Analyzing the Impact of Push-Pull Technology, Gender, and Irrigation on Food Security in Rural Kenya

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Introduction

I have always bought my food from a supermarket. In the suburban Safeways where I grew up I would walk the aisles with my mom, begging for dinosaur-shaped fruit snacks, colorful cereal, sweet, pink watermelon. To me food was always a given, much like the hot water that flowed from our faucets. As I grew older and learned about food insecurity throughout the world, I began to see that what I had taken for granted was a luxury to so many. Compelled by the injustice, and its accompanying guilt, I became determined to help.

When writing my paper for the 2009 World Food Prize Youth Institute, however, I realized just how limited my capacity to assist the hungry really was. I could rattle off statistics about the malnourished or water resources in Uganda, but that was about it. The majority of the world's poor lives in rural areas, in desperate need of ways to increase yields. My entire life has been spent in Arlington, Virginia, five miles outside of Washington D.C. As someone who had never been to a real working farm, how could I even think I would be able to help smallholders grow more maize? I couldn't. I was too ignorant.

At the Youth Institute, however, I found a way: the Borlaug-Ruan Internship Program, a once-in-a-lifetime opportunity to learn about a different culture, see its problems first-hand, and even work side-by-side with its people. I knew instantly where I wanted to go – Africa. For years I had volunteered with The Arlington Academy of Hope, a school in rural Uganda and my elementary school's sister school. What I want to do is another question. I want to be a civil engineer, want to help provide safe, clean water. I saw my time in Kenya as simply a corollary to my technical studies. I never imagined how relevant it would be.

Originally, my objective at *icipe* was to determine the role of women in the dissemination of push-pull technology. After talking to my mentor Dr. Zeyaur R. Khan, head of the push-pull project, however, he had a slightly different idea. I would still research the role of women in push-pull, but I would also assess the potential for small-scale pedal pump irrigation in the Suba district. I would spend weeks in the field interviewing Kenyan farmers. It was a dream come true.

Background Information

icipe

icipe, the International Centre for Insect Physiology and Ecology, is Africa's leading arthropod (insects, arachnids, crustaceans) research center. It was founded in 1970 by the late Thomas R. Odhiambo (TRO) to research insect vectors and pests, which account for many constraints facing tropical developing nations. Odhiambo, a prominent entomologist who also helped establish the Third World Academy of Sciences, the Kenya National Academy of Sciences, and the African Academy of Sciences, created *icipe* to find African solutions to African insect-related problems. Today *icipe* is led by Director General Prof. Christian Borgemeister and employs 233 staff and more than 50 visiting scientists from around the world. Together, at *icipe* headquarters in Nairobi, the TRO Field Station in Mbita, Kenya, or the smaller outposts in Ethiopia, coastal Kenya, Sudan, Congo, and Cameroon, the many scientists and technicians research insects from the malaria-transmitting mosquito to the honey-producing bee. Operating under the "4-H Paradigm" focusing on environmental, human, plant, and animal health, *icipe* works towards its mission of alleviating poverty and improving food security through insect management. Its goals are to "create knowledge, build capacity, develop policy, and reduce poverty."

Thomas R. Odhiambo Field Station in Mbita, Kenya

On the shore of Lake Victoria and in the swarms of resident insects, the Thomas R. Odhiambo Field Station in Mbita, Kenya is home to *icipe*'s malaria, tsetse fly, and habitat management programs. It was established in 1980 to aid the struggling Lake Victoria region through insect research. Mbita, with an urban population of 6,100, is the local capital of the Mbita District, which recently split from the larger Suba District. Suba has a population of approximately 200,000 people and includes Rusinga and Mfagano islands in Lake Victoria.

Although electricity reached the area in 2005, Suba is a largely undeveloped farming and fishing community. The lifespan is only 37 years, caused by high incidence rates of malaria, water-borne diseases, and HIV/AIDS. Sadly, Suba has the highest HIV prevalence rate in the country – 30% compared to the national average of 6.7%. It is a problem made worse by low education, lack of infrastructure and access to medical care, and high-risk sexual practices within the fishing community. Compounded with erratic weather and other farming constraints, food insecurity also affects the region; the daily per capita caloric consumption is 1490 calories, and protein intake of adults is 28.5 grams compared to the necessary 45 - 55.

Habitat Management Program and Push-Pull Technology

While farmers in the Mbita District face a variety of farming constraints, the three that most affect food security are stemborer moths, *Striga* weed, and low soil fertility. Both stemborers and *Striga* attack maize and sorghum, the two staple crops that feed the majority of Kenyans. Farmers attempt to control the pests in many ways, such as the application of fertilizer or manure, crop rotation, and repeated weeding and uprooting, but to no avail. Year after year, countless Kenyans go hungry because of the low yields caused by stemborers and *Striga*. *Icipe* estimates that if losses due to *Striga*, stemborers, and low soil fertility were eliminated, the increased cereal yields could feed 27 million people in East Africa.

Stemborers in Nyanza province, known in the local Luo as "Kundi," belong to either the native *Busseola fusca* or the Asian species *Chilo partellus*. Unseen by farmers, the females lay their eggs at night on the young maize plants. Then, true to their name, the larvae enter the stem and begin to burrow after feeding on the leaves. It is at the larvae stage that the insect causes the most damage, leaving maize stems weakened, stunting growth, and chewing holes in the stems and leaves. After growing fully, the larva pupates within the maize stem, emerges as a moth, mates, and lays eggs, repeating its cycle of destruction. Stemborers cause average maize losses of 20 to 40 %, but can destroy up to 80% of the crop, making them the most devastating maize pests in Africa.

Figure 1. *Striga hermonithica*

Even more destructive, the witch weed *Striga hermonthica* (Figure 1), known in Luo as "Kayongo," is responsible for maize losses of 30 to 100 percent that are worth an estimated US $700 million per year. The seeds of the parasitic weed lie dormant in the soil for up to 20 years, waiting for a host to attack. When maize is planted in a *Striga*-infested plot, the weed germinates and attaches to the maize roots, sucking nutrients, stunting growth, and eventually damaging entire maize plots. A pretty and seemingly innocent purple flower, *Striga* can be found in many farms in Kenya and throughout most of Sub-Saharan Africa. There, it weakens and wilts maize, sorghum, millet, rice, and sugarcane.

In order to assist ailing farms, entomologists at *icipe*, headed by project leader Dr. Zeyaur R. Khan, began research on stemborers in 1994 with funding from the Gatsby Foundation, giving their work the name "The Gatsby Project." After studying the relationship between native grasses and stemborers, they found a few species that attracted both stemborers and parasitoids, their biological predators. The scientists knew, however, that farmers would not warm easily to the idea of planting grass around their crops that would attract insects, even if those insects would be drawn away from their maize. *icipe* approached the Kenya Agricultural Research Institute (KARI) to find out which grasses also made for good fodder. It turned out that Napier grass, *Pennisetum purpureum*, is not only an excellent fodder and attractive to stemborers, it also secretes a sap that kills the stemborers trying to attack it. *icipe* had found the perfect grass to pull away the pest.

Along the way, the Gatsby Project team began intercropping maize with legumes as another way of attracting farmers. Legumes had been found to produce a smell that would repel stemborers and, additionally, could provide food or fodder and increase soil fertility by fixing nitrogen from the atmosphere into the soil. On *icipe*'s test plots at the TRO campus in Mbita, scientists began intercropping maize with cowpea, soybean, sun hemp, and desmodium, among others. All of the test plots at *icipe* were infested with *Striga*, yet researchers found that on the intercropped plots the *Striga* was lessened, and on the plots with desmodium, a green vine legume with silver-streaked leaves, it was completely gone. Being entomologists, the Gatsby Project scientists hadn't looked into *Striga* management. But as luck would have it, they didn't need to. The answer had come to them.

After further research, *icipe* discovered the mechanism behind the *Striga* suppression. Many legumes contain isoflavones, organic antioxidant compounds, which make them especially nutritious for humans. In addition, desmodium released specific isoflavones (one known and three discovered by *icipe*) that caused what they call *Striga*'s "suicidal germination." The presence of desmodium stimulated *Striga* germination, but the isoflavones inhibited the growth of the weed's radical haustoria (the seedlings' embryonic root that attaches to the roots of the maize). As a result, *Striga* was not only being prevented from attaching to maize, but its seed banks in the soil were being depleted as well.

Combined, *icipe*'s discoveries of the special properties of both Napier grass and Desmodium form the integrated pest management system called "push-pull technology." The push: Desmodium intercropped with maize to repel stemborers and suppress *Striga* attack. The pull: Napier grass planted in border rows around the plot of maize to attract and kill stemborers. In 1997 Ada Omulo, a farmer in Mbita District, became the first push-pull adopter. Since then, more than 30,000 smallholders in western Kenya, northwestern Tanzania, and southeast Uganda have adopted the technology. Not only have they controlled their *Striga* and stemborer problems, most farmers have experienced increased yields, better soil fertility and moisture, and fodder to feed healthier dairy animals, among other benefits. As a result, many farmers have been able to move beyond subsistence farming to selling surplus maize at markets, thus providing better lives for their families.

With the science behind push-pull virtually complete, the Gatsby Project team is now looking to make the technology a sustainable farming tool. In conjunction with the Kenyan Government's Ministry of Agriculture, *Icipe* now focuses on extending push-pull to many farmers in the areas around Lake Victoria. *icipe* has many publications that provide farmers with information, but the most effective tools are farmer field days and farmer teachers. On a farmer field day, *icipe* staff travels to a push-pull adopter's farm where local farmers gather to see push-pull benefits first-hand and learn from demonstrations. Farmer teachers are local push-pull adopters who give advice to their peers and act as a link between *icipe* and fellow farmers. These channels, along with barazas (town meetings), seminars, print materials, radio, and farming groups, comprise the dissemination of push-pull information.

Pedal Pump Irrigation

Another farming constraint affecting smallholders in Sub-Saharan Africa is inadequately watered crops due to erratic weather and a lack of farm implements. In the past few decades, one of the most successful tools for increasing smallholder yields has been the pedal pump, also known as a treadle pump, a manually operated foot pump used for irrigation. Starting in the early 1990s, International Development Enterprises (IDE)

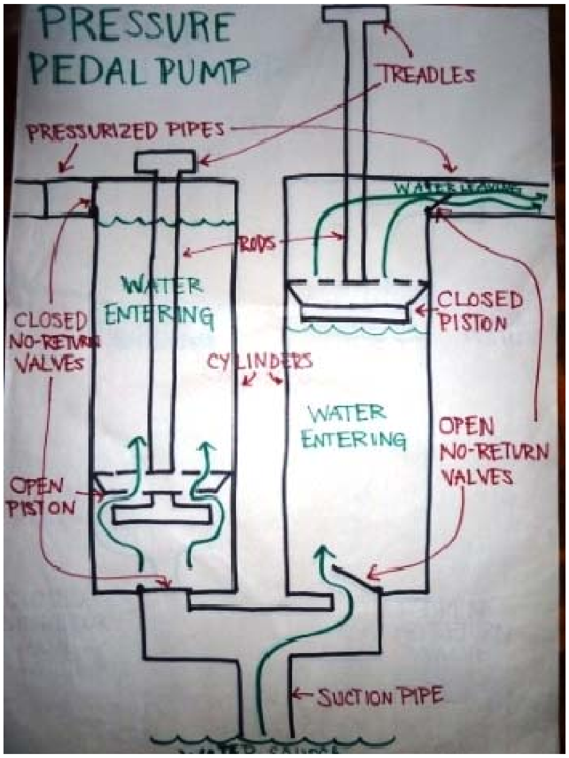

Figure 2. Diagram of a pedal pump

began distributing pedal pumps in India. They then launched a successful program in Bangladesh which has spurred similar projects across the globe.

