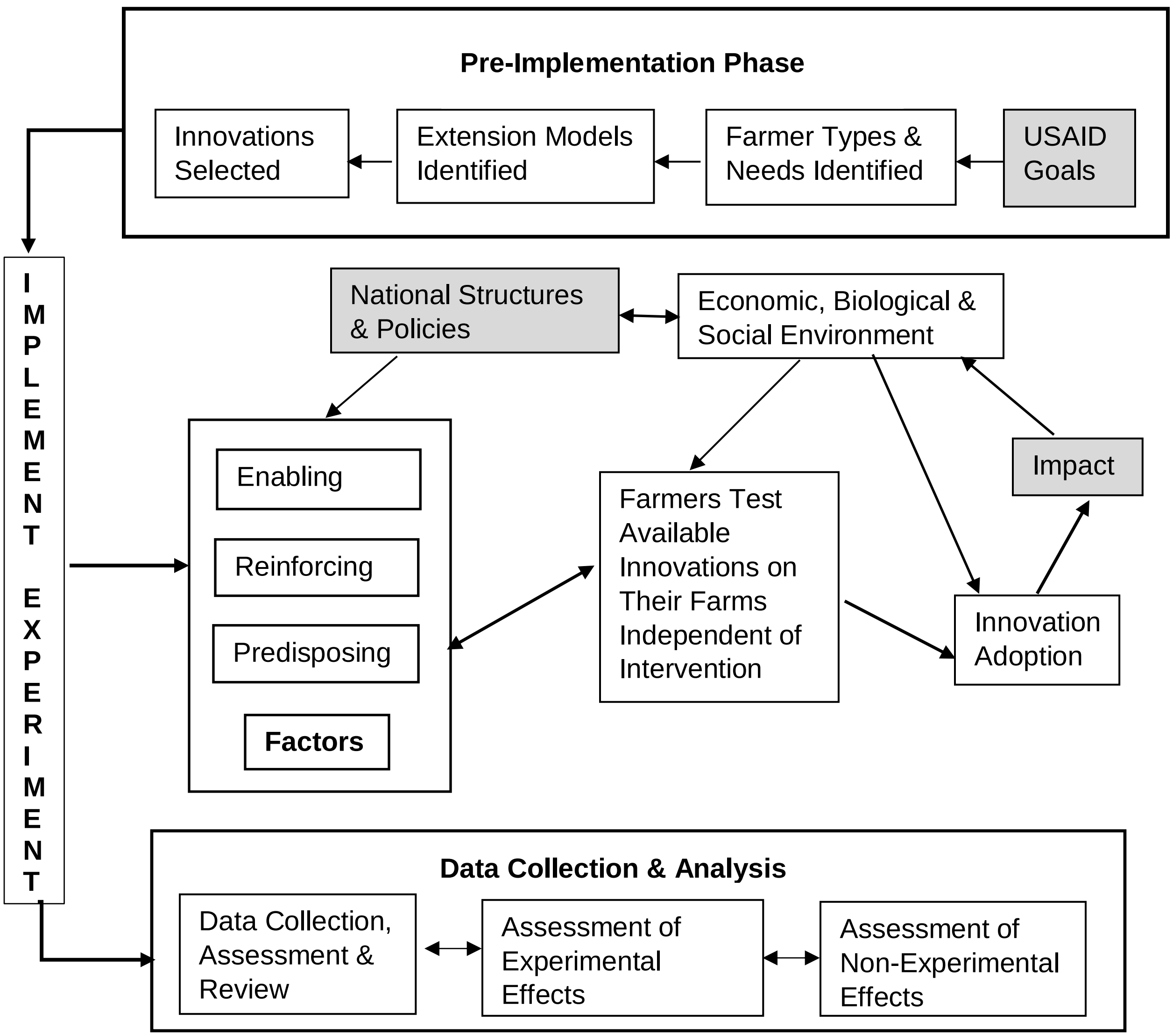
Conceptual Model of the Extension Experiment

The PRECEDE-PROCEED model (Figure 1) provides the conceptual basis for this extension experiment. It is a theory of change that draws upon elements of several social theoretical frameworks rather than a specific theory. It draws upon constructs in both rational actor, social network and action network theories and can incorporate some of the descriptive traits used in diffusion theory. It is used commonly to guide public health interventions, with a focus on the role of contextual traits and characteristics in health behavior outcomes, but some have used it as a general approach to community-based interventions designed to address a range of community issues. This is one of relatively few theories of behavioral change that specifically treat change as an interactive process that is embedded in larger social structures. It therefore facilitates understanding the relative importance of individual traits and experiences compared to influences of the large and small scale structures in which decision-makers are situated.

The PRECEDE-PROCEED theory of change rests on four related assumptions. (1) Voluntary behavioral change is more likely to be effective if the change process has the active participation of stakeholders. In our project, primary stakeholders include farmers, their associations, and the public and private organizations and agencies that serve farmers. (2) Community environment and history, including the physical, social, political and economic context, deeply influence individual behaviors, which evolve and persist within the context of community. Understanding the context in which a behavior has evolved is therefore critical. For example, farmers may consume seed rather than save it for planting because they have no way of saving seed that will preserve germination rate. (3) The cost or benefit of a behavioral change may not be simple or direct. For example, an innovation may produce little increase in yield, but generate an important indirect effect like reduced likelihood of losing the labor cost involved in land preparation if the cultivar introduced is less sensitive to planting date than existing cultivars. Alternatively, a cultivar that shows a significant change in yield may be unacceptable to a farmer if it must be planted in a period when another crop has higher priority for household survival. (4) A sustained change in behavior typically requires that a specific behavioral change contribute to a constellation of factors in ways that result in overall improved quality of life. Put another way, people weigh the value of a behavior change in terms of its overall effect on their lives, not just the single effect that agricultural scientists are likely to consider as a measure of the benefits of an innovation. For example, farmers may plant rice, corn and squash together in one field even though they require very different water regimes because the three crops together increase the likelihood that the farmer can take advantage of rainfall that is erratic in timing and quantity. One advantage of this model for the Haiti project is that it fits well with the USAID evaluation framework because it incorporates evaluation at each stage of design and delivery of innovations to groups of clients.

