Analysis of the Impact of Push-Pull Technology on Household Food Security and Nutrition in Eastern Uganda and Western Kenya

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Abstract

For over twenty years, push-pull technology has changed the lives of thousands of farmers and their families in Eastern Africa. Developed by Dr. Zeyaur Khan at the International Centre of Insect Ecology and Physiology (*icipe*), push-pull technology is a cropping system that "integrates pest, weed, and soil management with sustainable yield increases in cereal-based farming systems." For the duration on my Borlaug-Ruan International Internship, I worked on a study with Dr. Khan, Dr. Jimmy Pittchar, Dr. Charles Midega, and Matilda Ouma. This aim of this study is to analyze the impact of push-pull technology on household food security and nutrition in Western Kenya, and Eastern Uganda.

A hypothesis was derived from information based on previous studies on push-pull technology, which indicate that because of the control of stem-boring insects, the eradication of Striga weed, and the increase of soil fertility, the yields of cereal crops increases significantly. The hypothesis is: Push-pull technology provides farmers and their families with a sustainable cropping system that simultaneously addresses household food insecurity and improves household nutrition. Should this hypothesis be true, push-pull technology would reduce the prevalence of nutritional related illnesses, and address the issue of malnutrition throughout Eastern Africa.

Before the experiment takes place, a pretest was conducted with a group of push-pull farmers to determine the questionnaires efficiency. After the proper edits were made to the questionnaire, series of interviews and focus group discussions with male and female push-pull farmers took place in Migori County, Kenya and in Tororo District, Uganda. Through the quantitative analysis of data obtained from responses to these questionnaires and focus group discussions, the study explored the trends and themes regarding household food security and household nutrition because of adopting push-pull technology.

The data from this experiment highlights how push-pull technology has made a significant impact on household food security and household nutrition. The outcomes of this experiment suggest that the adoption of push-pull technology addresses household food insecurity and improves household nutrition, therefore proving the hypothesis. This experiment helps the global community understand the relationship among push-pull technology, food security, and household nutrition. Additionally, the results provide further insight on how push-pull technology could prove to be a viable alternative to traditional cropping methods in East Africa and abroad.

Background Information

ICIPE:

> "The idea was actually very simple: Get the very best people and then if you have more money, put buildings and equipment around them."
>
> -Thomas Risley Odhiambo, Founding Director of *icipe*

In 1970, acclaimed entomologist Thomas R. Odhiambo founded the International Center for Insect Physiology and Ecology, also known as *icipe*. Since its established over forty years ago, *icipe* has stood faithfully by its mission to "help alleviate poverty, ensure food security, and improve the overall health state of people of the tropics, by developing and extending management tools and strategies for harmful and useful arthropods, while preserving the natural resource base through research and capacity building."

My initial perception of *icipe* was that it conducted research exclusively on entomology, but my naivety was proven following a tour of the Centre's main campus in Nairobi, Kenya. The institute utilizes insect research for "…sustainable development, to ensure food security, and improve the overall health of communities in Africa by addressing the interlinked problems of poverty, poor health, low agriculture productivity, and environmental degradation." To effectively address these issues, the Centre conducts research embodied by the Centre's 4-H paradigm, denoting animal health, plant health, human health, and environmental health.

This multiple disciplinary approach enables the institute to assemble a team of scientists from diverse educational backgrounds including, but certainly not limited to entomologists, chemical ecologist, molecular biologists, and acarologists participating in research throughout over thirty countries in Africa. Additionally, through collaborations with national, regional, and international organizations, the Centre is conducting research in programs such as fruit fly IPM, animal Trypanosomiasis, Malaria, 'Push-Pull' IPM, and climate change and biodiversity.

ICIPE - Thomas Odhiambo Campus:

Established in 1977, the *icipe* Thomas Odhiambo Campus (ITOC) is nestled on the shores of Lake Victoria in the township of Mbita Point, Homa Bay County. In total, the station rests on roughly sixty acres of land with a large portion dedicated to experimentation fields. The ITOC is the location of most *icipe*'s field based research. Projects conducted at the station include 'Push-Pull' integrated pest management (IPM) Technology, various studies pertaining to Malaria and Tsetse, and fruit fly IPM.

Additionally, on the ITOC are the Mbita Point International School for primary students, St. Jude's Clinic, and housing facilities for the numerous scholars, international students, and scientists who participate in research and other projects at the station. My time at the ITOC was spent participating in research in the Habit Management, specifically in 'Push-Pull' IPM Technology.

'Push-Pull' Integrated Pest Management Technology:

Agricultural productivity is key to the success of small-scale farmers throughout Eastern Africa. In the region, most crop failures can be attributed to three limiting factors: *Striga* weed, stem-boring pests, and poor soil fertility due to the over usage of lands. However, many farmers in the region have could rid their plots of land of these nuisances by adopting 'Push-Pull' technology.

Ever since its invention in 1997, Dr. Zeyaur Khan has been directing the 'Push-Pull' program at the ITOC and making adaptation to the technology to address the continuously changing threats small-scale farmers face in Eastern Africa. 'Push-Pull technology (PPT) is a "…cropping system that integrates pest, weed, and soil management with sustainable yield increases in cereal based farming systems."