Unlike many modern methods of irrigation, pedal pumps are fully manual, which greatly reduces the cost and environmental impact, but at the same time also limits pumping power and irrigation range. Most pedal pumps sold today are pressurized pumps, where water is sucked from the source into one piston, pushed through the other, and flows out through a rubber pipe to the farmer's plot. One-way valves attached to the walls of the pistons maintain the pressure and control the water flow (see figure 2). The maximum pumping height of a pedal pump is 14 meters and the maximum horizontal pumping distance is 200 meters. Because of pedal pumps' limited power, the more well-off farmers use generator pumps instead, which are fuel operated.

In Kenya, pedal pumps are sold by the American company KickStart. Their pumps, which are called Super MoneyMaker Pumps (Figure 3), have been adapted for use in Africa from those in Southeast Asia. The main difference is that they are portable and relatively light-weight compared to IDE's permanent pumps. KickStart also manufactures a hip-pump, which is operated with one's arms instead of legs and uses only one piston.

Figure 3. Testing a pedal pump on Rusinga Island

Methodology

The data for this study was collected using questionnaires administered to 40 farmers in order to address the following objectives: assess farmers' perceptions of push-pull technology, determine the knowledge gap between project and non-project farmers, evaluate the role of women in the dissemination of push-pull information, and assess the potential for pedal pump irrigation in the Mbita District. During my first week in Mbita, I researched push-pull and pedal pumps, so I could create a survey for my interviews. Writing an effective questionnaire, I soon found out, was much more difficult than I expected. After many revisions and consultations with mentors, an appropriate survey was developed.

In the process of revising my questionnaire, we decided that focus group discussions would help me further refine my survey. I met with two groups of farmers: push-pull adopters and farmer teachers in Lambwe Division and farmers unexposed to push-pull on Rusinga Island. I facilitated the discussion as they answered my questions. Before beginning the actual surveys, I also pre-tested my questionnaire with non-exposed female farmers in Lambwe Division. The pre-test allowed me to time my interviews, gauge their effectiveness, and reword any confusing or misleading questions.

After two weeks of preparation I began my interviews. In order to receive valid results representative of Mbita district farmers, I interviewed 20 push-pull and 20 non-project farmers, which were further divided into four groups of 10: push-pull farmer teachers, non-teaching push-pull adopters, non-project farmers exposed to push-pull technology, and non-project farmers not exposed to push-pull. Each group also had equal numbers of men and women, with the exception of farmer teachers (six women and four men), so that responses between the two genders could be compared. All farmers interviewed lived in Lambwe District except for the non-exposed farmers who were from Rusinga Island due to the heavy presence of push-pull in Lambwe.

After all 40 questionnaires were administered, I entered the farmers' responses into SPSS, a data analysis program. From that data trends were observed, analysis conducted, and conclusions formed.

Figure 4. Interviewing a project farmer in Lambwe Division

Results

Summary

In this study, 40 farmers were interviewed from the following groups: 10 farmer teachers, 10 push-pull adopters, 10 non-adopters exposed to PPT, and 10 farmers not exposed to the technology. Groups were also divided equally by gender, so 11 female and 9 male project farmers and 10 male and 10 female non-adopters were interviewed (Table 1.1). All push-pull and exposed farmers lived in Lambwe Division and all non-exposed were from Rusinga Island in Mbita District (Table 1.4)

Out of the four respondent groups, farmer teachers were the oldest, with an average age of 57 and non-exposed were the youngest, with an average age of 39, compared to an overall average of 48 (Table 1.2). Largely because of their increased age, farmer teachers also had the largest household sizes and most farm labor (Tables 1.5 and 1.6). That group was also the most educated: half had studied beyond primary school and three attended college. In general, push-pull adopters were more educated. Half attended secondary, while only 25% of non-adopters had. Male and female project farmers had comparable education levels, but the gap was more pronounced among non-project farmers: not a single female non-adopter had gone beyond primary school, yet half the males had (Table 1.9). Among all farmers, 70% were married, 25% were widowed, and just 5% were single (Table 1.7).

Push-Pull farmers focused more on farming; non-adopters had more diversified sources of income (1.10). Because of this, and also because of more farming success, project farmers had larger farms with more crop diversity than their non-adopting peers (Tables 1.13 – 1.16).

While push-pull farmers and non-adopters differed in many aspects, they all suffered from the same three major farming constraints: *Striga* weed, stemborers, and drought. Many farmers from both categories struggled with a lack of equipment and labor, although these percentages were higher among project farmers (65% vs. 35%, and 18% vs. 13%, respectively) (Table 1.17). The severity of *Striga* and stemborers, however, varied among the farmers. 75% of non-adopters and 15% of project farmers described *Striga* on their farm as “very severe”; 65% of non-adopters and 15% of project farmers described stemborers on their farm as “severe” or “very severe” (Tables 2.1 and 2.2).

In addition to a knowledge gap about push-pull (all project farmers could fully explain the technology), there was a difference as well between the awareness of adopters and non-adopters about the source of *Striga* and the lifecycle of stemborers. Most project farmers (90%) knew the stemborer lifecycle compared to just 15% of non-adopters. The majority of all farmers, 55% of adopters and 75% of non-adopters, did not know the correct source of *Striga* (Tables 2.4 – 2.7).

Apart from push-pull technology, few farmers, adopters and non-adopters alike, knew other effective methods of controlling *Striga* and stemborers. To control *Striga*, 68% of all farmers weeded and uprooted and 45% applied manure, but 82% said such methods were “not effective” (Tables 2.8 – 2.10). The majority (56%) of all farmers, including all non-exposed, had no alternative method of controlling stemborers (Tables 2.11 – 2.13). Because of this, all non-adopters were interested in learning more about and adopting push-pull technology (Table 3.1).

Beyond *Striga* and stemborers, few farmers also had the means to combat drought and erratic weather. A quarter of all farmers said they did not know how to solve the problem and the most common methods were short maturing crops and timely agronomic practices, which depend on rainfall (Tables 5.1 – 5.2). Only 18% had access to a pedal or generator pump (Table 5.4). While 78% of farmers were interested in obtaining a pedal pump, 55% of all farmers, and only 40% of the 30 farmers living in Lambwe Division had suitable water sources (Table 5.7). Furthermore, only 19% of the interested farmers had the means to obtain a pedal pump individually (Table 5.8 – 5.9). Although 56% had access to credit of some sort, half considered purchasing a pump through a group (Tables 5.10 – 5.13).

When asked about their sources of agriculture information, the most common response among all farmers interviewed was "fellow farmers" (68%). Other important sources of information were barazas among farmer teachers (80%), farmer field days among adopters (90%), and farmer teachers among exposed (100%). The same trend was seen in farmers' initial sources of push-pull information (Tables 4.1 – 4.5) and can be corroborated by the fact that all project farmers had helped others to adopt (Tables 4.9 – 4.11). It should be noted, however, that many of the exposed farmers were found by talking to farmer teachers, which partially explains the high percentage.

Although few farmers listed groups as a source of information, the majority (70%) of farmers were members of at least one farming group, although half of non-exposed farmers did not belong to any (Table 4.6). Females were also more likely to be a group member than males (81% vs. 58%) (Table 4.7).

Detailed results can be found in the data tables and descriptions on the following pages and in appendix I. All data tables follow the interview questions and are numbered accordingly.

Farmers' Background Information

Tables 1.1, 1.3, 1.4, 1.6, 1.7, 1.10 - 1.14 can be found in Appendix I.

Table 1.2: Age of Respondents

Age Group (Years)	Farmer Teacher	PPT Adopter	Exposed	Non-Exposed
20 – 29	0	2	2	4
30 – 39	0	0	2	1
40 – 49	2	2	1	2
50 – 59	6	4	2	2
60 – 69	1	2	2	1
over 70	1	0	1	0
Mean	57	47	49	39

The farmers ranged from age 21 to 83. In general, push-pull adopters were older than farmers who had not adopted. 90% of all push-pull adopters were above the age of 40. All farmer teachers were above the age of 40, with 60% between the ages of 50 and 59. Farmers who had never been exposed to push-pull were the youngest category, with 70% younger than 50. The age distribution of non-adopting farmers exposed to push-pull was even. Farmer teachers also had the highest mean age of 57 years, adopters and exposed had similar means of 47 and 49 years, respectively, and non-exposed farmers were by far the youngest, with a mean age of 39.

Table 1.5: Household Size

Household Size (Persons)	Farmer Teacher	PPT Adopter	Exposed to PPT	Not Exposed to PPT
3 – 5	1	4	3	5
6 – 8	5	3	5	4
9 – 11	2	1	2	1
12 and over	2	2	0	0
Mean Household Size	9	8	7	6

Farmer teachers had the largest households with 90% having six or more people. Farmers never exposed to push-pull had the smallest households with 50% having five or less members. Among all push-pull farmers, only 25% had households of five or less people while 40% non-adopters had small households. The mean household size also decreased with each respondent category: nine, eight, seven, and six persons for farmer teachers, adopters, exposed farmers, and non-exposed, respectively. According to these findings, the farmers not exposed to push-pull were the youngest, which could explain the smaller households.

Table 1.8: Education Levels

Highest Level of Education	Farmer Teacher	PPT Adopter	Exposed to PPT	Not Exposed to PPT
None	0	1	1	1
Primary	5	4	7	6
Secondary O	3	5	2	2
College	2	0	0	1

All farmer teachers had received some level of education and half had schooling beyond primary. None of the non-teacher PPT adopters had gone beyond secondary, but half had gone beyond primary school. 75% of all non-adopter farmers had never been beyond primary school. In general, push-pull farmers were more educated, especially the farmer teachers.

Table 1.9: Education Levels by Gender

Highest Level of Education	MPF	FPF	MNPF	FNPF
None	0	1	1	1
Primary	4	5	4	9
Secondary O	4	4	4	0
College	1	1	1	0

More than half of all male farmers attended secondary school, but 76% of all women interviewed had only a primary education. Female non-adopters were the least educated group; none had gone beyond primary. While the education levels of male push-pull farmers and male non-adopters were very similar, the education gap among women farmers was distinct. 45% of female project farmers had a secondary education, whereas all non-adopting women were limited by a primary education.

Table 1.15: Total Crop Acreage

Total Acreage	Farmer Teacher	PPT Adopter	Exposed to PPT	Not Exposed to PPT
<2	0	0	2	4
2 – 4	4	6	6	4
5 – 7	2	2	1	1
8 – 10	0	1	0	1
11+	4	1	1	0

No push-pull farmers had less than 2 total acres, while 30% of non-adopters had very small farms. Half of all push-pull farmers had a total of at least five acres of crops. Only 20% of non-adopters had a total acreage of at least five. The largest farms belonged mostly to farmer teachers and the smallest farms mostly to non-exposed farmers.