Note that shaded boxes in Figure 1 are parts of the PRECEDE-PROCEED model that lie outside the frame or potential for impact for this project. Most important, the AREA project is not makes no attempt to affect laws, legal structures and policies at the national level. While impact is the ultimate goal of this project, overall impact probably cannot be measured within the timeframe of this project because impact unfolds as a result of innovation adoption and usually emerges well after adoption occurs. It is also unlikely that true farmer adoption – defined as permanent or sustained use of an innovation or set of innovations – will be measurable within the timeframe of a single project, although we may be able to provide indicators of adoption and impact. This experiment is concerned primarily with effect of the experimental treatments on enabling, predisposing, and reinforcing factors. See the University of Kansas website for a more detailed discussion of the PRECEDE-PROCEED model. http://ctb.ku.edu/en/table-contents/overview/other-models-promoting-community-health-and-development/preceder-proceder/main

Figure 1: Modified PRECEDE-PROCEED Model for Extension Experiment



The enabling factors are the conditions that either foster or inhibit an individual's ability to engage in a behavior – regardless of whether s/he concludes that the benefits of doing so would outweigh the costs. For example, a farmer may conclude that the cost of fertilizer would clearly be outweighed by the value of the increased yield obtained, but also conclude that the time and effort required to actually acquire the fertilize (transportation, locating the kind of fertilizer needed, time away from the farm) are so great that the behavior is not feasible. The enabling factors, in particular, are typically highly influenced by the social, bio-physical, and economic environment in which the farmer lives and works. Over time, changing the enabling factors that individual farm households experience can change the environment – which is part of the PRECEDE-PROCEED Model, but for purposes of this project we would argue that the environment will remain essentially unchanged and therefore innovations must be tailored to overcome the enormous effects of environment on predisposing factors. The "classic" PRECEED-PROCEED model incorporates changes in policy, law and higher order (national, for example) institutions to change the environment, and we are not attempting such transformation in this project.

The reinforcing factors are conditions that support a behavior. For example, farmers may have tried to use improved seed because they were told and believed that this would increase yield. However, if the seed required higher soil nutrients than traditional seeds – a factor not known by the farmer or perhaps by the technology transfer agent – the farmer may get no increased yield, thus reinforcing a return to the traditional practice of using his/her own seed. On the other hand, providing a secure, reliable, affordable source of well-managed improved seed could reinforce repeated use of improved seed by farmers who participate in an on-farm trial.

Predisposing factors are the pre-existing knowledge and perceptions that all of us bring to any consideration of behavioral change. They are specific to the individual and include knowledge, attitudes, beliefs, values and confidence. However, they are amenable to change over time through targeted interventions. Extension or technology transfer programs target predisposing factors, and the three models that we include in this experiment are primarily aimed at changing predisposing factors.

These factors encompass many of the variables considered in the various theoretical frameworks about technology transfer discussed previously. While they are defined as three different types of factors, they are obviously not independent of each other. For example, the Ministry of Agriculture model includes a strong focus on supporting access to inputs, which would affect enabling factors. The farmer field school model incorporates "hands on" training or demonstration plots in farmers' fields, which should affect confidence, a reinforcing factor. At any rate, our interest is not in identifying which of the three types of factors are affected, but rather understanding if three different extension models that use different techniques to effect behavioral change affect the immediate outcome that we have defined: "Farmers test available innovations on their own farms independent of intervention." By this we mean that farmers at "try out" an innovation without further encouragement to do so by the technical staff on this project. There may be, of course, other sources of encouragement. In fact, all three theoretical frameworks used commonly in extension hypothesize that there is a dissemination effect beyond individual contact between the extension agent or technical advisor and individual farmers.

Experimental Design

This is a quasi-experiment with multiple post-tests designed to address five related research objectives, discussed below. The treatments consist of three levels of one factor – extension model. Farmer groups play a critical role in all three of the extension models under comparison. Therefore, we will assign farmer groups to treatments, not individual farmers. The farmer groups or associations are only pseudo-replicates, not true replicates because we cannot match make meaningful pre-experimental tests of traits or characteristics of the groups that may affect the outcome of the experiment. In fact, identifying and assessing the importance of various observable traits of the farmer associations is a research objective. The primary outcome variable is the rate of adoption by farmer association of one or a combination of five agricultural innovations that we will introduce. All data will be aggregated at the farmer association level, including traits or characteristics of individual households. While individual farmers will or will not elect to adopt a specific innovation, we anticipate that membership in a specific farmer organization or group and the traits and characteristics of that group may be central to the adoption decision. Figure 2 summarizes the key features of the design discussed above and some non-experimental variables that we will have to measure to reduce to the degree possible unexplained variance. Others will probably emerge.