Before PPT, both *Striga* weed and stem-boring pests wreaked havoc on farmer's staple produce; however, PPT implements a sustainable and environmental friendly way to eradicate *Striga* and kill stemborers. By intercropping staple crops with desmodium, stemborers are 'pushed' away from the crops and, simultaneously, 'pulled' by the Napier/Brachiaria grass, which eventually kills the larvae stem-boring pests after they eggs are hatched. Moreover, the desmodium suppresses the *Striga* weeds and causes it to perform a suicidal germination, thus eradicating the parasitic weed from farmer's plots.

In addition to addressing the issues associated with Striga weed, and Stemborers, PPT provides farmers with additional benefits. First and foremost, the desmodium utilized to 'push' away the stem-boring pests, and eradicate *Striga* weed, also fixes nitrogen, which adds soil nutrients and conserves soil moisture. Furthermore, due to the limited amount of fertile grazing lands, many farmer's livestock suffer from fodder insufficiency, which results in additional hardships; however, desmodium, Napier grass, and Brachiaria grass all provide high quality feed for livestock, thus addressing the issue of fodder insufficiency and labor costs of free grazing.

Through research partnerships with the Rothamsted Institute, the Kenya Agriculture Institute, the National Agriculture Research Organization, the Lake Zone Agriculture and Development Institute, and other extensions partners, Dr. Khan aims to "end hunger and poverty for ten million people by extending PPT to one million households in sub-Saharan Africa by 2020."

Introduction

> "The people came out of their houses and smelled the hot stinging air and covered their noses from it. And the children came out of the houses, but they did not run or shout as they would have done after a rain. Men stood by their fences and looked at the ruined corn, drying fast now, only a little green showing through the film of dust."
>
> -John Steinbeck, *The Grapes of Wrath*, 1939

The quotation above is derived from the novel, *The Grapes of Wrath*, written by John Steinbeck in 1939. The novel is focuses on a family of poor tenant farmers who are evicted from their farm because of drought and economic hardships because of the changing agriculture industry in America and by the Dust Bowl. The Dust Bowl was an environmental catastrophe that plagued the America Midwest during the 1930s caused by the over cultivation of arid grasslands that were converted into croplands. Consequently, much of the soil's nutrients were depleted and led to miserable crop yields.

This quotation encompasses the emotions, hardships, and reality that small-scale farmers throughout Eastern Africa. Farmers come out of their houses watching the life slowly being sucked out of their maize, pondering how they will survive till the next raining season. With only a minimal yield of staple produce, they are forced to ration it sparingly, or sacrifice breakfast and lunch each day. In the short term, they can get by, but as time goes on further problems sprout. The children are unable to take-in adequate amounts of protein and start to develop symptoms of suffer from kwashiorkor. Their stomachs and cheeks begin to swell, their hair starts now has a rusty complexion, and frequently experience bacterial infections because their immune system begins to fail. Access to protein and a more balanced diet would easily rid them of the illness. Parents must work to generate extra income to pay for the hospital fees and purchase small amounts of supplemental food, meanwhile their sole source of income withers away. The farm can no longer sustain itself. Although the scenario above seems theoretical and dramatized, that is the reality for many small-scale farmers in Eastern Africa face; yet, farmers prove to be resilient and hope for a brighter and more prosperous tomorrow.

If the proper steps are taken, malnutrition in Eastern Africa, much like the Dust Bowl in America, can become a thing of the past. For many farmers who have successfully adopted "Push-Pull" Technology, malnutrition is indeed something of the past and no longer strikes fear into their heats. Children will no longer have to fall asleep while their stomachs yearn for food. Parents will no longer have to gaze upon plots filled with stunted maize and scorched earth. Families will prosper.

Methodology and Objectives

Methodology

This aim of this study was to analyze the impact of 'Push-Pull' technology on household food security and nutrition in eastern Uganda and western Kenya. A questionnaire was drafted to obtain quantitative information pertaining to the impact the 'push-pull' technology has on a farmer's household food security and nutrition.

Prior to experimentation, a pretest was conducted with 'push-pull' farmers in Migori County, Kenya to determine the questionnaires efficiency. After proper edits were made to the questionnaire, thirty interviews were administered in Tororo and Busia Districts in Easter Uganda. These interviewees were divided equally between female and male 'push-pull' farmers to ensure a balance in opinion based on gender. Icipe field extension officers randomly selected farmers who were required to have been practicing the 'push-pull' technology for at least one year. Interviews took place in non-formal, comfortable settings, and isolated from other farmers to prevent response bias among the respondents. In addition, a focus group discussion took place with fourteen 'push-pull' farmers from Migori County, Kenya to obtain further insight and information relevant to the study.

Through the quantitative analysis of data obtained from responses to these questionnaires and the focus group discussion, the study examined trends and themes regarding household food security and household nutrition because of adopting push-pull technology using a statistical analysis program (Statistical Package for Social Science).