Table 1.16: Crop Diversity

Total Crop Number	Farmer Teacher	PPT Adopter	Exposed to PPT	Not Exposed to PPT
1 – 3	0	0	2	2
4 – 6	6	4	8	8
7 – 9	4	5	0	0
10+	0	1	0	0

Push-pull farmers practiced greater crop diversity than non-adopters. While 20% of non-adopters only grew between one and three different crops, all push-pull farmers cultivated at least four different crop varieties and half cultivated seven or more. No non-adopter grew more than six different crops. Among push-pull farmers, farmer teachers had less crop diversity than did adopters: 60% of farmer teachers grew six or fewer different crops whereas 60% of adopters grew seven or more.

Table 1.17: Farming Constraints

Farming Constraint	Farmer Teacher	PPT Adopter	Exposed to PPT	Not Exposed to PPT
Striga	10	10	10	10
Stemborer	10	10	10	10
Drought	10	10	10	10
Lack of Equipment	6	6	4	3
Lack of Capital	3	1	0	4
Lack of Extension Services	0	0	0	2
Lack of Labor	5	2	3	2
Wildlife	3	1	1	3
Pests	3	2	3	5
Weeds	1	0	0	0

Lack of Certified Seeds	0	1	0	0
Animal Disease	0	1	0	0
Low Soil Fertility	0	0	2	0

Every farmer interviewed listed *Striga* weed, stemborers, and drought as major farming constraints. 60% of push-pull farmers identified lack of equipment, but only 35% of non-adopters did. The only farmers affected by lack of extension services were non-adopters from Rusinga Island and the only farmers who expressed concerns over low soil fertility were non-adopters from Lambwe Division. Farmer teachers were most likely to recognize a lack of labor as a major constraint: 50% experienced the problem, most likely due to their increased age and household size. Most other farming constraints were identified in similar numbers among the different groups (i.e.: wildlife, pests) or were only acknowledged by a small number of individuals (i.e.: weeds, animal disease)

Objective: assess the knowledge gap between push-pull farmers and non-adopters
Tables 2.1 - 2.3, 2.7, 2.9, 2.12, 2.14, and 2.15 can be found in Appendix I

Table 2.4: Knowledge of the Source of *Striga*

Striga Source	Farmer Teacher	PPT Adopter	Exposed to PPT	Not Exposed to PPT
Soil	3	3	1	3
low fertility soil	2	1	1	0
wind dispersal	1	0	1	0
carried by insect	0	0	0	1
foreign seeds	0	1	2	0
doesn't know	4	5	5	6

Table 2.5: Knowledge of the Source of *Striga* vs. Gender

Striga Source	MPF	FPF	MNPF	FNPF
Soil	5	1	3	1
low fertility soil	1	2	0	1
wind dispersal	0	1	0	1
carried by insect	0	0	1	0
foreign seeds	0	1	2	0
doesn't know	3	6	4	7

The seeds of the *Striga* weed lay dormant in soil and can lead to a large loss of soil fertility, so responses of "soil" or "low fertility soil" were correct. 45% of push-pull farmers knew the source of *Striga* weed, compared with 25% of non-adopters. The knowledge gap between males and females is also distinct: out of the farmers interviewed, 47% of males and 24% of females knew the correct source of *Striga*. Female farmers were also more likely to admit that they did not know the source: 37% of men compared with 62% of women. Male non-project farmers were the most likely (30%) to state an incorrect source of *Striga*.

Table 2.6: Knowledge of the Stemborer Lifecycle

Knowledge of Stemborer Lifecycle	Farmer Teacher	PPT Adopter	Exposed to PPT	Not Exposed to PPT
Yes	10	8	1	2
No	0	2	7	6
Partial	0	0	2	2

All 10 farmer teachers, 80% of adopters, and 15% of non-adopters had a complete knowledge of the stemborer lifecycle. Out of the 20 non-adopters, 20% had a partial knowledge. Non-adopters exposed to push-pull technology actually had a lesser understanding than farmers who had never been exposed to the technology (10% vs. 20%, respectively). Gender had no effect on the farmer's knowledge; 53% of men and 52% of women had a complete knowledge.

Table 2.8: *Striga* Control Methods

Striga Control Method	Farmer Teacher	PPT Adopter	Exposed to PPT	Not Exposed to PPT
Push-Pull Technology	10	10	0	0
Weeding/Up-rooting	3	8	7	9
Manure	6	5	6	1
Crop Rotation	1	3	0	1
Intercropping	3	1	0	1
Fallowing Land	1	0	0	1
IR Maize	1	0	0	0
None	0	0	0	1

In addition to push-pull, the farmer teachers and PPT adopters used various other methods for controlling *Striga* on their land not under push-pull. 30% of farmer teachers and 80% of adopters weeded and uprooted *Striga*. 60% and 50% of farmer teachers and adopters, respectively, applied manure. 30% of farmer teachers intercropped maize with various legumes and 30% of adopters practiced crop rotation. Farmers exposed to push-pull had only two methods of controlling *Striga*: weeding and uprooting (70%) and the application of manure (60%). Non-exposed farmers had a wider range of techniques, but 90% weeded and uprooted. Out of all farmers interviewed, only one, a male farmer teacher, used IR (imazapyr-resistant) maize.

Table 2.10: *Striga* Control Method (other than push-pull) Efficacy

Striga Control Method Effectiveness	Farmer Teacher	PPT Adopter	Exposed to PPT	Not Exposed to PPT
Effective	0	0	0	1
Somewhat Effective	3	1	0	2
Not Effective	7	9	10	6

no other method	0	0	0	1

In this study, only one farmer reported using a non-ppt *Striga* control method that was effective (the application of manure). Another 15% of farmers interviewed had control methods that were "somewhat effective," but the majority (80%) described their efforts as "not effective." The most common method described as "somewhat effective" was the application of manure; however, farmers stated that manure did not control *Striga*, but rather improved the health and yield of the crop offsetting some damage caused by the weed.

Table 2.11: Stemborer Control Methods

Stemborer Control Method	Farmer Teacher	PPT Adopter	Exposed to PPT	Not Exposed to PPT
Push-Pull Technology	10	10	0	0
Herbal Concoctions	3	1	1	0
Weeding/Up-rooting	2	1	1	0
Ash	3	0	0	0
Intercropping	0	2	0	0
Manure	1	1	0	0
Crop Rotation	0	1	0	0
None	0	0	8	10

In addition to push-pull, some project farmers used other methods of stemborer control, but not as many as *Striga*. The most commonly used method was the application of herbal concoctions (20% of project farmers). On the other hand, non-adopters had very few methods of controlling stemborer attack on maize. Only two exposed farmers had some method of control and not a single non-exposed farmer attempted to control stemborers. Gender had no discernible effect on the control methods used.

Table 2.13: Stemborer Control Method (other than push-pull) Efficacy

Stemborer Control Method Effectiveness	Farmer Teacher	PPT Adopter	Exposed to PPT	Not Exposed to PPT
Effective	0	0	1	0
somewhat effective	3	1	0	0
not effective	5	3	1	0
no other method	2	6	8	10

This table demonstrates that farmer teachers were most likely to use additional methods of stemborer control (80%). These methods, however, were largely ineffective; only 30% described efforts as "somewhat effective." Only one farmer, a male exposed to PPT, had an "effective" method of control, which was the application of herbal concoctions.

Objective: assess perceptions of push-pull technology
Tables 3.5 - 3.7 can be found in Appendix I.

Table 3.1: Willingness to Learn More about Push-Pull Technology

Willing to Learn about Push-Pull	Farmer Teacher	PPT Adopter	Exposed to PPT	Not Exposed to PPT
Yes	N/A	N/A	10	10
No	N/A	N/A	0	0

All non-adopters interviewed were interesting in learning more about push-pull technology and many were also interested in adopting.

Table 3.2: Years Using Push-Pull Technology

Years Practicing PPT	Farmer Teacher	PPT Adopter	Exposed to PPT	Not Exposed to PPT
non-adopter	0	0	10	10
1 – 3	1	4	0	0
4 – 6	1	3	0	0
7 – 9	2	1	0	0
10+	6	2	0	0

No farmer teacher interviewed had been using push-pull for less than three years and only two for six or fewer years. The majority (60%) had adopted push-pull 10 or more years ago. The largest number of adopters (40%) had been practicing push-pull for one to three years. Only 20% of adopters had 10 or more years experience with push-pull.

Table 3.3: Years Using Push-Pull Technology vs. Gender

Years Practicing PPT	MPF	FPF	MNPF	FNPF
non-adopter	0	0	10	10
1 – 3	2	3	0	0
4 – 6	3	1	0	0
7 – 9	1	2	0	0
10+	3	5	0	0

In general, the women push-pull farmers interviewed had been practicing push-pull longer than the men. 64% of women and 44% of men adopted push-pull seven or more years ago. It should also be noted that of the five women practicing push-pull for 10 or more years, four were farmer teachers.

Table 3.4: Benefits of Push-Pull Technology

PPT Benefit	Farmer Teacher	PPT Adopter
Striga/Stemborer Control	10	10
Increased Yields	10	9
Fodder	9	6
Increased Soil Fertility	4	2
Increased Dairy Production	3	1
Increased Income	1	2

Decreased Weeding Labor	1	0
Healthy Crops	0	1
Increased Farming Knowledge and Skill	0	1
Increased Soil Moisture	0	1
Soil Erosion Control	1	0

All project farmers interviewed listed the control of *Striga* and stemborers as a benefit of using push-pull technology. Only one farmer did not report increased yields. Almost all farmer teachers (90%) and a majority of adopters (60%) benefitted from fodder made from Napier and Desmodium. As a result, 20% of farmers reported increased dairy production. Farmers also experienced improved soil fertility (30%) and one farmer each reported increased soil moisture and control of soil erosion.

Objective: determine the role of women in the dissemination of push-pull technology
Tables 4.4, 4.6, 4.8, 4.9, 4.12 – 4.15, 4.17, and 4.18 can be found in Appendix I.

Table 4.1: Sources of Agriculture Information

Source of Agriculture Info	Farmer Teacher	PPT Adopter	Exposed to PPT	Not Exposed to PPT
Fellow Farmers	6	6	9	6
Extension Officers	7	4	4	4
Farmer Field Day	6	9	2	2
Farmer Teachers/Leaders	0	6	10	1
icipe	3	4	4	1
Baraza	8	1	2	0
Radio	3	1	2	2
Seminars	4	1	2	1
Farmer Field School	2	1	2	0
Publications	3	0	0	1
Groups	1	0	1	1
NGO	2	0	0	0
Stockists	0	0	0	2
Books and Research	0	0	0	1
None	0	0	0	1

The most common source of information for farmers was fellow farmers (68%). Farmers, especially farmer teachers (70%), also received help from Kenyan Ministry of Agriculture extension officers. Almost all push-pull adopters (90%), 60% of farmer teachers, and 20% of non-adopters had been to a field day. Most farmer teachers (80%) used barazas as a source of information, while only 10% of adopters, 20% of exposed farmers, and no non-exposed farmers did. Farmer teachers were also most likely to use radio (30%), seminars (40%) and publications (30%). Farmer teachers themselves were a widely used source of information by adopters (60%) and exposed farmers (100%). In order to find 10 farmers exposed to push-pull technology we asked for some names from farmer teachers, which partially explains why all 10 exposed farmers used farmer teachers as an information source.