Figure 2: Key Features of Design

Factors	Extension model (treatment)
Outcome Measures	Rate of farmer members of associations who test innovations on their own farms without direct intervention by AREA project technical personnel Effect of farmer organization traits on rate of on-farm innovation testing (e.g., interaction between treatment and group traits)
Experimental Predictor (Independent) Variables	Adoptability of innovation Gender of farmer (within and across organizations) Organizational attributes Effect of farmer organization on individual farmer or farm household decisions (e.g., interaction between individual and group)
Non-Experimental Variables Used for Statistical Control of Variance	Spatial proximity of farmer organizations to each other (likelihood of interchange of information and experiences)

We will be cautious in generalization of results for a number of reasons. One is that the region of focus for the AREA project differs in social, economic and agro-ecological characteristics from many other regions in Haiti. We will be able to reach conclusions about the efficacy of the extension models and the interactions between extension approach and farmer group traits that are generalizable to other areas in Haiti and even other nations. However, we cannot generalize the magnitude of differences that we observe in this setting. Second, quasi-experiments by definition require care in extending results because the primary protective feature of experiments, random assignment to treatment groups, is not used. This greatly reduces the researcher's ability to establish a direct cause-and-effect relationship between treatment and outcome. Specifically, quasi-experimental designs do not allow the researcher to verify that there are no relevant differences between treatment groups prior to experimentation. We hypothesize that group traits and characteristics will be central to understanding the adoption process and anticipate that there may be interactions between extension model and adoption decision-making by individual farmers. Further, the farmer organizations themselves pre-date the experiment and our stated assumption is that they do differ with regard to traits and characteristics of importance to the outcomes of the study. We address these design weakness through three components of the design. (1) We will collect data about group characteristics of potential importance to the innovation adoption decisions of farmers as described above (structure, level of functionality, membership trust and commitment, leadership quality, and others). (2) We apply multiple post-tests, which provide repeated measures and strengthen our ability to discern between treatment and error effects. (3) We plan to include ten farmer groups in each treatment, which will give us some ability to assess the interactions between treatment, and characteristics of specific farmer groups, such as organizational capacity. Given that we are conducting this experiment specifically to identify one or more extension models that show most promise to scale up outreach in Years 4 -5 of this project, we do not regard the weaknesses of the design as critical for our intended use of the results.

Research Objectives

Objective 1: Evaluate differences of three commonly used models of extension in Haiti as measured by the percentage of farmers in each of 30 farmer associations who test any one of five innovations on their own farms after exposure to the innovations through the three extension models.

This is the overall and most important research objective and therefore three different models of or approaches to technology transfer comprise the treatments in this experiment. We are primarily interested in comparing models that (1) have had some success in Haiti and (2) rest on different assumptions about the technology adoption process. We have collaborated with three partner organizations to develop the treatments, each of which has extensive experience with extension and technology transfer in Haiti. These organizations are the Kenskoff CRDD (master farmer model), the Food and Agriculture Organization (farmer field school model), and the Haiti Ministry of Agriculture (supply driven).

Master Farmer. The Master Farmer (MF) model is the approach utilized by the regional research and outreach centers developed (CRDDs) under the USAID-funded WINNER project. The model is based on rational actor theories that rest on the assumption that behavior change is a voluntary behavior based on cost-benefit analysis by the individual. The theory of planned behavior is probably the commonly utilized of these theories in extension. The MF model also calls upon the innovation diffusion model where early adopters (master farmers) play an important role as the initial adopters of new ideas and technologies that than spread to farmers who are more reluctant or unable to adopt the proposed changes, in part because these later adopters gain confidence through observing the success of early adopters. The master farmer model was successful in the WINNER project, but the relatively high socio-economic status of many of the farmers who took advantage of the opportunity to participate in WINNER makes it critical to further test this approach with farmer group types that differ from the farmers involved with WINNER.

Farmer Field School. FAO uses the Farmer Field School (FFS) model discussed earlier in the literature review of extension models. This model: "…uses innovative and participatory methods to create a learning environment, including learning networks, in which the land users have the opportunity to learn for themselves about particular crop production problems, and ways to address them, through their own observation and participation in practical learning-by-doing field exercises." See http://www.fao.org/nr/land/sustainable-land-management/farmer-field-school/en/ for a more complete description of this approach. Theoretically, it is closely aligned with experiential learning theory and even more particularly with discovery learning. It also calls upon some key concepts in the broader array of approaches that often go under the general term "social learning."

Input Supply Driven. Both the Ministry of Agriculture and non-governmental organizations are involved in getting needed inputs to farmers, which goes under the general name of Input Supply Advisory Services, which we shorten to Input Supply Driven (ISD). As described in our literature review, this is also a commonly used approach in Asia, Africa, and Latin America. This approach is theoretically based on the classic assumptions of supply and demand. It has become very important, in practice essentially a form of privatization of extension, in most industrialized nations, including the United States. McNamara provides a succinct description of the model in these settings: "**Input Supply Advisory Services** are one-on-one advisory services provided by private-sector input supply firms (and input-supply cooperatives) to farmers who purchase production inputs from these firms. This is the dominant model in most industrially developed countries because it has become a 'win–win' arrangement. Farmers get sound technical advice from certified crop advisors, and the input supply firms are able to recover the cost of advisory services through profits generated from the sale of inputs, especially to commercial farmers (http://www.meas-extension.org/home/glossary)". Farmer coops organized to secure inputs at a reduced cost are another version of the model prominent in both industrialized and developing nations. Where the private sector is less able to reach farmers, non-profit and public organizations have adopted the supply function as we have described. We know from prior work that access to inputs remains a critical bottleneck to agricultural productivity in Haiti and we are examining how input supply chains develop and function as part of our on-going social research in this project. Our first year research has revealed that farmer organizations are often deeply committed to taking advantage of any opportunities to secure inputs offered by organizations, such as seed, fertilizer, and pesticides. They mobilize resources to secure these inputs and are deeply disappointed if the process fails for some reason (e.g., seeds do not arrive in time for planting). We have also conducted an inventory of the supplies available to farmers in the study region through the national system of input dealers.