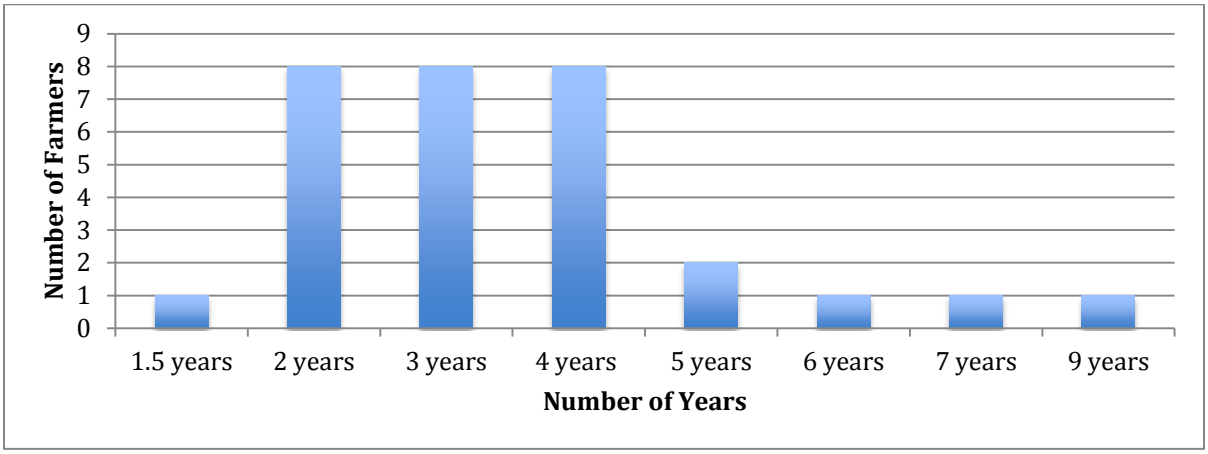
Research Objectives

1. Assess the benefits of push-pull technology and its impact on crop production to promote household nutrition
2. Assess the benefits of push-pull technology on livestock production and health to promote household nutrition
3. Explore the relationship between push-pull technology and income to address household nutrition
4. Determine the impact of push-pull technology on household health and food security

Results

Section A: Preliminary Household Information

Table 1 – Years of Participation



The majority of farmers, 80.1 %, have practiced the 'push-pull' technology in-between two and four years. Only three farmers have practiced the technology for longer than five years, and only one less than two years.

Table 4 – Age of Respondents

	30-39 years	40-49 years	50-59 years	60-69 years	70-79 years
Female	2	7	3	3	0
%	6.70%	23.30%	10.00%	10.00%	0.00%
Male	3	7	2	0	3
%	10.00%	23.30%	6.70%	0.00%	10.00%
Total	5	14	5	3	3
%	16.70%	46.70%	16.70%	10.00%	10.00%

The ages of the respondents fell in between thirty and seventy-none years of age. A plurality of the respondents, 46.7%, indicated that they were between forty and forty-nine years of age. The data suggests that there is an equal distribution between males and females. The oldest 30% of female farmers were between sixty and sixty-nine years of age, while the oldest 30% of male farmers were between seventy and seventy-nine years of age and were the oldest respondents of this study.

The total number of people in a household ranged from two to seventeen members with an average of roughly eight people. It is understood that the size of roughly 68% of the respondents ranged from five to thirteen members. The majority of households had slightly more females than males with the average number of males in a household ranging from three to four, and the average number of females in a household ranging from four to five. The average number of

children under the age of twelve in each household was about three; however, the maximum number of children was fifteen. This value is an outlier and was due to the fact that the respondent took care of orphans.

Table 4 – Level of Education

	Primary	**Secondary**	**College**	**University**
Total	11	14	1	4
%	36.70%	46.70%	3.30%	13.30%

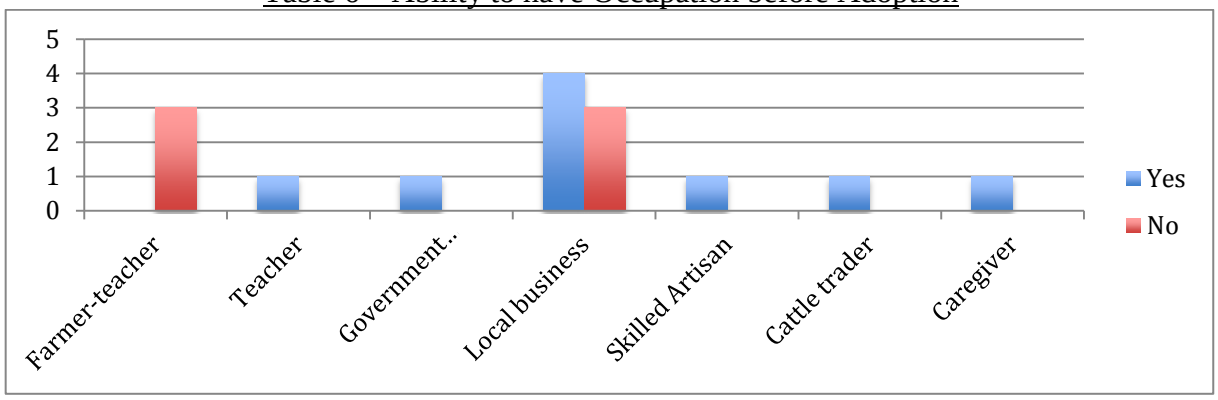
Regardless of the respondent's gender, every farmer had some level of education. The plurality of respondents, 26.7% males and 20% females, had gone to secondary school. The second largest group of respondents indicated that primary school was their highest level of education. Only four farmers, 16.6%, indicated that they received some level of education beyond secondary school. Three female farmers received a university level of education compared to only one male, while only one male went to college.