Table 4.2: Sources of Agriculture Information vs. Gender

Info Source	MPF	FPF	MNPF	FNPF
Baraza	3	6	2	0
Publications	1	2	1	0
Radio	2	2	2	2
Fellow Farmers	5	7	8	7
Farmer Teachers/Leaders	4	2	6	5
Farmer Field School	0	3	0	2
NGO	0	2	0	0
icipe	2	5	3	2
Farmer Field Day	7	8	2	2
Extension Officers	5	6	5	3
Groups	0	1	0	2
Seminars	2	3	2	1
Stockists	0	0	2	0
Books and Research	0	0	1	0
None	0	0	0	1

The majority of female project farmers (55%) used barazas for information, while only 26% of all men and no female non-project farmers did. Male non-project farmers were the most likely (60%) to get information from farmer teachers, followed by female non-project farmers (50%), than male project farmers (44%), and female project farmers (18%). It should be noted however, that all five of said female non-project farmers were exposed to push-pull. Male non-project farmers were also most likely (80%) to receive information from fellow farmers, compared with 67% of all females and 44% of male project farmers. No males interviewed attended farmer field schools, but 24% of females had. Extension officers were information sources for roughly half of all males and female project farmers, but only 30% of female non-adopters. Females were the only farmers to list groups as a source of information, although many farmers were group members. Gender had no effect on the likelihood that a farmer would attend a field day.

Table 4.3: Initial Source of Push-Pull Information

Initial Source	Farmer Teacher	PPT Adopter	Exposed to PPT	Not Exposed to PPT
Barazas	5	0	0	0
field day	1	5	0	0
Icipe	1	3	2	1
fellow farmer	2	0	0	0
extension officer	1	0	0	1
farmer teacher	0	2	7	0
farmer field school	0	0	1	0

N/A	0	0	0	8

Among all farmers exposed to push-pull, there seemed to be a change in initial push-pull information sources between farmer teachers, push-pull adopters, and non-adopters. Half of all farmer teachers first heard of push-pull from barazas, but they were the only group to do so. Half of the push-pull adopters initially learned about push-pull at a farmer field day, which was not true for any non-adopters. The majority (70%) of non-adopters learned about push-pull from farmer teachers, compared with 20% of adopters and no farmer teachers. Again, this can be partially explained by our methodology of finding the exposed farmers.

Table 4.5: Initial Source of Push-Pull Information vs. Years Practicing PPT

Initial Source	non-adopter	1 - 3 Years	4 - 6 Years	7 - 9 Years	10+ Years
Barazas	0	0	0	1	4
field day	0	1	3	0	2
Icipe	3	1	1	1	1
fellow farmer	0	1	0	0	1
extension officer	1	0	0	1	0
farmer teacher	7	2	0	0	0
farmer field school	1	0	0	0	0
N/A	8	0	0	0	0

All farmers in this study who first learned of push-pull from a farmer teacher adopted push-pull less than three years ago. Out of all farmers practicing push-pull for seven or more years, 45% first heard of push-pull at a baraza. For adopters practicing for 6 or fewer years, the most common information source was field days (44%). The most common push-pull information source for non-adopters was farmer teachers (58%) followed by *icipe* (25%).

Table 4.7: Farming Group Membership vs. Gender

Number of Farming Group Memberships	MPF	FPF	MNPF	FNPF
0	3	1	5	3
1	2	4	4	6
2	3	4	1	1
3	1	1	0	0
4	0	1	0	0

Females were more likely than males to be members of farming groups; out of all farmers, 42% of men and 19% of women were not members of any. The majority of female project farmers (54%) were members of at least two farming groups, while 44% of male project farmers and only 10% of all non-adopters were.

Table 4.10: Number of New Adopters Helped

Number of Adopters Helped	Farmer Teacher	PPT Adopter
None	0	1
1 - 3 Adopters	0	7
7 - 9 Adopters	1	2
10 - 12 Adopters	4	0
13+ Adopters	5	0
Mean	12	3

All project farmers interviewed except for one had helped at least one fellow farmer adopt push-pull technology. No adopters helped more than seven farmers adopt, while no farmer had helped less than eight. The majority of adopters (70%) helped between one and three fellow farmers to adopt push-pull and 50% of farmer teachers helped 13 or more farmers adopt. The mean number of adopters helped was also quite different between the two groups: on average farmer teachers helped 12 farmers adopt and adopters helped 3.

Table 4.11: Number of New Adopters Helped vs. Gender

Number of Adopters Helped	Male	Female
None	1	0
1 - 3 Adopters	3	4
7 - 9 Adopters	1	2
10 - 12 Adopters	3	1
13+ Adopters	1	4
Mean	6	9

The only project farmer who had not helped others to adopt push-pull was a male adopter. 33% of males and 36% of females helped between one and three fellow farmers adopt. No farmers helped between four and six adopters. The majority of both men (56%) and women (63%) helped seven or more people to adopt; however more women (36%) than men (11%) helped 13 or more adopters. Women also helped a higher mean number of new adopters than did men; nine farmers compared with six, respectively.

Tables 4.12 – 4.16: Division of Household and Farming Labor (4.12 – 4.15 can be found in Appendix I)
Farmers were asked if males, females, or both completed the following farming tasks.

Table 4.16: Fetching Water

	MPF	FPF	MNPF	FNPF
Males	0	0	1	0
Females	8	11	9	7
Both	1	0	0	3

Through the interviews, distinct gender roles became apparent. No women did all of the plowing, tilling, or hand-digging, and no men did all of the harvesting. Only two farmers said men did all of the weeding, but it should be noted that both farmers were widows: one was helped by children and the other by her grown son. Women clearly carried the burden of fetching water for the household. Many of the men interviewed laughed when asked and proclaimed “that is the women’s work.” Only one man collected water for his family, and that was because his wife was sick. The distribution of harvesting labor varied greatly between male and female farmers; 84% of men claimed that both genders harvested, but 71% of females interviewed said that women did all of the harvesting.

Objective: evaluate the potential for pedal pump irrigation in Mbita District.
Tables 5.2, 5.3, 5.6, and 5.13 – 5.15

Table 5.1: Drought-Coping Mechanisms

Drought-Coping Method	Farmer Teacher	PPT Adopter	Exposed to PPT	Not Exposed to PPT
Short-maturing Crops	3	4	4	1
Bucket Irrigation	1	1	3	5
Timely Agronomic Practices	2	2	1	2
Carry Water with Donkey	1	1	4	0
Pond/Water Pan	3	0	0	0
Crop Variety	0	2	0	0
Conservation Agriculture	1	0	0	0
Drought-resistant Crops	0	0	1	0
Water Channels	0	0	1	0
pedal or generator pump	2	1	0	3
None	2	3	4	1

The farmers interviewed relied mainly on rain-fed agriculture. A farmer's push-pull status had no effect on whether or not he or she knew how to cope with drought and erratic weather. 25% of both project and non-project farmers had no method whatsoever. The most common practice was the planting of short-maturing crops, used by 30% of farmer teachers, 40% of adopters and exposed, and 10% of non-exposed farmers. Half of all non-exposed farmers used bucket irrigation, especially for vegetables, but that is largely because the non-exposed farmers lived on Rusinga Island and had easy access to Lake Victoria. Farmer teachers were the only group to create water pans for use (30% did). Non-exposed farmers (30%) were most likely to use a pedal or generator pump for irrigation, followed by farmer teachers (20%) and then adopters (10%). No exposed farmers used a pump.

Table 5.4: Water Pump Ownership

Pump Ownership	Farmer Teacher	PPT Adopter	Exposed to PPT	Not Exposed to PPT
pedal - ind.	1	0	0	0
pedal - group	4	0	0	0
generator - ind.	0	0	0	2
generator - group	0	1	0	0

Very few farmers owned either a pedal or generator pump. Four farmer teachers, however, owned a pedal pump as part of a group. They were all female farmer teachers, three of which owned the pedal pump with the Lambwe Organic Farmers Group (LOFAG). Only one female farmer teacher owned a pedal pump individually and two non-exposed male farmers owned generator pumps individually.

Table 5.5: Perceptions on Pedal Pump Benefits

Benefit from Pedal Pump	Farmer Teacher	PPT Adopter	Exposed to PPT	Not Exposed to PPT
Yes	10	10	7	9
No	0	0	3	1

All project farmers interviewed said they would benefit from pedal pump irrigation and were interested in obtaining one. The majority of non-adopters (75%) saw pedal pumps as beneficial as well, but 30% of exposed and 20% of non-exposed farmers did not. Two of the non-interested exposed farmers had salty sources of water not suitable for irrigation, and the third was concerned with obtaining a water source before a pump. The non-interested farmer not exposed to push-pull already owned a generator pump.

Table 5.7: Water Source suitable for Irrigation

Water Source	Farmer Teacher	PPT Adopter	Exposed to PPT	Not Exposed to PPT
Yes	6	4	2	10
No	2	6	5	0
domestic use only	2	0	1	0
Seasonal	0	0	2	0

Although most farmers were interested in obtaining a pedal pump, few had water sources that could be used for irrigation. 60% of farmer teachers had a usable water source; however, two of those six had access to a group water pond not adjacent to their own farm. The majority (60%) of adopters as well as exposed farmers did not have suitable water sources. All non-exposed farmers had a water source – Lake Victoria.

Table 5.8: Means of Obtaining a Pedal Pump Individually

Means of Obtaining a Pump Individually	Farmer Teacher	PPT Adopter	Exposed to PPT	Not Exposed to PPT
Yes	4	0	1	1
No	4	9	5	7
N/A	2	1	4	2

In addition to a lack of water sources, farmers were also faced with a lack of means to obtain a pedal pump individually without assistance of some sort. Farmer teachers were the most capable: half of all interested farmer teachers had the capacity to buy a pump on their own. No adopters had individual means, and only one exposed and one non-exposed farmer were capable of obtaining a pump without assistance. N/A indicates that a farmer was not interested in obtaining a pedal pump.

Table 5.9: Means of Obtaining a Pedal Pump Individually vs. Gender

Means of Obtaining a Pump Individually	MPF	FPF	MNPF	FNPF

Yes	2	2	2	0
No	7	6	5	7
N/A	0	3	3	3

The percentages of farmers with the means of obtaining a pedal pump individually were similar between male adopters, female adopters, and male non-adopters (22%, 25%, and 29%, respectively). No female non-adopters, on the other hand, had similar capacity.

Table 5.10: Access to Credit

Access to Credit	Farmer Teacher	PPT Adopter	Exposed to PPT	Not Exposed to PPT
Formal	7	1	5	4
Informal	4	3	5	1
None	1	7	3	6

Farmer teachers had the greatest access to formal credit (70%), followed by exposed farmers (50%), then non-exposed (40%), and finally, adopters (10%). Adopters had the least access to credit (70%), followed closely by non-exposed farmers with 60%. Exposed farmers had the greatest reported percentage of access to informal credit (50%). It also should be noted that several farmers with access to credit had both formal and informal sources.

Table 5.11: Access to Credit vs. Gender

Access to Credit	MPF	FPF	MNPF	FNPF
Formal	4	4	7	2
Informal	4	3	2	4
None	3	5	3	6

Similar percentages of male and female project farmers (44% and 36%, respectively), but 45% of female project farmers did not have access to any credit source, while only 33% of male project farmers had no access. Male non-adopters had the highest rate of formal credit access of 70% and female non-adopters had the lowest rate of only 20%. In general, females had less access to credit (48%) than did men (68%).

Table 5.12: Obtain Pedal Pump through Group Purchase

Obtain Pedal Pump through Group	Farmer Teacher	PPT Adopter	Exposed to PPT	Not Exposed to PPT
Yes	4	6	4	6
No	6	4	6	4

Overall, half of all project farmers and half of all non-adopters would consider purchasing a pedal pump through a group.