The outcome of this experiment will provide evidence of which of three extension models is most likely to achieve adoption of innovations by Haitian farmers, which is the ultimate objective for USAID and therefore of the AREA Project. The immediate test is of farmer willingness to test innovations using their own resources on their own farms and without further technical interventions after an initial exposure to five innovations. We distinguish between innovations and technologies. The biological research in AREA is discovery research with the goal of technological innovation – e.g., breeding a new corn variety. However, our research to date to identify farmer types and develop a typology of farmers in the region has shown that many farm households can benefit greatly from adaptation of existing, well-established practices such as altering plant spacing or using simple tests to determine seed germination rates. These are innovations for these farmers because while they are known practices that are effective, they are new practices for these farmers. We have purposefully chosen five innovations that are ***not*** currently used in Haiti and that farmers should not have encountered previously.

The outcome of the experiment will inform the AREA Project team's decisions about which of the three models to emphasize during the life of this project and will provide evidence for USAID and others to use in developing longer-term strategies for change in agricultural and natural resource management in Haiti. The WINNER project worked successfully with some farmer groups in ways that led to the sustained use of innovations generated by that project. Due largely to the nature of those innovations, the requirements for successful adoption were relatively high (access to land, labor, national and international market chains, for example). The intent in the AREA Project is to develop innovations that require fewer resources for successful adoption and therefore to reach types of farmers who were not the primary target clientele for the WINNER project.

Objective 2: Assess the interactions between extension models and farmer associations as predictors of farmer willingness to test innovations on their own farms.

Farmer associations are the unit of analysis for all experimental outcomes. The single most critical outcome measure in this experiment is the ***percentage of members in each of the 30 groups that participate in the experiment (ten groups per extension model) that "trial" one or more of five innovations presented to them through their associations.*** We analyze at the farmer association level for a number of reasons. Agricultural producers in Haiti are usually members of one or more social networks based on combinations of proximity, various forms of kinship, and shared interests, as well as complex webs of mutual obligations and differential access to resources and power. The farm population in Haiti is characterized by widespread, almost universal, membership in these farmer associations. The predecessor project to the current USAID project of which we are a part relied on these farmer organizations to in their extension activities, as do all of the collaborating public and private organizations for the agricultural extension component in our project. Further, farmer associations evolved from largely semi-formal or non-formal networks into nonprofit organizations registered with the Haitian government in the aftermath of the 2010 earthquake and 2011 flood in the country when these associations became critical in aid and recovery activities. A long, rich history of research describes these basic social networks prior to their formalization over the last 15 years (Mintz, 1960, 1961; Murray, 1978, 1980, 1982). We have conducted initial research to characterize the post-earthquake formal farmer structures in the region served by the USAID-funded AREA project in which team members interviewed the leadership of all farmer associations that are currently active in the Kenskoff area where we will conduct this experiment. We used this information to develop a typology of these farmer associations. The current research will allow us to assess whether there are differences in how the five types of farmer groups we have identified that affect the technology adoption process. If there are differences, this information could can used to enhance the efficacy of farmer organizations as agents of change and permit development practitioners to better ascertain the potential outcomes of disseminating new technology through different types of farmer groups. The fundamental unit of analysis in this experiment therefore the farmer association for several reasons. One is the prevalence of these associations in rural Haiti. Another is that they are *de facto* arms of extension and outreach for technology transfer in Haiti – something that is actually a worldwide trend. Third, it is critical to understand how these social structures interact with other factors like individual farmer traits, the traits of technologies that are available for adoption, and extension delivery model to design improved technology transfer systems best adapted for the Haitian context. Therefore, we will use group level data as the primary outcome measures for this experiment.

To achieve Objective 2, we will collect data to ascertain the traits of farmer organizations that are most influential in the experimental outcome. Our decisions about the variables to measure reflect the findings of research reviewed above and other research results about the importance of farmer organizations, formal or not, in agricultural behavioral change. For example, we will assess organizational quality through measures like those discussed by Sangole et al (2014) and Coomes et al (2015), including member perceptions of egalitarianism and fairness in the organization, transparency, frequency of meetings, active participation in meetings, and member satisfaction with organizational performance. We also draw on the work of Fischer and Qaim (2014) who studied determinants of participation in smallholder groups and found that members' commitment to the group and participation reflected variance in marginal costs and benefits among members.

Our review of the literature about the growing role of farmer organizations in technology transfer shows that understanding the relationships between the extension models and the associations is critical. If farmer association traits important factors in the efficacy of the extension models, creating the proper "match" between group traits and extension model is important. If our research shows that group traits are better predictors of farmers' willingness to try new innovations on their farms, development agencies may want to devote greater attention to development of these groups. Virtually all of the literature we reviewed about farmer groups as disseminators of technology make some recommendations regarding the need to use public and private resources to enhance their efficacy. This experiment will provide guidance regarding the importance of doing so in the Haitian context. Variability in organizational traits – such as inclusiveness, resources available through and to the organization, and cohesiveness – are potentially critical to adoption rate. We will identify the traits most likely to affect farmer use of innovations and will refine the typology of farmer organizations we have developed over the past year based on the data we collect. This will enhance the utility of the typology for work in Haiti and provide information that other researchers involved in research about farmer organizations can use.