Table 5 – Total Acreage vs. Total Acreage Devoted to 'Push-Pull'

	¼ acres	**½ acres**	**¾ acres**	**1 ≤ x acres**	**Total**
1 ≤ x < 2 acres	1	0	0	0	1
%	3.30%	0.00%	0.00%	0.00%	3.30%
2 ≤ x < 3 acres	1	3	0	4	8
%	3.30%	10.00%	0.00%	13.30%	26.70%
3 ≤ x < 4 acres	2	1	0	1	4
%	6.70%	3.30%	0.00%	3.30%	13.30%
4 ≤ x acres	3	3	2	9	17
%	10.00%	10.00%	6.70%	30.00%	56.70%
Total	7	7	2	14	30
%	23.30%	23.30%	6.70%	46.70%	100.00%

56.7% of the respondents indicated that they owned at least four acres of land, but only 30% of those respondents said that they had 'push-pull' plots measuring at least one acre. 20% of the female 'push-pull' farmers and 26.7% of the male 'push-pull' farmers said that they had 'push-pull' plots larger than one acre. There is no significant relation between the gender of the respondent and the size of his or her 'push-pull' plot or land holdings.

Table 6 – Ability to have Occupation before Adoption



Half of the respondents, the majority being females, indicated that they had an occupation in addition to being 'push-pull' farmer. 87.5% of the females, who had an additional occupation, either ran a local business or were farmer-teachers. No male farmers indicated that they were farmer-teachers. Of the farmers who had an additional occupation, 46.7% of them ran local businesses. The majority of farmers were able to have their occupations before adopting the push-pull technology. However, 40% of the males could have their occupation before adoption compared to 20% of the females.

Section B: Push-Pull Technology and Crop Production

Table 1 – Amount of Maize Seed Used and Yields Before and After Adoption

	Amount of Seeds Used Before (kg)	**Amount of Seeds Used After (kg)**	**Yields Before (kg)**	**Yields After (kg)**
Mean	4.1786	3.6	198.1429	902
N	28	30	27	30
Median	3	2	90	450

On average, the amount of maize seed farmers used within the measurements of their 'push-pull' plot decreased 0.6 kilograms. Before adopting the 'push-pull' technology, the average amount of seeds used was roughly 4.2 kilograms compared the average amount used after being 3.6 kilograms. In addition to the amount of maize seeds used, the 'push-pull' farmers experienced a significant increase in maize yields. Where the average yield of maize was about 198 kilograms, the average yield of maize after adopting rose to 902 kilograms. The median ratio of maize seeds used to yield before adopting the 'push-pull' technology was one kilogram of maize seed planted to thirty kilograms of maize harvested. The median ratio after adoption is one kilogram of maize seed planted to 225 kilograms of maize harvested. Both the amount of maize seeds used and yields before and after is in part dependent on the size of the farmer's 'push-pull' plot. Additionally, regardless of the 'push-pull' technology, 73.3% of the farmers reported that droughts still negatively affect their maize crop yields, but is less severe than before. Two farmers began farming with the 'push-pull' technology without prior use of traditional cropping methods.

Table 2 – Size of Cobs

Size Before Adoption		
	Frequency	**Percent**
Small	26	92.90%
Large	2	7.10%
Total	28	100.00%

Size After Adoption		
	Frequency	**Percent**
Medium	1	3.30%
Large	29	96.70%
Total	30	100.00%

Most farmers indicated that there was a change in the size of the maize cobs after they adopted the 'push-pull' technology. Before adoption, 92.9% of the farmers produced cobs that were considered to be 'small', while a minority of respondents considered their cobs to be large. However, after adoption, twenty-nine farmers considered their cobs to be 'large', while only one farmer considered her cobs to be 'medium-sized'. Furthermore, three farmers mentioned that drought negatively affected the size of their cobs regardless of the 'push-pull' technology, but indicated that the size was still larger than it was before adoption.

The majority of farmers experienced an increase in the number of cobs each stem produced. Before, 82.1% of the farmers interviewed produced at most one cob per stem on average, while 17.9% produced between one and two cobs. After adoption, 90% of the stems began to produce between two and three cobs. However, the number of cobs per stem is dependent on the type of seeds used, but only one farmer was aware this.

Table 4 – Type of Fertilizer Used

Following the adoption of the 'push-pull' technology, there was an increased in the use of fertilizers among farmers. Farmers also began using NPK and organic compost in addition to diammonium phosphate (DAP), carbamide (UREA), and manure, all of which were already being used in farming systems. Before adoption, 82.1% of the farmer used no type of fertilizer, and only 10.7% of the farmers used manure as fertilizer despite 82.1% of them owning at least one livestock animal. The number of farmers using fertilizer increased once the 'push-pull' technology was adopted with only 6.7% saying that they do not currently use any type of fertilizer. A majority of the respondents used at least manure, or DAP. Following DAP, and manure, UREA was the third most commonly used type of fertilizer.

Table 5 – Intercropped Produce

Before the adoption of the 'push-pull' technology, 35.7% of the respondents did not practice intercropping, while 57.1% practiced intercropping with at least beans, 21.4% with at least soybeans, and only 3% with at least cassava. With the adoption of the 'push-pull' technology, there was decrease in the number of farmers who intercropped beans, soy and cassava. Only three of the respondents intercropped desmodium with another type of produce.

Table 6 – Fodder Produce

82.1% of farmers did not produce any sort of livestock fodder before adopting the 'push-pull' technology despite 82.1% of the farmers owning at least one livestock animal. The plurality of

the farmers who did indeed produce fodder before adoption, 14.3%, produced Napier grass, while no farmers produced Mulato grass (Brachiaria grass). However, following after adopting the technology, 100% of the farmers produced at least two types of fodder produce. Napier grass was more commonly produced compared to Mulato grass. Overall, adopting the 'push-pull' technology enabled farmers to produce their own feed for livestock and poultry animals.