Discussion and Conclusion

The farmer stood up, finished with his demonstration of how to establish a push-pull plot. “Now,” he instructed, “you pray for rain.” That day, at the farmer field day near Kisumu, I realized the most common way Kenyans cope with drought – prayer. They use push-pull technology to manage weeds and pests, but the watering of their crops is left to God.

When asked about major farming constraints, every farmer responded with *Striga* weed, stemborers, and drought (see table 1.17). Furthermore, most farmers said that stemborers were only a concern during the dry season. Others told me that rainfall was the single defining factor for the success of a crop. Yet despite the recognition of the problem, few farmers had solutions other than timely planting of short-maturing crops. The class-six students to whom I taught science could tell me that germination requires “sunlight, oxygen, and moisture,” but few people of any age received that moisture from a source other than the long rains.

At the beginning of my research, I was thrilled to work with pedal pumps, convinced they could single-handedly rescue farmers from the seasonality gap in production. It only took one interview, however, for them to come crashing off their pedestal. 90% of the farmers interviewed believed they would greatly benefit from a pedal pump, but only 55% had a suitable source of water. Excluding farmers from Rusinga Island with easy access to Lake Victoria, only 40% had a water source (see table 5.7). It was clear that before farmers could even think of irrigation, they needed a source from which they could pump.

Even though the Mbita District is plagued by erratic weather, water sources are not scarce. In all of Kenya, including the northern arid regions, the per capita natural renewable water resources per year is 749 cubic meters, but the yearly consumption is only 46. Mbita District has both bodies of water and a high water table that could be drilled, but the most abundant and affordable resource comes to Mbita in deluges twice a year: rain. With cisterns, reservoirs, roof catchment systems, or water pans, farmers could have water year-round.

Another factor hindering development is the lack of capital, whether for obtaining a water source or a pedal pump. KickStart, the company that manufactures pedal pumps in Kenya, which are specifically called the Super Moneymaker Pumps, only sells at full cost. A complete system, including a pedal pump, 200 meters of rubber pipe, and five sprinklers, capable of irrigating up to two acres, would cost 27,740 Kenyan Shillings (KSH) plus 800KSH annually for repair, or $346.75 plus $10 annually. $350 might seem like a small investment to an American, but to a Kenyan smallholder it is rarely possible without assistance.

Out of the 31 farmers interested in obtaining a pump, only six, or 19%, said they had the means to obtain a pump individually (see table 5.8). 58% of farmers had access to credit, be it formal or informal, but only 48% of women had access (see table 5.10). Many farmers, however, even some with access to credit, were hesitant to take out a loan for fear of being unable to repay.

When visiting the farms, it was clear that various NGOs had attempted to help farmers through donations. It was also clear that many good intentions had gone to waste. As we walked up a steep hill to one farmer’s (James Oduya’s) house, I saw the top of a windmill over the trees. A few years ago, World Vision, a prominent Christian non-profit organization, installed a windmill to power a water pump that tapped into the water table. Then, as all machines do at one time or another, the windmill broke. James Oduya does not have the money or knowledge to repair the windmill. It is now decoration.

James Oduya's windmill is just one symptom of a larger problem crippling the developing world: dependency. In a conversation I had with Jimmy Pittchar, one of my mentors and a social scientist working with the Gatsby Project, he described the situation: recently, more and more NGOs have been created to help developing nations alleviate poverty. These organizations donate pumps, water tanks, animals, and so on to needy farmers. As a result, many farmers become dependent upon foreign aid, relying on the charity of others rather than their own initiative. If a pump breaks, for example, they wait for the organization to fix it. Sometimes those repairs come, but often they do not.

It was interesting how the reactions Mr. Pittchar and myself differed in regards to the problem of dependency. As a Kenyan himself, Mr. Pittchar criticized the dependents and the common methods of distributing aid, urging the need to take control of one's success. As an American, and an engineer, I saw the blame in a slightly separate light. I believe it stems from the misguided belief, that I shared just months ago, that the newest, cutting-edge technology can solve most problems. In reality, as I saw with the windmill, technology is only as helpful as the users make it. That solitary, out-of-place windmill represented the lack of foresight, cultural understanding, and proper evaluation that can unfortunately come with new ideas. It was apparent that many farmers needed some level of assistance to break the cycle of poverty, but as Jimmy wisely told me, "development comes from the people." Without a personal investment, farmers are much less willing to maintain technology. Free is not sustainable.

I witnessed a similar problem to the windmill in a group setting. The Lambwe Organic Farmers Group, of which a few surveyed farmers were members, had received a pedal pump from World Vision. Like the windmill, the pump eventually broke, but the problem was not lack of capital, but rather that repair plans were tangled in messy group dynamics. While all registered groups are required by the Kenyan government to have constitutions, many lack member expectations and requirements for specific purposes. What starts out as a great way to pool resources can turn into battles of who is entitled to what, when.

Group dynamics were also sometimes exacerbated by farmers' lack of water. Unlike other farm implements, such as plows or mills, which can be used most anywhere, pedal pumps have a very limited range: a maximum vertical pumping height of 14 meters and horizontal distance of 200 meters. Some farmers listed another's water source as one they could use, which was true, but the possibilities of irrigation are small. With a pedal pump's limited power, irrigated land must be near, if not adjacent to, the water source. Therefore, groups using a shared source would need to either farm on communal land or on one member's property, which could easily lead to conflict.

Another factor inhibiting the pedal pump's success is farmers' lack of knowledge about the pump itself. In our focus group discussion on Rusinga Island, farmers lamented over the pedal pump's labor demand. They claimed it was too labor-intensive, which made it gender-unfriendly. In a culture where it is the woman's job to fetch water (men laughed when I asked who collected water in their household) (see table 4.16), all irrigation systems must be suited for women's use. I mentioned these concerns to representatives from KickStart when I visited their exhibit at the Ministry of Agriculture's national show in Kisumu. Their response? Farmers were using the technology incorrectly. They showed me how pressing the pedals only half-way achieved the same results as pushing them fully to the ground. If used correctly, they assured me, pedal pumps were indeed gender friendly.

It seemed to me that such a small problem could be easily fixed by teaching the farmers. Apparently KickStart provides free lessons on both using the pump and horticulture, but that information had clearly not reached Rusinga. The problem lies in the distribution of the pumps; KickStart sells not only to farmers, but also to other dealers and NGOs. When a farmer purchases a pump from a dealer or receives one as a donation, they get the pump, but not the education that should come with it. Simple details, such as how far to push the pedal, are overlooked.

Lack of education extends beyond pedal pumps to push-pull as well. While half of all push-pull farmers surveyed attended secondary school, only a quarter of non-adopters did. Such trends are present across Kenya; the literacy rate is 61.5%, but only 29.6% have the "desired mastery level of literacy," as defined by DVV International. Most of the population, even those described as "literate," lack many reading and comprehension skills. Low literacy levels pose many challenges for Kenyan development, including the spread of push-pull technology. Push-pull must be implemented in a specific and precise way to be effective, which is described in many booklets published by *icipe*. When much of the target audience cannot read the information, problems arise.

One such problem facing *icipe* is perception. According to a push-pull impact assessment conducted by Intercooperation, a Swiss organization, PPT is "perceived as knowledge-intensive," which is intimidating to farmers, especially those with little education. This fact is reflected in the farmers' sources of information: only 10% used publications. On the other hand, 68% received information from fellow farmers, a friendlier, more approachable source.

Fellow farmers and farmer teachers could also be a way to empower females in rural Kenya. Out of all farmers interviewed, the female non-adopters lacked education the most: not a single one was educated beyond primary. None of these women received information from publications, and one woman had no sources of any kind. Each female farmer teacher that I met was an inspiration in so many ways, from the size of her maize yields to the health of her children. One such example is Mama Sarah Obama, President Barack Obama's grandmother. Although a recent celebrity, she is also a successful push-pull farmer who has taught many women in Kogelo, her small highland village. Women like Sarah Obama, Mary Rabilo, and Herrin Odera (farmers I interviewed)

Figure 5. Visiting Mama Sarah Obama

are integral to the success of other female farmers.

One potential setback, however, that could hinder the success of *icipe's* farmer teacher program is the age of the farmers. The mean age of farmer teachers interviewed was 57, compared with 39 for farmers not exposed to push-pull. 80% of farmer teachers were above 50 while 70% of non-exposed farmers were below. When I mentioned this trend to Isaac Mbeche, a social scientist working with the project, he echoed my concern. Not only might younger farmer teachers be able to reach out to younger farmers, they would help ensure sustainability of the program.

Although *icipe*'s habitat management is currently researching Napier Stunt Disease, a recently discovered insect-transmitted disease crippling Napier grass, the science behind push-pull technology is complete. What is still in progress is the program's infrastructure. As one of my colleagues said, "*icipe* will not be around forever;" the organization is currently working with the Kenyan government's Ministry of Agriculture to ensure the longevity of push-pull. Many of the current farmer teachers are part of the first push-pull generation. For the science to become a wide-spread and integral part of East African agriculture, measures must be taken to ensure each successive generation of farmers will embrace the technology and then pass it along.

While my sample size of farmers was too small to yield statistically significant results, my research revealed important trends:

- In order for pedal pumps and other irrigation methods to increase yields and help farmers break the seasonality gap, farmers must first have adequate sources of water. Given the seasonal rains in Mbita, this could be accomplished through improved rain catchment systems.
- Many farmers, especially women, lacked the means of obtaining pumps. Since KickStart only sells pedal pumps at full cost, they would need loans or cost-sharing plans to afford the technology.
- More education must come with irrigation technology. Pedal pumps have the potential to be gender-friendly and time-saving if used correctly, and in order for that to happen, farmers much be taught how to properly use the equipment.
- Farmer teachers are integral to the dissemination of push-pull. In an area of low literacy, fellow farmers are an approachable and understandable source of information. The farmer teachers I interviewed were role models within their community and could reach out to struggling farmers. In this way they are also a source of empowerment to local women through their example and success.
- To further the impact of its farmer teacher program, *icipe* should train younger farmer teachers. My study showed that, on average, farmer teachers were almost 20 years older than non-exposed farmers. Younger farmer teachers would both reach out to more non-project farmers and help ensure the sustainability of the program.

My research also taught me an important lesson about the role of nongovernmental organizations and new technology in international development. As James Oduya's motionless windmill demonstrated, and as Mr. Pittchar told me, "Unless the people themselves perceive their problems, conceive and demand the provided solutions, no development will take place." It was clear through interviews that the farmers of Mbita needed help, that while they worked their hardest, the cycle of poverty was too powerful to break. But without caution, without cultural knowledge and grassroots empowerment, aid can further perpetuate the poor in a cycle of dependency.

Personal Reflection

"When in the end, the day came on which I was going away, I learned the strange learning that things can happen which we ourselves cannot possibly imagine, either beforehand, or at the time when they are taking place, or afterwards when we look back on them. […] On such occasions you yourself keep in touch with what is going on by attentively following it from moment to moment, like a blind person who is being led, and who places one foot in front of the other cautiously but unwittingly."
-Isak Dinesen, *Out of Africa*

Stepping off the plane in Nairobi was unlike any experience I've ever had. My day of travel had been filled with anxiety over leaving my family and friends and entering a world I had never seen. In the previous months I had tried to picture Kenya, tried to imagine seeing, breathing, and living in Africa, but never could. The internet showed me endless savannah, yet my mind drew a blank, terrified by the unknown. When I exited the plane, climbing down the stairs onto the tarmac, I met the cold air with exhilaration, blinded by the lights of the airport and the jet-black sky. After months of preparation, after shots, after sad goodbyes, I had made it. Across an ocean, across a continent, to Kenya.