Eliminating farmer group type as a second experimental factor in the original factorial design for this study is the most important design change we have made over the past year. We based the typology of farmer group types on interviews conducted in Year 1 of the project. We collected data from all farmer associations groups that we were able to contact in the study area and conducted interviews with the elected representatives of each group. These groups are by definition formal because they are registered nonprofit organizations with the Haitian government. We did find important differences in structure and organization that we will address in this experiment. However, farmer group type is no longer an experimental factor for three reasons. (1) Our typology reveals differences in types, but we became convinced that the most critical factors in determining whether a group has an effect on technological adoption probably lie outside the functional organizational traits we were able to assess in our first year data collection. (2) We wanted a large number of farmer associations assigned to each treatment (model) because we know that some may drop out of the experiment and because a larger number of replicates within treatments is more important in drawing inferential conclusions that a second factor. (3) Logistically, it would be very difficult, if not impossible, to maintain separation of two factors – extension model and farmer group type – in the limited geographic area in which we can conduct the experiment. Maintaining the primary treatment was clearly more important. We therefore now treat farmer association attributes as non-experimental predictor variables. This change does ***not*** affect our ability to draw conclusions about the relationships between group attributes and farmer willingness to test innovations, but it does reduce our ability to test statistical relationships, particularly interactions, between ***pre-determined categories of farmer group types*** and extension model.

Objective 3: Assess the degree to which attributes of innovations influence the interactions between extension model and rate of farmer tests (by farmer association) of introduced innovations.

We will measure the ***rate on-farm tests*** of a menu of five innovations offered to all participating farmer groups. The primary objective of this experiment is to test efficacy of different extension models and understand the relationships between farmer group type and differences in efficacy among the models, not to measure the adoption of any specific technology or innovation. Our research does seek to compare the rate of adoption by treatment at the farmer group level of five innovations. We draw upon innovation diffusion theory to select the menu. We will rely on the five attributes of innovations demonstrated in a large body of research to affect the rate of adoption of innovations (Figure 2). The menu of innovations will include at least one innovation that is potentially very readily adoptable with regard to at least three, preferably all five attributes of innovations and at least one innovation that would be marginally adoptable with regard to at least three attributes. There are five other traits of innovations in the innovation diffusion model that are less commonly used to characterize innovations. We may employ some of those traits as well if they appear salient to our work.

Figure 3: The Five Key Attributes that Affect Rate of Adoption of Innovations

Attribute	Definition
Relative Advantage	The degree to which farmers think an innovation is better than what they currently due – a mental calculation of the benefits
Compatibility	The degree to which an innovation meets the needs of farmers, builds on past (positive) experiences, and complements what they want to achieve
Complexity	How difficult it is for someone to understand and test the innovation
Testability	The degree to which a farmer can try an innovation on a small scale, or at little risk, or with few inputs and associated changes
Observability	The degree to which the effects of an innovation are clearly visible and obvious to the farmer and to others, the degree to which one can actually see the result without relying on statistical tests or other measures not available to the farmer

Objective 4: Determine whether there exists a relationship between the gender of the farmer and the efficacy of the extension model.

We incorporate gender into every aspect of the AREA project, including this extension experiment. We know that some farmer groups are all women, while others are all men or include both genders. We will assign at least two female only farmers associations in each treatment. Our treatments will reveal the effect of gender for women only groups, but we will need additional data to understand how gender affects access to and use of innovations in mixed membership groups. Therefore, we will collect data during post-test measures to assess the degree to which women are represented in the overall measure of rate of adoption – it is possible that a group could have a high rate of test and use of innovations, for example, but that none or very few women in the group were represented in the users. We will also collect data to better understand whether men and women perceive of their associations differently and, in mixed gender associations, whether women and men perceive differences in the membership experienced based on gender.

Site Selection & Sampling

We will conduct the experiment in the agro-ecological zone around the Kenskoff CRDD. There are two reasons for limiting the geographic area included in the experiment. (1) The Kenskoff area has fairly reliable rainfall. While our agronomic research will certainly address water scarcity, working in an area where rainfall in and of itself would most likely be the primary reason for farmers not adopting a technology or innovation would limit our ability to draw reliable conclusions about the efficacy of different extension models. (2) The area is also compact and relatively close to Port-au-Prince, the major urban market for both securing inputs and selling agricultural products. This reduces the effects of distance or more appropriately difficulty of travel on experimental results. (3) The compact area and proximity to Port-au-Prince also reduce the cost of the experiment and enhances the ability of two of our colleagues who will have major responsibility for this experiment to oversee and interact with the field personnel who will implement the treatments. Given the difficulty and cost (time and money) of travel to distant field sites, this is an important consideration. (4) The Kenskoff CRDD is well-established and has been a very valuable partner with USAID in the past. It is “up and running” at this time and provides an excellent home base for our field staff to use for communications and to implement some aspects of the treatments (e.g., a field day for example).

This quasi-experiment relies on replication sampling logic rather than descriptive statistical sampling. E.g., we are not trying to generate a statistically representative sample of all farmers in the study region based on traits or characteristics that could affect adoption of innovations. Rather, our sample is designed to provide replications within the experimental approach because farmer group is the basic level of data collection. Data from individual farm households are collected, but the households are not independent of the organization to which the household belongs. Therefore, fundamental conclusions are reached and can be generalized to farmer organizations, not individual farmers or households. We have conducted a planning session with our collaborators to identify specific organizations to invite to participate in the experiment. In reality, our decision to include ten groups per treatment for a total of 30 farmer groups will probably exhaust the number of groups who wish to collaborate in the experiment. The increase in number of farmer organizations reduces the threats to validity from attrition and, in any case, we cannot use replacement procedures because the implementation phase must occur simultaneously for all participating organizations in order to minimize the between-treatment effects of non-experimental conditions like weather or pest outbreaks.