Table 7 – Surplus Produce

The most popular thing to do with surplus produce by nearly all of farmers was to feed the fodder produce it to their livestock animals. The majority of the farmers did not feed staple produce to their animals. 73.3% of the farmers indicated that they sold their surplus maize produce to generate extra income. In a few cases, farmers only sold their surplus produce when their children were in school to generate an income in order to pay for their children's school fees. In 13.3% of the cases, farmers often opt to give their surplus produce to their neighbors or to members of their family if they are in need in addition to other things. None of the farmers indicated that they did not have surplus produce since they adopted the 'push-pull' technology.

Section C: Push-Pull Technology and Livestock

Table 1 – Farmer's Reason for not Owning Livestock Before Adoption

	Frequency	**Percent**	**Valid Percent**
Lack of funds	1	3.30%	14.30%
Lack of feed	6	20.00%	85.70%
Total	7	23.30%	100.00%
Not Applicable	23	76.70%	
Total	30	100.00%	

In total, seven out of the thirty farmers interviewed did not own any livestock before adopting the 'push-pull' technology. Only one farmer said that they did not own livestock before adoption due to financial reasons, but the other six attributed their lack of ownership to problems associated with feed. Meaning that they either could not afford nutritional feed, or that they could not afford to take time to graze their animals. 100% of farmers who did own livestock before adopting the 'push-pull' technology said that their livestock animals suffered from fodder insufficiency.

Table 2 – Type of Livestock Owned

Type of Livestock Before Adoption			
	N	**Percent**	**Percent of Cases**
Local cow	10	22.20%	33.30%
Hybrid cow	1	2.20%	3.30%
Local goat	13	28.90%	43.30%
Bull	5	11.10%	16.70%
Pigs	6	13.30%	20.00%
Sheep	1	2.20%	3.30%
Rabbit	1	2.20%	3.30%
None	7	15.60%	23.30%
Local calf	1	2.20%	3.30%
	45	100.00%	

Type of Livestock After Adoption			
	N	**Percent**	**Percent of Cases**
Local cow	11	23.90%	37.90%
Hybrid cow	2	4.30%	6.90%
Local goat	16	34.80%	55.20%
Bull	6	13.00%	20.70%
Pigs	7	15.20%	24.10%
Local calf	4	8.70%	13.80%
Total	46	100.00%	

A majority of farmers owned livestock before adopting the 'push-pull' technology. 43.3% of farmers owned local goats, with local cows being the second most frequent livestock animal owned before adoption. Compared to before, only one farmer did not own any livestock animals after adopting the 'push-pull' technology. Although local goats and local cows remain the most frequently owned livestock animals, the frequency of these animals increased after adoption. No farmers owned rabbits or sheep after adoption.

Table 3 – Animal Products Produced

	N	**Percent**	**Percent of Cases**
Milk	12	22.60%	40.00%
Meat	8	15.10%	26.70%
Eggs	6	11.30%	20.00%
Manure	20	37.70%	66.70%
Labor	6	11.30%	20.00%
Not applicable	1	1.90%	3.30%
Total	53	100.00%	

The two most frequent animal products produced were manure and milk each representing 66.7% and 40% of the cases respectively. Only a minority of the population used their animals to produce meat. Labor was labeled as an animal product because farmers often hire other farmer's bulls to plow fields, or conduct other labor extensive chores. One farmer only owned one local calf so he was unable to produce any animal products yet.

Table 4 – Purpose of Animal Products

	N	Percent	Percent of Cases
Consume	17	27.00%	56.70%
Sell	18	28.60%	60.00%
Share with neighbors/family	1	1.60%	3.30%
Use as fertilizer	20	31.70%	66.70%
Hired labor	6	9.50%	20.00%
Not applicable	1	1.60%	3.30%
	63	100.00%	

All farmers who produced manure used it as fertilizer for their farms. A majority of farmers also consumed and sold their animal products, while only 3.3% shared their products with family or neighbors. All of the farmers who owned bulls hired them out to other farmers to generate income, or exchanged their services for other goods such as milk.

Table 5 – Quantity of Milk Produced

Quantity of Milk Produced Before			
	N	**Percent**	**Percent of Cases**
0 Liters	2	16.70%	16.70%
1 Liters	4	33.30%	33.30%
2 Liters	4	33.30%	33.30%
4 Liters	1	8.30%	8.30%
5 Liters	1	8.30%	8.30%
Total	12	100.00%	

Quantity of Milk Produced After			
	N	**Percent**	**Percent of Cases**
1 Liters	1	8.00%	8.00%
2 Liters	2	16.70%	16.70%
3 Liters	3	25.00%	25.00%
4 Liters	4	33.30%	33.30%
5 Liters	1	8.30%	8.30%
8 Liters	1	8.30%	8.30%
Total	12	100.00%	

Before farmers adopted the 'push-pull' technology, most farmers who owned cows (66.6%) indicated that their cows produced between one to two liters of milk per day. In 16.7% of the cases, farmers' cows produced no milk due, while only a minority of farmer's cows produced more than four liters per day. After adoption, most farmers (58.3%)indicated that each cow they owned produced between three to four of milk a day. All farmers' cows produced at least one liter of milk with the maximum number of liters increasing from five to eight liters.