My first few days in Kenya were surreal. Like Dinesen, I followed it "from moment to moment," never quite sure where I was going, stumbling after the steps of my guides. I was "like a blind person who is being led," overwhelmed by the new country and culture, struggling to keep my eyes open, to see it all. Nothing ceased to amaze me, and I left in awe of Kenya's beauty.

One day, as we were coming back from a farm, I made the driver stop the car, climbed out and up onto the hood, and snapped some pictures. Matilda, one of my mentors, laughed and asked, "Do you not have sunsets at home?" I paused, thinking before I answered. The sun hung low in the sky, a brilliant crimson, surrounded by blankets of pastels fading from pink to yellow to blue. It hung over scraggly mountains and trees disappearing into the dusty, purple haze. The African sun was the same I saw at home, yet was more vibrant and raw than any sky I had seen in Virginia.

Unfortunately, rural Kenya is as troubled as it is beautiful. This summer was my first encounter with abject poverty, and I don't think I will ever fully get over the shock. It is one thing to read statistics about hunger, and another to witness it first-hand. My mind is forever burned with images of children leading skin-and-bone cattle and babies with swollen bellies; rural huts made of dung and urban slums made of corrugated iron. My nose will forever smell the fumes of rotting litter. My ears will forever hear the moans from the local funerals.

Yet while I will always remember the poverty I saw, it was not the part of my trip that affected me the most. More fragrant than the trash will be the papaya I got as a gift. The funeral dirge will not ring as loudly as the laughter of the school children. And most importantly, the rusting iron roofs will be far outshone by the smiles of the people I met. While in Mbita I became able to look past the poverty. Most of the families' stories were not disparaging, but inspirational. They worked tirelessly to provide for their family. I was humbled by the pride and dignity they felt for all of their possessions, from their chickens to their latrines. Even in dire situations they had hope.

In June, when I boarded my plane for Nairobi, I did not know what the next two months would hold. I had heard from every intern about how incredible the experience was, how I wouldn't come back the same. Now that I'm home, I know just how true that is. I can't tell you if I act any differently – you would have to ask my family – but I do know that I have been forever changed by my experience in Kenya. Some changes were expected, like my greater concern over wasting food, but some were not. For the first time, I lived on my own and experienced the thrilling independence and lingering loneliness that coincide. I rekindled my passion for reading. I overcame my fear of cockroaches. In between I realized how dearly I love my family and friends and made some new ones I will never forget.

Most importantly, I know that the lessons I learned in Kenya will always stay with me. I was a complete stranger, the cries of "mzungu" (white person), followed me wherever I went, yet I never felt out of place. The farmers that I interviewed not only answered my questions, but welcomed me into their homes. They offered me food and asked me to marry their sons. The people I worked with not only accompanied me to farms, they made me feel at home. When I wanted to teach at the school, they gave me materials for science experiments. When I was sick, they brought me cases of water. I left Kenya longing to return, not to see lions, but the friends I made. The people I met shaped my experience, and I am forever grateful. Many thanks, asante sana, ero kamano.

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Appendix I

Table 1.1: Respondent Distribution

Gender of Farmer	Farmer Teacher	PPT Adopter	Exposed to PPT	Not Exposed to PPT	Total
Male	4	5	5	5	19
Female	6	5	5	5	21
Total	10	10	10	10	40

Each category of respondent was divided into equal numbers of males and females in order to compare the responses between genders.

Table 1.3: Age of Respondents by Gender

Age Group (Years)	MPF	FPF	MNPF	FNPF
20 – 29	2	0	2	4
30 – 39	0	0	2	1
40 – 49	2	2	2	1
50 – 59	2	8	3	1
60 – 69	2	1	0	3
over 70	1	0	1	0
Mean	50	54	45	42

Female project farmers were the oldest group with 100% over 40 and 81% over 50. Female non-project farmers were the youngest group with 50% under the age of 40. 60% of male non-project farmers and 44% of male project farmers were under 50. The push-pull status of the farmer was more likely to determine the age of the farmer than gender. For example, female project farmers had an average age of 54 while non-project farmers had an average age of 42.

Table 1.4: Location

Location	Farmer Teacher	PPT Adopter	Exposed to PPT	Not Exposed to PPT
Lambwe East	5	2	3	0
Lambwe West	5	8	7	0
Rusinga East	0	0	0	3
Rusinga West	0	0	0	7

All farmers exposed to push-pull technology were from Lambwe Division and all farmers not exposed to push-pull were from Rusinga Island in the Mbita Division.

Table 1.6: Farm Labor Size

Mean Farm Labor in Persons					
Farm Labor	Farmer Teacher	PPT Adopter	Exposed to PPT	Not Exposed to PPT	Total
Male >18	1.9	1.2	1.8	1.7	1.65
Female >18	2	1.6	1.2	1.3	1.5
Boy 12 – 17	0.3	0.5	0.4	0.3	0.4
Girl 12 – 17	0.4	0.4	0.2	0.4	0.4

Children	0	0.2	0.2	0.3	0.2
Total	4.6	3.9	3.8	4	4.15

Farmer teachers had the greatest average work force of 4.6 persons. Non-teacher push-pull farmers and farmers not exposed to push-pull had very similar work force sizes of about four persons.

Table 1.7: Marital Status

Marital Status	Farmer Teacher	PPT Adopter	Exposed to PPT	Not Exposed to PPT	Total
Single	0	1	1	0	2
Married	8	6	6	8	28
Widowed	2	3	3	2	10

The majority, 70%, of all farmers interviewed were married. A quarter of all farmers were widows and only two were single. It should also be noted that both of the single farmers were male.

Table 1.10: Sources of Income

Source of Income	Farmer Teacher	PPT Adopter	Exposed to PPT	Not Exposed to PPT
Farming	10	10	10	10
Petty Business	1	1	3	1
Fishing	0	0	0	3
Casual Labor	0	1	1	0
Dairy Animals	1	0	0	1
Employment	0	0	1	1
Pension	0	0	1	1
Driver	0	0	0	1
Lumber Sales	0	0	1	0
Masonry	0	0	1	0
Merry-go-round Contribution	0	1	0	0

Among all push-pull farmers, only five had sources of income apart from farming. Non-adopters, however, had very diversified sources of income, from lumber sales to casual labor. With the greatly improved yields given by push-pull most adopters did not need additional sources of income and could focus on farming.

Table 1.11: Mobile Phone Ownership

Mobile Phone Ownership	Farmer Teacher	PPT Adopter	Exposed to PPT	Not Exposed to PPT
Yes	10	7	5	7
No	0	3	5	3

Table 1.12: Mobile Phone Ownership vs. Gender

Mobile Phone Ownership	MPF	FPF	MNPF	FNPF

Yes	8	9	7	5
No	1	2	3	5

As mobile phones become ubiquitous in the Mbita district, they also become an indicator of household income. All farmer teachers had mobile phones and as did all but one male project farmer. Half of exposed farmers did not have mobile phones. Female non-adopters were also less likely (50%) to have a phone than male non-adopters (70%).

Table 1.13: Maize Acreage

Maize Acreage	Farmer Teacher	PPT Adopter	Exposed to PPT	Not Exposed to PPT
0 - 1.5	0	1	5	8
2 - 3.5	4	6	3	1
4 - 5.5	5	2	1	1
6+	1	1	1	0

As farmers' exposure to push-pull decreased, so did their maize acreage. All farmer teachers and 90% of adopters were growing at least two acres of maize, where as half of exposed farmers and 80% of non-exposed farmers were growing less than two acres. 60% of all farmer teachers were growing more than four acres of maize, but only 30% of all non-exposed farmers were growing the same amount.

Table 1.14: Additional Crop Acreage

Crop Acreage	Farmer Teacher	PPT Adopter	Exposed to PPT	Not Exposed to PPT
0 - 1.5	4	7	8	8
2 - 3.5	2	2	1	1
4 - 5.5	0	0	1	0
6 - 7.5	3	1	0	1
8+	1	0	0	0

In addition to greater maize acreage, push-pull farmers had more acres on non-maize crops than did non-adopters. 60% of farmer teachers, 30% of adopters, and 20% of non-adopters grew at least two acres of additional crops.

Table 2.1: *Striga* Severity

Striga Severity	Farmer Teacher	PPT Adopter	Exposed to PPT	Not Exposed to PPT
Very Severe	2	1	8	7
Severe	0	0	1	3
Moderately Severe	1	1	1	0
Mild	3	5	0	0
Reduced	4	3	0	0

75% of all non-adopters described their *Striga* weed problem as "very severe" while only 15% of push-pull farmers did. The push-pull farmers experiencing severe *Striga* problems stated, however, that *Striga* was only very severe on their land not under push-pull. All non-adopters but one had "severe" or "very severe" and the lone farmer said his farmland was virgin, making weeds and pests much lesser problems. 40% of push-pull farmers experienced mild *Striga* infestation and 35% described *Striga* on their farm as "reduced."

Table 2.2: Stemborer Severity

Stemborer Severity	Farmer Teacher	PPT Adopter	Exposed to PPT	Not Exposed to PPT
Very Severe	1	0	1	2
Severe	1	1	6	4
Moderately Severe	0	2	1	3
Mild	5	5	2	1
Reduced	3	2	0	0

65% of non-adopters described stemborer attacks on their farm as "severe" or "very severe" while only 15% of push-pull farmers did the same. 50% of push-pull farmers and 15% of non-adopters said their stemborer problem was "mild" and 25% of push-pull farmers had seen stemborers "reduced." It must also be noted that many farmers reported that stemborer severity varied with rainfall: in times of drought stemborer attack was severe, but the problem was manageable with adequate rainfall.

Table 2.3: Knowledge of Push-Pull

Knowledge of Push-Pull	Farmer Teacher	PPT Adopter	Exposed to PPT	Not Exposed to PPT
Yes	10	10	10	2
No	0	0	0	8

Unexpectedly, two farmers presumed to have never been exposed to push-pull had some knowledge of the technology. Both had a vague knowledge, however, and had not seriously considered adopting.

Table 2.7: Knowledge of the Stemborer Lifecycle vs. Gender

Knowledge of Stemborer Lifecycle	MPF	FPF	MNPF	FNPF
Yes	8	10	2	1
No	1	1	6	7
Partial	0	0	2	2

Table 2.9: *Striga* Control Methods vs. Gender

Striga Control Method	MPF	FPF	MNPF	FNPF
Push-Pull Technology	9	11	0	0
Weeding/Uprooting	7	4	7	9
Manure	1	10	4	3
Crop Rotation	2	2	0	1

Intercropping	1	3	0	1
Fallowing Land	0	1	1	0
IR Maize	1	0	0	0
None	0	0	1	0

Out of all project farmers, males (78%) were more likely to weed and uproot *Striga* while women (91%) were more likely to apply manure. Women project farmers also intercropped maize with legumes more frequently (27%) than did men (11%). Most non-adopters (80%) weeded and uprooted *Striga*, although a higher percentage of women did (90%) than did men (70%). 35% of non-adopters also applied manure.