The second critical sampling decision is how many households to include in the observational data collection. We will use these data to understand:

- Organizational dynamics and processes;
- The farmer decision-making process and experiences with the extension models specifically focusing on the degree to which the proposed innovations and extension model affected the enabling, predisposing, and reinforcing factors in the PRECEDE-PROCEED model of behavior change; and
- If and how women's experiences with the extension models and organizational processes differed from those of men and the degree to which those differences influence their decision-making.

We will employ both statistical and qualitative data analysis. For example, we will be able to conduct statistical analyses of data that concerns frequency of certain types of interactions among farmer group members based on direct observation, but we can also use the data from semi-structured interviews to conduct qualitative analyses to understand how participants viewed these interactions. The combined quantitative and qualitative models will provide a better understanding of the processes and dynamics of interest listed above. However, the use of two approaches to data analysis does complicate sampling because the considerations in determining sample size and composition differ significantly for the two type of analyses.

Sampling for Statistical Data Analysis

Statistical analysis relies on statistical sampling logic where the intent of the sample is to secure a statistically representative sample of the population in the study with regard to traits or attributes of interest. We rely on the advice of Dr. James Colee, project collaborator with the IFAS statistical advising service in making decisions about the sampling for statistical analytic purposes. Dr. Colee will also provide assistance with data analysis and development of publications from this project.

Ultimately, the measure of "adoption" versus "non-adoption" occurs at the household level. We will collect self-reported data from farmer organizations about which households have (or not) tried and then re-used the five innovations. Therefore, we will treat household units as "users" or "non-users" and we need to know how many households we need ***per treatment.*** We have discussed a number of factors that affect the number of households to sample with Dr. Colee. These include confidence interval, overall variance in the population, and defining a meaningful effect size in the context of this experiment. We have reached the following decisions. (1) We will probably analyze between-treatment effects using an alpha of 0.10 rather than 0.05 simply because we have no way of estimating variance at this time, although if possible, we will reduce alpha to 0.05. (2) More important, we have concurred that only a large effect size is meaningful both with regard to between-treatment effects and with regard to the impact of independent non-experimental variables on adoption rate between households. We will classify the "adoptability" of the innovation using Rogers' factors described in the experimental protocol. However, in a context where people struggle for survival and are risk averse, potential adopters need to see a very marked improvement to be able to trust any proposed changes in doing what has "worked" for them. Effect size between extension models is more important than simple statistical differences in order to conclude that there are differences among extension models that will likely persist under non-experimental conditions. Based on long consideration by the team members, we concluded that a minimum of 25 households per farmer organization should be included in the sample, but we base our logistical considerations, including the time needed to collect data with each of four data collection instruments, on a desired sample size of 30.

The farmer organizations include all male, all female and mixed gender groups. Sampling to detect differences in adoption and other variables of interest regarding the three non-experimental variables listed above requires that we determine sample size and approach for females in mixed groups. In organizations with more than 30 female members, we will first select a random sample of 30 households. We will then increase the total number of female-headed households (or households where females make the primary decisions about technology use) to at least 30 in order to permit analysis for gender effects across treatments and farmer organizations. The overall sample is then a combination of a random sample of users and non-users and a quota sample of female participants used only in the cross-case gender analyses. We anticipate a total sample size of 900, consisting of approximately 630 males and 270 females. However, this is an estimation only because we do not know at this time the gender composition of mixed gender groups nor do we know how many groups are male-only in membership, both of which would affect the size of the quota sample for women.

Sampling for Qualitative Data Analysis

There is less general agreement about how to determine both sample size and sampling approach (for example, use of purposive as opposed to random sampling). We emphasize the concept of rigor in our approach to sampling for qualitative data analysis, calling on the methodological work of Malterud, Siersma and Guassora (2013) to inform our decision-making. These authors consider five factors in determining sample size:

- <u>Aim</u> of the study (broad or narrow). A narrow aim increases information power and reduces needed sample size.
- <u>Specificity</u> of the sample (dense or sparse). This is essentially the degree to which purposive sampling is possible -- where people are selected because they have certain traits of specific interest. It requires that the researcher know something about the people ahead of time to make it possible to select individuals who will provide the full range of responses for any given trait. Specificity reduces needed sample size while increasing or maintaining information power.

- Established theory (applied or not). Using an established theory (as opposed to approaches like ethnographic research or grounded theory) reduces sample size while increasing power. Our research is theory-based.
- Quality of dialogue (strong or weak). This refers to the ease (in all senses) of communication between the participant and the researcher. This has to do with the degree to which the researcher knows the context, previous experience in data collection, and knowledge of the subject matter. Strong dialogue decreases sample size and increases information power. We will rely on the agronomists and their supervisor, all of whom have extensive experience working with the population.
- Analysis strategy (case or cross case). This deals with whether the aim is to reach general conclusions about the topics of the research (similar to the concept of statistical generalization) or to select respondents to represent ***different*** perspectives and perspectives that are of specific interest in the study (similar to the concept of theoretical generalization). Our objective is to get a variety of perspectives on some rather narrow topics – a "case strategy" using the authors' terminology. This strategy requires a smaller sample and increases power.

This approach does not provide a formula for determining sample size. Rather it focuses on how to get the greatest explanatory power under conditions where large samples are either not feasible or where statistical analyses are not the objective. We use this approach in part because it replaces the concept of "saturation" with five specific considerations that affect the explanatory power of a study. The term saturation, although commonly used, is not defined and different researchers may or may not include similar considerations in establishing sample size. We prefer the more clearly defined approach of Malterud and others and we will adopt this framework for determining sample size for the in-depth interviews.