Table 7 – Combination of Feed After Adoption

100% of the farmers who owned livestock before adopting the 'push-pull' technology (23) said that their animal suffered from fodder. Most farmers (91.3%) grazed their animals on local grass, while only 8.7% grazed their animals and fed them a Napier grass as well. Only one farmer purchased feed for his livestock before adoption.

Of the twenty-nine farmers who owned livestock after adopting the 'push-pull' technology, all said that their animals do not suffer from any fodder insufficiency. All farmers used desmodium in their feed combination. Between the Napier and the Mulato grass, more farmers used Napier grass in their feed combination. 6.9% of the farmers included some of their maize harvest in their feed combination. Only one farmer did not own any livestock after she adopted the 'push-pull' technology, but she intended to obtain a hybrid cow from the government.

Most the famers who owned livestock before adopting the 'push-pull' technology (63.3%) said that the overall health of their livestock improved after adoption. Only 13.3% said that the overall health of their livestock did not change after adoption. No farmers said that the health worsened.

Section C: Push-Pull Technology and Income

Table 1 – Average Sales of Cereal Consumed and Sold

	Quantity consumed before (kg)	**Quantity consumed after (kg)**	**Quantity sold before (kg)**	**Quantity sold after (kg)**
Mean	175.8519	360.1667	37.4074	442.3333
N	27	30	27	30
Std. Deviation	197.54799	313.84568	87.16	904.296
Median	90	270	0	135

Both the average quantity of cereal consumed and average quantity of cereal sold increased after adopting the 'push-pull' technology. The average quantity consumed increased from roughly 176 kilograms to about 360 kilograms after adopting, while the average quantity sold increased from about 37 kilograms to roughly 442 kilograms. The standard deviation values are large due to some farmers owning larger plots of lands than others and therefore able to produce larger quantities of cereal grain. Thus, the median values are a more reasonable representation of the average quantity of cereals consumed and sold.

Table 2 – Average Sales of Milk Consumed and Sold

	Quantity consumed before (liters)	Quantity consumed after (liters)	Quantity sold before (liters)	Quantity sold after (liters)
Mean	4.85	5.9091	1.3	3.0909
N	10	11	10	11
Std. Deviation	3.66705	4.96396	2.86938	4.90825
Median	4	4.5	0	1

The average quantity of milk consumed and sold increased as well after farmers adopted the 'push-pull' technology. The average quantity of milk consumed rose about 1.1 liters of milk, while the average quantity of milk sold increased about 1.8 liters. Most farmers were unable to sell any quantity of milk before adoption due to low milk yields.

Table 5 – Extra Income

	N	Percent	Percent of Cases
Pay school fees	26	44.10%	86.70%
Purchase more livestock	5	8.50%	16.70%
Invest in farm	6	10.20%	20.00%
Domestic uses	12	20.30%	40.00%
Pay workers	4	6.80%	13.30%
Building projects	2	3.40%	6.70%
Promote business	2	3.40%	6.70%
Pay bills	2	3.40%	6.70%
Total	59	100.00%	

The standout majority of farmers (86.7%) paid school fees with some of their additional income. 40% of farmers used their extra income on domestic uses including, but not limited to purchasing clothes, additional foods, and medicine. Only 6.7% of the farmers used their extra income to start building projects, to promote their business, or to pay their bills. 20% chose to use extra income to invest in new farming projects, while 16.7% used extra income to purchase additional livestock.

Of the thirty farmers, twenty-eight believed that the 'push-pull' technology enabled their household to diversify its income. Because of adopting the 'push-pull' technology, 64.3% of farmers said they could sell surplus crop produce, while 21.4% indicated that adoption enabled them to sell surplus milk. 14.3% said that they were able to use their bulls as a method to generate income. Only 3.5% of the farmers said that they sold seeds, sold their fodder, or acquired an additional occupation as a result of the 'push-pull' technology.

Only one farmer said that there are no economic costs cut because of adopting the 'push-pull' technology. Most farmers who believed that there were economic costs cut because of the technology (62%) said it cut labors costs in regards to weeding, grazing livestock, and hiring

other farmers to work their land. 31% of farmers said that they did not have to purchase staple foods from the market because of increased yields. A minority of farmers indicated that they saved money on feeds (20.7%), or that they saved money on seed (3.4%).

Section D: Push-Pull Technology and Nutrition

Table 1 –Breakfast Meal Combination

Combination Before Adoption		
Animal protein	**Plant protein**	**Carbohydrates**
4	3	14

Combination After Adoption		
Animal protein	**Plant protein**	**Carbohydrates**
13	13	28

Before the adoption of the 'push-pull' technology, 60% of farmers said that they had breakfast every day; while the remaining 40% indicated that their family would normally go without it. Although 60% indicated that they ate breakfast before adoption, only 46.7% had a breakfast with at least one of the following: carbohydrates, vitamins, animal protein, and plant protein. A majority of the farmers indicated that they would consume dry tea (tea without milk) or porridge with a source of carbohydrates such as cassava, or maize/millet bread. In only 13.3% of the cases were families able to have a source of protein with their tea such as groundnuts or milk.

After adoption, all farmers said they could eat breakfast regularly; however, two farmers still only were able to drink dry tea for breakfast. All but 16.6% of the farmers consumed at least one source of protein during breakfast, and all but 6.7% consumed a source of carbohydrate during breakfast after adoption.