Table 2.12: Stemborer Control Method vs. Gender

Stemborer Control Method	MPF	FPF	MNPF	FNPF
Push-Pull Technology	9	11	0	0
Herbal Concoctions	2	2	1	0
Weeding/Uprooting	1	2	0	1
Ash	1	2	0	0
Intercropping	1	1	0	0
Manure	1	1	0	0
Crop Rotation	0	1	0	0
None	0	0	9	9

Table 2.14: Symptoms of *Striga* Attack on Maize

Striga Symptom	Farmer Teacher	PPT Adopter	Exposed to PPT	Not Exposed to PPT
Stunted Growth	10	8	10	9
Low Yield	9	9	5	9
Small/No Cobs	4	7	8	6
Unhealthy Look	2	5	2	1
Yellowing	1	4	2	2
Drying	2	1	0	0
Striga on Roots	1	1	1	0
Weak Stem	0	2	0	1
Dry/Hard Soil	2	0	0	0
Low Soil Fertility	1	0	0	0

The most commonly reported symptom of *Striga* attack on maize was stunted growth (93%) followed by low yield (80%). Only half of exposed farmers listed low yield, but 80% reported small or no cobs, which is essentially another way of stating “low yield.” Most farmers focused on the visible effects of *Striga* on maize; only two farmer teachers commented on the effect of *Striga* on soil health.

Table 2.15: Symptoms of Stemborer Attack on Maize

Stemborer Symptom	Farmer Teacher	PPT Adopter	Exposed to PPT	Not Exposed to PPT

Holing	9	9	9	4
Stunted Growth	2	3	2	5
Drying	4	2	0	2
Yellowing	3	3	2	0
Low Yield	0	2	1	4
Rotting	2	1	1	1
Liquid from Stem	1	0	0	2
Small Cobs	1	2	0	0
Weak Stem	0	1	0	2
Wilting	1	0	0	2
Dead Heart	1	0	1	0

The most commonly reported symptom of stemborer attack among all farmers interviewed was holing (78%), although only 40% of non-exposed farmers listed the symptom. 50% of non-exposed farmers stated "stunted growth" as a symptom, compared with 23% of all other farmers. No farmer teachers commented on low yields caused by stemborers, but 40% of non-exposed farmers did.

Table 3.5: Benefits of Push-Pull Technology vs. Gender

PPT Benefit	Male		Female	
	Frequency	Percent	Frequency	Percent
Striga/Stemborer Control	9	100	11	100
Increased Yields	9	100	10	91
Fodder	5	56	10	91
Increased Soil Fertility	2	22	4	36
Increased Dairy Production	2	22	2	18
Increased Income	2	22	1	9
Decreased Weeding Labor	0	0	1	9
Healthy Crops	0	0	1	9
Increased Farming Knowledge and Skill	1	11	0	0
Increased Soil Moisture	1	11	0	0
Soil Erosion Control	0	0	1	9

Most push-pull benefits were reported in similar numbers between men and women. Fodder, however, was listed by more women (91%) than men (56%). More women (36%) also reported increased soil fertility than did men (22%).

Table 3.6: Push-Pull Expansion

Push-Pull Expansion	Farmer Teacher	PPT Adopter
Yes	10	5
No	0	5

All farmer teachers had expanded their push-pull plots since adopting, but only half of the adopters had expanded. No farmers interviewed modified their push-plots in ways other than expansion.

Table 3.7: Knowledge of how Push-Pull Technology Controls *Striga* and Stemborers

PPT knowledge	Farmer Teacher	PPT Adopter
Yes	10	10
No	0	0

All project farmers interviewed knew and could explain how push-pull technology controls *Striga* and stemborers.

Table 4.4: Initial Source of Push-Pull Information vs. Gender

Initial Source	MPF	FPF	MNPF	FNPF
Barazas	1	4	0	0
field day	4	2	0	0
Icipe	1	3	3	0
fellow farmer	1	1	0	0
extension officer	1	0	1	0
farmer teacher	1	1	3	4
farmer field school	0	0	0	1
N/A	0	0	3	5

A distinct change in initial push-pull information sources is found between project and non-project farmers, but the differences between males and females are not as distinct. 36% of female project farmers and 11% of male project farmers first heard of push-pull from barazas. 44% of male and 18% of female project farmers learned about push-pull at field days. *icipe* was used more by female (27%) than by male project farmers (11%), but no female non-adopters learned from *icipe*, where as 43% of all male exposed non-adopters did.

Table 4.6: Farming Group Membership

Number of Farming Group Memberships	Farmer Teacher	PPT Adopter	Exposed to PPT	Not Exposed to PPT
0	0	4	3	5
1	2	4	6	4
2	6	1	1	1
3	1	1	0	0
4	1	0	0	0

I did not ask farmers for the exact number of farming groups they belonged to, but I did ask them to list their main farming groups, from which I calculated these numbers. All farmer teachers were a member of at least one farming group and most (80%) were a member of two or more. 40% of adopters, 30% of exposed farmers, and 50% of non-exposed farmers were not members of any farming groups. The majority of exposed farmers (60%) and 40% of non-exposed farmers were a member of one farming group.

Table 4.8: Farming Group Types

Group Type	Farmer Teacher	PPT Adopter	Exposed to PPT	Not Exposed to

				PPT
None	0	3	3	5
Women	6	1	1	1
General Farming	1	2	0	2
Organic Farming	3	1	0	1
Push-Pull	3	1	1	0
Widow	1	1	2	0
Horticultural	1	1	1	0
Seed Bulkers	1	1	1	0
Merry-go-round	0	1	1	0
Youth	0	0	1	1
Dairy Animal	0	0	1	0
Farmer Teacher	1	0	0	0
Fruit Tree	1	0	0	0
GOK Extension	1	0	0	0

The majority of farmer teachers (60%) were members of women groups. Even though 60% of farmer teachers were females, two of the six members of women groups were men. Farmer teachers also had a higher number of organic farming group members (30%). Interestingly, only one farmer teacher was a member of a farmer teacher group. Membership in other types of groups was scattered among the different respondent categories.

Table 4.9: Push-Pull Assistance

Push-Pull Assistance to Fellow Farmers	Farmer Teachers	PPT adopters
Yes	10	10
No	0	0

All project farmers interviewed said they had helped fellow farmers learn about push-pull technology.

Tables 4.12 – 4.15: Division of Household and Farming Labor

Farmers were asked if males, females, or both completed the following farming tasks.

Table 4.12: Plowing, Tilling, and Hand-digging

	MPF	FPF	MNPF	FNPF
Males	5	4	4	4
Females	0	0	0	0
Both	4	7	6	6

Table 4.13: Weeding

	MPF	FPF	MNPF	FNPF
Males	0	1	0	1
Females	1	7	0	3
Both	8	3	10	6

Table 4.14: Harvesting

	MPF	FPF	MNPF	FNPF
Males	0	0	0	0
Females	1	8	2	7
Both	8	3	8	3

Table 4.15: Bringing Goods to Market

	MPF	FPF	MNPF	FNPF
Males	0	1	1	1
Females	4	10	0	2
Both	3	0	3	0
no surplus	0	0	6	7
farm gate	2	0	0	0

Table 4.15 gives less insight into gender roles than it does into the socio-economic status of the farmers interviewed. All 20 project farmers grew enough to sell, while 65% of non-adopters did not have any surplus to bring to market.

Table 4.17: Hired Farm Labor

Hired Help	Farmer Teacher	PPT Adopter	Exposed to PPT	Not Exposed to PPT
Yes	2	1	2	4
No	8	9	8	6

Table 4.18: Hired Farm Labor vs. Gender

Hired Help	MPF	FPF	MNPF	FNPF
Yes	2	1	2	4
No	7	10	8	6

Most farmers did not hire help on their farms. 40% of female non-adopters, who account for most of the 40% of non-exposed farmers, hired labor. All other groups had percentages of 22% or less. Among the five women who hired labor, four were widows. The two oldest farmers, two males over 80, both hired help as well.

Table 5.2: Drought-Coping Mechanisms vs. Gender

Drought-Coping Method	MPF	FPF	MNPF	FNPF
Short-maturing Crops	5	2	4	1
Bucket Irrigation	0	2	2	6
Timely Agronomic Practices	3	1	3	0
Carry Water with Donkey	1	1	3	1
Pond/Water Pan	0	3	0	0
Crop Variety	2	0	0	0
Conservation	1	0	0	0

Agriculture				
Drought-resistant Crops	0	0	1	0
Water Channels	0	0	0	1
pedal or generator pump	0	3	3	0
None	1	4	2	3

Women were more likely than men to have no method of coping with drought and erratic weather (33% and 16%, respectively). The majority (56%) of male project farmers used short-maturing crops while only 18% of female project farmers, 40% of male and 10% of female non-adopters did. 60% of female non-adopters used bucket irrigation, but no male project farmers did. The only groups to use pedal or generator pumps were male non-adopters (30%) and female project farmers (27%). Female project farmers were the only farmers to dig water pans to collect rainwater. Generally, more males (32%) used timely agronomic practices than did women (5%).

Table 5.3: Pedal Pump Knowledge

	Farmer Teacher	PPT Adopter	Exposed to PPT	Not Exposed to PPT
Heard of Pump	10	10	10	9
Used Pump	5	1	2	2

All farmers interviewed had heard of pedal pumps, except for one female non-adopter who only knew of generator pumps. Half of all farmer teachers had used a pedal pump, but only 10% of adopters and 20% of non-adopters had.

Table 5.6: Interested in Obtaining a Pedal Pump

Interest in Obtaining a Pedal Pump	Farmer Teacher	PPT Adopter	Exposed to PPT	Not Exposed to PPT
Yes	8	9	6	8
No	2	1	4	2

While all project farmers thought they would benefit from a pedal pump, not all of them were interested in obtaining a pump because they already owned either a pedal or generator pump. The two non-exposed farmers were also not interested in pedal pumps because they already owned generators. On the other hand, the four non-interested exposed farmers had concerns about suitable water sources; two said they were focused on first obtaining a water source and two said the water sources available were too salty.

Table 5.13: Obtain Pedal Pump through Group Purchase vs. Gender

Obtain Pedal Pump through Group	MPF	FPF	MNPF	FNPF
Yes	5	5	4	6
No	4	6	6	4

Slightly less than half of all men interviewed (47%) and slightly more than half of all women interviewed (52%) would consider purchasing a pedal pump as part of a group.

Table 5.14: Potential for Pedal Pump Hire

Obtain Pump through Daily	Farmer Teacher	PPT Adopter	Exposed to PPT	Not Exposed to PPT

Lease				
Yes	6	3	2	3
No	4	7	8	7

Farmer teachers were the only group to have a majority (60%) think it possible for farmers to lease pedal pumps daily from a local individual. The majority of the other groups (70% of adopters, 80% of exposed farmers and 70% of non-exposed farmers) did not see leasing as a possible option. Most farmers were skeptical of leasing possibilities because they did not know of any pedal pumps for hire or believed that most people with pedal pumps had bought them only for individual use.

Table 5.15: Potential for Pedal Pump Hire vs. Gender

Obtain Pump through Daily Lease	MPF	FPF	MNPF	FNPF
Yes	4	5	3	2
No	5	6	7	8

Gender had no discernible effect on farmers' perceptions on the possibility of leasing a pedal pump. Most farmers did not see it as a viable option.

Appendix II

Focus Group Discussion with Non Push-Pull Farmers

Objective**:** To elicit general perceptions of women farmers on Striga and Stemborer constraints and how to control them in order to assess the knowledge gap between farmers who use PPT and those who do not.