Experimental Implementation

We originally planned to work with the staff in local NGOs and MoA to implement the experiment. Based on extensive discussion at our full team meeting in July 2016 in Gainesville, we have decided that we will sign collaborative agreements with the organizations involved, but we will hire three individuals (one for each model) to implement the model and collect all data. Two on-site team members already involved in our social research and on-site in Port-au-Prince will be responsible for overseeing the work of these individuals, storing and analyzing data, and assisting in monitoring and evaluation. Several arguments made at the team meeting led to this decision. (1) We are not imposing on already stretched fiscal and human resources of collaborators if we hire our own staff. (2) Since we will work in the Kenskoff area, we can use the CRDD as a center for communications, meetings, and other logistics and our staff members can be housed locally, reducing reliance on collaborating organizations. (3) We maintain greater direct control over data collection and storage, which reducing the need for non-UF personnel to complete ethics training, learn how to collect and record data, and fit data collection into already busy schedules. This permits us to collect more data than would be possible in the original plan. (4) We can more effectively integrate data collection for the experiment and the monitoring and evaluation component of the project. (5) We also decided that it would be useful to collect some data from farmer groups that are not working with us in the experiment if possible. This is not critical because these groups cannot serve the role of a standard current treatment normally treated as the control. All of our models are already in use to some degree in Haiti and some or all of the farmer groups that we recruit for the experiment may be familiar with one or more of them. However, the information we can get through some observation and some interviews with farmers in non-participating groups might be useful in interpreting the results of the experiment.

There are four phases to this study (Figure 4). Phase I consists of providing training in the three models for project technical advisors (one for each model), recruiting collaborating farmer organizations, and securing the materials needed for each of the five innovations that will be tested. In Phase II the technical advisors work directly with farmers to put in demonstration plots, secure inputs (input supply model), or conduct tests of innovations. We refer to this as "Assisted Testing." In Phase III, the project technicians observe how farmer organizations and individual farmers respond to the innovations ***without direct encouragement or intervention from project staff.*** We refer to this as "Independent Testing." In Phase IV, project staff complete all data analysis and prepare manuscripts for publication.

Figure 4: Timeline for Implementation

Activity	**2017**						
	June	**July**	**Aug**	**Sept**	**Oct**	**Nov.**	**Dec.**
Phase I: Initiate Implementation Technical staff trained, farmer organizations recruited, innovations made available							
Phase II: Assisted Testing by Farmers Farmers demonstrate innovations on their own farms or acquire inputs (supply drive model) with assistance of the project technical advisor							
	2018						
	Jan	**Feb**	**Mar**	**Apr**	**May**	**June**	**July**
Phase III: Independent Testing by Farmers Farmers test innovations they observed or demonstrated ***without*** intervention by technical advisor							
Phase IV Final data analysis and publication of results							

Instrumentation and Data Collection

We have developed four instruments for data collection associated with this experiment referred to as: (1) Previous Awareness, (2) Observation, (3) Group Dynamics, and (4) Exit Interview. We will conduct cognitive tests of instruments with leaders of the farmers associations. We will conduct initial tests for reliability using Cronbach's alpha and item-total correlation of quantitative (ordinal) data after the first 40 to 80 responses for each instrument have been acquired. We describe each instrument and indicate its role in overall analysis and interpretation of the results of the experiment below. Figure 5 shows when each type of data will be collected.

Previous Awareness is a questionnaire largely employing nominative yes/no response format items to ascertain the degree to which individual farmers have knowledge of or have used any of the five innovations we introduce prior to before learning about them in this experiment. We will sample only individuals who are present at the initial presentation of the innovation to a farmer association at a training or demonstration. This will occur primarily during the early portion of Phase II of the experiment. The data generated are group level data and will be used to test effect of prior awareness of the innovations on Assisted Testing and Independent Testing by Farmers. These are association (group) level data.

Figure 5: Data Collection (June 2017 – May 2018)

	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May
Test instruments with association leadership												
Previous Knowledge												
Assisted Testing												
Observation												
Group Dynamics												
Exit Interview												

Assisted Testing occurs during the implementation of the three extension models. This is anticipated to occur primarily with a subset of the membership of each group. For example, in the farmer field school, the model uses on-farm tests as part of the extension model. One or more farmers may participating in these tests. The master farmer model uses on-station demonstrations, but calls for farmers who participation in the on-station training stations to assist members of their association in testing the innovation on their own farms. The supply driven model uses a combination of training and provision of vouchers for farmers to have access to the test innovations without cost to them. The farmer organization representative will report number of households who host a demonstration or test an innovation during Phase II – with the direct assistance of the project technical advisor or as a planned test site for the extension model, depending on the treatment. The agronomist working for the project who helps farmers test the innovation during implementation of the extension model will select a random sample of farmers to verify the association representative's estimation of the number of farmers who choose to employ each innovation in the following growing season. We anticipate small numbers during model deployment season of data collection because the farm field school and master farmer models with be in the "training" mode.

Observation has two components. The agronomist who works with the farmer organizations included in each treatment will make direct observations of group meetings, trainings, and demonstrations during the course of the study. Immediately after the group function, s/he will complete a nominal (yes/no) assessment of events observed, such as whether the meeting started on time, whether people were largely paying attention or engaging in side conversations, and whether decisions were made. After the meeting, the agronomist will write a brief (one-half to one page) case summary of observations. The instrument includes a list of eight questions to guide development of the case summary. Examples are "If there was a lot of disagreeing, what were people disagreeing about and why?" "What, if any, specific actions or tasks were assigned and to whom?" We will use these data in quantitative analyses of the effect of group dynamics on Assisted and Independent Testing by Farmers. We will conduct qualitative analyses of the case summaries provided to identify common themes within and across the different associations. These data are association (group) level data.