Table 2 – Lunch Meal Combination

Combination Before Adoption			
Animal protein	**Plant protein**	**Carbo-hydrates**	**Vitamins**
8	14	26	23

Combination After Adoption			
Animal protein	**Plant protein**	**Carbo-hydrates**	**Vitamins**
22	23	30	30

86.7% of the farmers ate lunch every day before adopting the 'push-pull' technology. The remaining 13.3% of the farmers said that they could go without lunch. Of the farmers who ate lunch, 76.7% had a source of vitamins during meals, while 66.7% consumed a source of protein during lunch. Families would consume meat on average one to two times a week. All farmers were able to eat lunch every day with a source of carbohydrates, and vitamins. Only one farmer indicated that her family did not consume meat on a regular basis. On average, families who ate meat would consume it three to four times a week for lunch.

Table 3 – Supper Meal Combination

Combination Before Adoption			
Animal protein	**Plant protein**	**Carbo-hydrates**	**Vitamins**
11	16	26	23

Combination After Adoption			
Animal protein	**Plant protein**	**Carbo-hydrates**	**Vitamins**
25	21	30	30

13.3% of the farmers said that they did not eat supper before adopting the 'push-pull' technology, while the remaining 86.7% of farmers said that they ate supper every day. 10% of the farmers only consumed a source of carbohydrates for supper. Proteins were consumed by only 53.3% of the farmers in which 36.7% consumed meat on average one to two times a week. All farmers indicated that they could have supper consisting of at least a source of carbohydrates, vitamins, and a source of protein after adopting the 'push-pull' technology. On average, families who ate meat would consume it three or four times a week for supper.

Table 4 – Perceived Nutritional Benefits

Access to milk	**Balanced diet**	**Assured staple produce**	**Reduction in prevalence of illnesses**
6	13	9	2
20.00%	43.30%	30.00%	6.70%

Most plurality of farmers (43.3%) thought that the most nutritional benefit of the 'push-pull' technology is that it promotes a balanced diet. For the farmers who had limited access to milk before adoption, the access to milk was the most important benefit of adoption. 30% of the farmers believed that having an assured staple produce throughout the year was the most beneficial outcome. The smallest minority of farmers (6.7%) believed that he reduction in the prevalence of illnesses was the most beneficial impact.

Section E: Push-Pull Technology and Health and Food Security

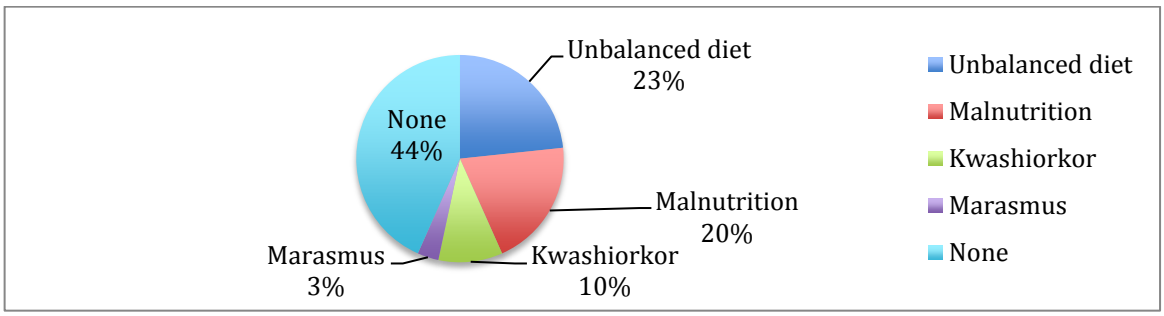
Table 1 – Most Severe Month(s)

Most Severe Month(s) Before			
	N	**Percent**	**Percent of Cases**
Spring months	25	39.70%	83.30%
Summer months	15	23.80%	50.00%
Fall months	4	6.30%	13.30%
Winter months	17	27.00%	56.70%
Not a problem	2	3.20%	6.70%
Total	63	100.00%	

Most Severe Month(s) After			
	N	**Percent**	**Percent of Cases**
Spring months	1	3.30%	3.30%
Not a problem	29	96.70%	96.70%
Total	30	100.00%	

Before adopting the 'push-pull' technology, farmers experienced levels of food insecurity throughout the year. The most common response was during the spring months from March to May in which 83.3% of farmers identified this season as the most severe. About half of the respondents indicated that June through August, and December through February were equally difficult. A minority of the respondents identified that the fall months (September through November) were the most severe. Two farmers said that their household did not suffer from any food insecurity before adoption. However, after the adoption of the 'push-pull technology, 96.7% of the farmers indicated that they were food secure throughout the year, while only one farmer indicated that he had trouble during the spring months.

Table 2 – Nutrition Related Issues



Most farmers (56.7%) said that their children suffered from a nutrition related issue. The plurality suffered from not having a balanced diet, while one fifth of the farmers said their children suffered from malnutrition. Four farmers could identify nutrition related illnesses in which three said their children suffered from Kwashiorkor and one said his children suffered from Marasmus. Both illnesses are caused by a lack of protein consumption. To address these issues, one third of the farmers purchased additional foods, 10% either worked to generate extra

income, or made visits to hospitals/clinics, and 6.7% modified their children's diets to prevent the illnesses in the future.