1. Knowledge of Striga and control methods
   - What do you know about Striga and how it attacks maize?
   - How severely are your farms affected by Striga?
   - How have you attempted to control Striga?
2. Knowledge of Stemborers and control methods
   - What do you know about Stemborers and how they attack maize?
   - How severely are your farms affected by Stemborers?
   - How have you attempted to control Stemborers?
3. What do you know about push-pull technology?
4. Need and potential for pedal pump irrigation
   - Do you have problems with rainfall shortage?
   - Do you know about pedal pumps and think you could use them?
   - How do you think you would benefit from pedal pumps?
   - How would you obtain a pedal pump? If you cannot afford one, would group purchases or leases from individual investors be options?
5. Any socio-cultural barriers preventing women from obtaining new farming technology?
   - Who has power over different agricultural decisions?
   - Are there any socio-cultural barriers that women farmers face that may prevent them from investing in new technology?
   - Are women in the area allowed to invest in new technologies?
6. Sources of agricultural information
   - What are your agricultural information needs in the area?
   - Where do you get most of this agricultural information?
   - What is the best way for women to learn new agricultural information?

Focus Group Discussion with Push-Pull Farmers and Farmer Teachers

Objective**:** To elicit general perceptions of the women farmers on Striga and Stemborer constraints and how to control them as well as assess the role of women in the dissemination of push-pull technology.

1. Knowledge of Striga and control methods
   - What do you know about Striga and how it attacks maize?
   - How severely are your farms affected by Striga?
   - How have you attempted to control Striga?
2. Knowledge of Stemborers and control methods

- What do you know about Stemborers and how they attack maize?
- How severely are your farms affected by Stemborers?
- How have you attempted to control Stemborers?

3. Push-Pull Technology
    - How have you benefitted from push-pull technology?
    - Have you taught any other farmers about push-pull technology? How many?
    - How does push-pull technology control Striga and Stemborers?
4. Need and potential for pedal pump irrigation
    - Do you have problems with rainfall shortage?
    - Do you know about pedal pumps and think you could use them?
    - How do you think you would benefit from pedal pumps?
    - How would you obtain a pedal pump? If you cannot afford one, would group purchases or leases from individual investors be an option?
5. Any socio-cultural barriers preventing women from obtaining new farming technology?
    - Who has power over different agricultural decisions?
    - Are there any socio-cultural barriers that women farmers face that may prevent them from investing in new technology?
    - Are women in the area allowed to invest in new technologies?
6. Sources of agricultural information
    - What are your agricultural information needs in the area?
    - Where do you get most of this agricultural information?
    - What is the best way for women to learn new agricultural information?

Appendix III

Questionnaire Non-Push-Pull Farmers
Objective**:** To determine the level of knowledge of cereal production constraints and willingness of non-push-pull farmers to learn about Push-pull technology, the role of women in the dissemination of push-pull technology, and the potential for pedal pump irrigation as a means of empowering women farmers.

Date of interview: __________
Personal Information
Name: ______________________ Age:__________ Gender: [ ]Male [ ]Female
Tel contact: ____________________________
Area of Residence: a) District: ______________ b) Division: ___________________
c) Location: _____________ d) Village: ____________________

1. a) How many people live in your household? _____________________________
b) How many people in your household provide farm labor?
Men > 18 yrs [ ] Women > 18 yrs [ ] Boys 12 – 17 yrs [ ] Girls 12 – 17 yrs [ ] Children, both boys and girls [ ]
c) What is your marital status?
Single [ ] Married [ ] Widowed [ ] Divorced [ ] Other (specify) [ ]
d) What is the highest level of education you have attained?
None [ ] Non-formal [ ] Primary [ ] Secondary "O" Level [ ]
Secondary "A" Level [ ] College [ ] University [ ] Other (specify) [ ]
e) What are your main sources of income?
______________________ _______________________ ____________________

2 a) How much of your farm (in acres) is used for growing maize? _____________
b) How much of your farm (in acres) is used for growing other crops? _________
c) What are the other crops that you grow? ________________________________

3. What are the major farming constraints that you experience?
Striga:___ Stemborers: ___ Lack of inputs: ___ Lack of money: ___ Lack of farming knowledge: ___ Lack of extension services: ___ Lack of labor: ___
Other (specify): __

4. a)Are you having problems with Striga? Yes/No
b) If yes, how severe is your Striga problem? Very [ ] Severe [ ] Moderate [ ] Mild [ ]
c) Where do you think Striga comes from? ________________________________
d) What are the symptoms of Striga attack on maize and sorghum? ____________
e) What method(s) are you using to control Striga?
Intercropping [ ] Crop rotation [ ] Weeding/uprooting [ ] Other (specify)
f) How effective is(are) the method(s)?
Very effective [ ] Effective [ ] Moderately effective [ ] Not effective [ ]

5. a) Are you having problems with Stemborers? Yes/No
b) If yes how severe is your stemborer problem? Severe [ ] Moderate [ ] Mild [ ]
c) Do you know about the lifecycle of stemborers? Yes/No
d) What are the symptoms of stemborer attack on maize?
e) What method(s) are you using to control Stemborers?

Intercropping [ ] Crop rotation [ ] Weeding/uprooting [ ] Other (specify)
f) How effective is(are) the method(s)?
Very effective [ ] Effective [ ] Moderately effective [ ] Not effective [ ]

6. a) Have you heard about Push-Pull technology for the control of Striga and Stemborers? Yes/No
b) If yes, from where?
c) If no, are you willing to learn more about it? Yes/No

7. Who on your farm does the following tasks?

Household Tasks	Male	Female	Both
Plowing/tilling/hand digging			
weeding			
harvesting			
bringing goods to market			
fetching water			

8. What are your sources of agriculture information? (check appropriately)
Barazas: __ Publications: __ Radio: __ Fellow farmers: __
Seminars/Workshops: __ Farmer teachers/leaders: __ NGOs: __ Other (specify): ____________________

9. a) Are you a member of any farming groups? Yes/No
b) If yes, which ones? ____

10. a) Do you have any challenges with rainfall shortage? Yes/No
b) If yes, how do you cope with the problem? ____________________________

11. a) Have you ever heard about pedal pumps? Yes/No
If no, explain pedal pumps and continue to question 10c.
b) If yes, have you used one? Yes/No
c) Do you think you would benefit from a pedal pump? Yes/No
Explain: ____
d) If yes, how would you obtain a pedal pump? ___________________________
e) Do you have access to credit? Yes/No
f) If yes, are they formal [ ] or informal [ ] credit sources?
g) Would you consider purchasing a pedal pump as part of a farming group?
Yes/No Explain: ____
h) Do you think an individual investor would be able to purchase a pedal pump and lease it to local farmers? Yes/No Explain: ____________________________

12. Do you have any questions, comments, or concerns about anything discussed in this interview?

Thank you.

Questionnaire for Farmer Teachers and Fellow Push-Pull Farmers

Objective**:** To determine the role of women in the dissemination of push-pull technology and assess the potential for pedal pump irrigation as a means of empowering women farmers.

The respondent is: [ ] Farmer Teacher [ ] Project Farmer
Date of interview: __________
Personal Information
Name: ________________________ Age:__________ Gender: [ ]Male [ ]Female
Tel contact: ____________________________
Area of Residence: a) District: ______________ b) Division: ___________________
c) Location: _____________ d) Village: ______________

1. a) How many people live in your household? ______________________________
b) How many people in your household provide farm labor?
Men > 18 yrs [ ] Women > 18 yrs [ ] Boys 12 – 17 yrs [ ] Girls 12 – 17 yrs [ ] Children, both boys and girls [ ]
c) What is your marital status?
Single [ ] Married [ ] Widowed [ ] Divorced [ ] Other (specify) [ ]
d) What is the highest level of education you have attained?
None [ ] Non-formal [ ] Primary [ ] Secondary "O" Level [ ]
Secondary "A" Level [ ] College [ ] University [ ] Other (specify) [ ]
e) What are your main sources of income?
______________________ ______________________ ____________________

2 a) How much of your farm (in acres) is used for growing maize? _____________
b) How much of your farm (in acres) is used for growing other crops? _________
c) What are the other crops that you grow? ______________________________

3. What are the major farming constraints that you experience?
Striga:___ Stemborers: ___ Lack of inputs: ___ Lack of money: ___ Lack of farming knowledge: ___ Lack of extension services: ___ Lack of labor: ___
Other (specify): __

4. a) How many years have you been using push-pull technology? ______________
b) What was your source of information about push-pull technology? __________
c) What have you benefitted from using push-pull technology? _______________
d) Have you modified push-pull technology on your farm? Yes/No
e) If yes, how? ____
f) Have you helped other farmers to learn about push-pull technology? Yes/No
g) If yes, how many farmers have adopted push-pull technology because of you?

5. a)Are you having problems with Striga after staring to use Push-pull technology? Yes/No
b) If yes, how severe is your Striga problem? Very [ ] Severe [ ] Moderate [ ] Mild [ ]
c) Where do you think Striga comes from? ________________________________
d) What are the symptoms of Striga attack on maize and sorghum? ____________
e) What method(s) are you using to control Striga? Push-pull technology [ ] Intercropping [ ] Crop rotation [ ] Weeding/uprooting [ ] Other (specify)
f) How effective is(are) the method(s)?
Very effective [ ] Effective [ ] Moderately effective [ ] Not effective [ ]
g) Do you know how Push-pull technology controls Striga? Yes/No
h) If yes, explain briefly: ____

6. a) Are you having problems with Stemborers after starting to use push-pull technology? Yes/No

b) If yes, how severe is your stemborer problem? Very[ ] Severe[ ] Moderate[ ] Mild[ ]
c) Do you know about the lifecycle of stemborers? Yes/No
d) What are the symptoms of stemborer attack on maize?
e) What method(s) are you using to control Stemborers?   Push-pull technology [ ] Intercropping [ ] Crop rotation [ ] Weeding/uprooting [ ] Other (specify)
f) How effective is(are) the method(s)?
Very effective [ ] Effective [ ] Moderately effective [ ] Not effective [ ]
g) Do you know how push-pull technology controls Stemborers? Yes/No
h) If yes, explain briefly: ____

7. Who on your farm does the following tasks:

Household Tasks	Male	Female	Both
Plowing/tilling/hand digging			
weeding			
harvesting			
bringing goods to market			
fetching water			

8. What are your sources of agriculture information? (check appropriately)
Barazas: __ Publications: __ Radio: __ Fellow farmers: __ Farmer field schools: __ Farmer teachers/leaders: __ NGOs: __ Other (specify):

9. a) Are you a member of any farming groups? Yes/No
b) If yes, which ones? ____

10. a) Do you have any challenges with watering plants and rainfall? Yes/No
b) If yes, how do you cope with the problem? ______________________________

11. a) Have you ever heard about pedal pumps? Yes/No
If no, explain pedal pumps and continue to question 10c.
b) If yes, have you used one? Yes/No
c) Do you think you would benefit from a pedal pump? Yes/No
Explain:____
d) If yes, how would you obtain a pedal pump? ____________________________
e) Do you have access to credit? Yes/No
f) If yes, are they formal [ ] or informal [ ] credit sources?
g) Would you consider purchasing a pedal pump as part of a farming group?
Yes/No Explain: ____
h) Do you think an individual investor would be able to purchase a pedal pump and lease it to local farmers? Yes/No Explain: ____________________________

12. Do you have any questions, comments, or concerns about anything discussed in this interview?

Thank you.