<u>Group Dynamics</u> assesses individuals' experiences and perception of their role and with the farmer association in which they are a member. It includes several components. The first consists of questions that deal with knowledge of association functions (e.g., who is the current president). We use multi-item ordinal measures of confidence in the association as an organization and in other members of the association. These measures assess attributes like one's confidence in fair treatment and equality among members, the competence of the association and its ability to achieve goals, and one's rights as a member. This instrument includes two questions administered to female members of mixed gender associations to ascertain whether women feel they are treated differently than males. The final section of the instrument consists of open response items that explore the topics covered in sections one and two in more depth. For example, we ask *how* members help each other. There are a number of questions that deal specifically with gender relations in the association that will be asked only in mixed gender associations, but will be asked of both males and females. There are also questions asked only of female-only associations that explore advantages and disadvantages of being a member of a female only group. These data will be used in both quantitative and qualitative analyses to understand how group traits – *as perceived by the members* – affect the outcome variables Assisted Testing and Independent Testing. We will also use these data, in combination with the observational data, to explore whether we can identify traits or characteristics of farmer associations that contribute to a higher rate of Assisted Testing or Independent Testing by Farmers. If the data permit, we will conduct tests for significant differences in Assisted or Independent Testing between groups with "high" and "low" scores based on Observations and Group Dynamics. If the data permit, we will also conduct tests to determine which of the various factors measured in these two instruments contribute the most to rates of Assisted and Independent Testing. Group Dynamics will be tested with a random sample of association members (see Sampling) and will occur during Phase II and III of this experiment, particularly in the period Dec. 2017 to Feb. 2018. Finally, these data will be combined with the data collected in 2016-17 regarding the structure of the farmer associations. We used the data collected in 2016-17 to develop a typology of types of farmer associations. We will enhance our typology using these data and attempt to develop models that tie specific organizational traits to response to the different extension models and differences in Independent Testing rates for the associations. These are group level data.

<u>Exit Interviews</u> include two components. We use the same random sample of members of the association selected for the group dynamics interviews to estimate rate of independent testing by farmers without direct project assistance or encouragement. This interview determines whether the individual did or did not choose to test the innovation and explores either (1) the benefits derived from using the innovation and whether s/he plans to continue using it, *or* (2) why the individual decided not to test the innovation on his/her land. The instrument uses a combination of closed (nominal yes/no) and open response items. The rate of Independent Testing for each participating farmer association is the most important outcome measure because this is an indicator of potential farmer adoption of the innovations. The project agronomist assigned to each model will verify the reported values by census (for organizations of 30 or fewer households) or random sample (organizations with more than 30 households) of households. The actual test or employment of each of the five technologies provides nominal (presence/absence) data. We will also ascertain whether there were **traits of the innovation** itself that made a farmer want or not want to try it. We will use a structured response format for these data with items representing each of the five attributes that affect adoption. We will employ a very simple response format – probably just three options. For example, for relative advantage we could ask about the relative advantage of the innovation in comparison to what the farmer does now with regard to labor demand, out-of-pocket costs, land requirements, and yield.

Hypotheses and Planned Data Analyses

This is a general overview of the planned comparisons and data analyses. We anticipate considerable post-hoc data analyses, probably including both statistical and qualitative analyses. Ultimately, we hope to generate one or more models that incorporate the full range of data we collect. These models can serve as guides to the most effective ways to achieve technology transfer because they will highlight and show the relationships between the most critical features of farmer associations, extension models, attributes of innovations and gender. We anticipate that these models will be both conceptual and statistical in nature. Figure 6 states the general or research hypotheses that will inform the statistical analyses performed. The qualitative data analysis will generate additional general hypotheses, but we cannot specify those at this time because the qualitative data analysis that we will use (inductive-deductive approach) is, in part a hypothesis formulation exercise in which researchers identify emergent hypotheses.

Figure 5: General Hypotheses

Treatment Effects	1. There will be a significant treatment effect, but we make no prediction about which of the three models will be superior (e.g., two-tailed hypothesis). 2. Treatment effects and attributes of farmer associations will exhibit significant interaction in effects on Assisted Testing and Independent Testing
Primary Hypotheses for Non-Experimental Predictor Variables	1. Attributes of farmer associations will be significant predictors of rate of Independent Testing 2. Associations with high scores for group dynamics will demonstrate higher rates of Independent Testing by Farmers 3. Organizational structure and functionality (Observations) will affect rate of Independent Testing by Farmers 4. Assisted Testing and Independent Testing of “highly adoptable” innovations will not be sensitive to treatment or attributes of farmer associations 5. Assisted Testing and Independent Testing of innovations will be less for women irrespective of treatment or attributes of farmer associations
Non-Experimental Variables Used for Statistical Control of Variance	1. Spatial proximity of farmer groups to each other will not affect Assisted Testing and Independent Testing of innovations Proximity of farmer groups to Port-au-Prince will have a positive relationship to Assisted Testing and Independent Testing of innovations 2. Proximity of farmer groups to Port-au-Prince will have a positive relationship with Assisted Testing and Independent Testing of innovations of “difficult to adopt” innovations

Relationship to Monitoring and Evaluation of the AREA Project

All of the data will be available to the project monitoring and evaluation (M&E) team. We anticipate that these data will contribute to the following indicators selected by the M&E team.

Output Indicators

Output Indicator: Number of research and extension publications as a result of project assistance – Custom

Output Indicator: Number of training events delivered – Custom

Outcome Indicators

Output Indicator: Number of technologies or management practices under research, under field testing, or made available for transfer as a result of USG assistance E.G.3.2-7

Output Indicator: Proportion of female participants in U.S. government–assisted programs designed to increase access to productive economic resources (assets, credit, income or employment) – GNDR-2

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