56.7% of the farmers said that family relations improved after adopting the 'push-pull' technology, 43.3% said that family relations remained the same, and no farmers said that relations worsened. Overall, both family relations and household health improved because of adoption.

Table 3 – Climate Change

Effect of Climate Change		
	N	**Percent of Cases**
Crop failure	22	73.30%
Loss of soil fertility	5	16.70%
No effect	3	10.00%
Total	30	100.00%

How PPT Addresses the Issue		
	N	**Percent of Cases**
Replenishes soil nutrients	8	26.70%
Assured yields	19	63.30%
No change	3	10.00%
Total	30	100.00%

Most farmers believed that climate change has, at some point in time, negatively affected their household food insecurity. 73.3% thought that drought causing crop failures was the most negative impact, while the loss of soil fertility was more severe to 16.7% of the population. Of the twenty-seven farmers who had been negatively affected by climate change, 63.3% said that even during a drought, their 'push-pull' plot will provide them with enough yields to last them throughout the season, while 26.7% said that the 'push-pull' technology replenishes soil nutrients and counteracts the loss of soil fertility as a result of climate change.

Overall, all of the farmers believed that they could prosper from just their 'push-pull' project. The plurality of farmers, 33.3%, felt this way because they became self-sufficient as a result of adoption. 30% said that they could prosper form just their 'push-pull' plot because of the increased crop yields, while 23.3% felt this way because they now had a balanced diet. Only 6.7% said they could because it eradicates Striga weed and stemborers.

Discussion

Malnutrition proves to be a major constraint on the prosperity of lives of small-scale farmers in Eastern Uganda and Western Kenya. In Kenya alone, malnutrition contributes to an estimated one third of the total deaths among children under the age of five. That number is almost doubled in Uganda as it contributes to roughly two thirds of the deaths. This epidemic is attributed with the posing threats of climate changes, the decreasing amount of farmland suitable for agriculture, and populations that continue to increase year after year. 'Push-Pull' technology was developed to address some of these issues to promote sustainable living among small-scale farmers in Eastern Africa. The aim of this study was to analyze how the technology impacts household nutrition and food security in Western Kenya and Eastern Uganda.

It is important to understand that all the farmers interviewed believed that there was not one standout factor that improved their household's nutritional status and food security. Instead, they agreed that it was a combination of numerous components, which were enabled by 'Push-Pull' technology.

It is well known and widely understood that 'Push-Pull' technology results in increased cereal crop yields, but the technology's impact on crop production goes beyond just an increase in yields. Every farmer interviewed realized that because of adopting the technology, the overall health of his or her cereal crops and soil improved greatly, which equates to not only a more nutritional staple crop, but also a more valuable commodity. The increased yields enabled farmers to have stable source of food throughout the year, while also enabling them to acquire additional foods, or service by selling and trading their surpluses.

Understanding the reasoning behind why 23.3% of the farmers interviewed did not own livestock before adopting 'Push-Pull technology is key to realizing the impact it has on livestock health. Most farmers who did not own livestock before adoption said it was because they did not have access to feed. This problem was experienced by all the farmers who owned livestock before adoption whose animal suffered from fodder insufficiency. However, after adoption, a consensus was made that this was no longer a problem due to that fact that 'Push-Pull' technology provides farmers with a high-quality livestock fodder in the form of desmodium, Napier grass, and Brachiaria grass resulting in the overall improvement in the health of farmer's livestock, and the quality and quantity of their livestock products including milk.

In a study conducted at Washington State University, researchers concluded that there was a connection between the health of the livestock animals and the health of their owner and his or her family. They concluded that the health between the two was connected in three ways: socio-economic in which the income achieved from livestock products provided farmers and their family's access to healthcare options, and education, nutritional in which a healthier livestock animal provides farmers with more nutritional products such as milk, and meats, and zoonotic in which the transmission of transferable diseases decreases and are less prevalent. This connection the health of humans and livestock proves to be a promising endeavor.

Because of adopting 'Push-Pull' technology, the increase in yields provides farmers with the opportunity to sell their products to generate extra income without sacrificing their household's

food security. Farmers practicing 'Push-Pull' are now able to diversify their income, and are cutting economic costs that were required in their traditional plots like weeding, and not having to purchase staple produce. Although an increased income does not guarantee food security or improved nutrition, it must be taken into consideration as it enables families to send their children to school, purchase additional, nutritional foods, access to healthcare, and the ability to expand and invest in their farm.

After adoption, farmers tended to not only eat more frequently on average, but also tended to consume more nutritious and balanced meals. Before, many families lacked protein in their diets, which leads to numerous nutritional problems and illnesses such as Kwashiorkor and Marasmus, but increased once 'push-pull' was established. Furthermore, the plurality of farmers who said their family did not maintain a balanced diet, which spurred further illnesses due to a weakened immune system. Additionally, the number of vitamins and micronutrients increased since farmers were now able to purchase diverse foods. To address these nutritional related illnesses, farmers were had no other choice, but to spend whatever money they had to purchase supplemental foods, visit hospital or local clinics, or even take time out from farming and perform casual labor to increase their household's income.

An interesting theme was revealed after the completion of all of the interviews. Many of farmers said that although they were able to eat breakfast, lunch, and supper on a regular basis, the size of their meals was significantly smaller. In other words, it was the size and composition of the meals that changed greatly as a result of adoption, and not necessarily the frequency of the meals. An equally noteworthy theme that was originally observed in the focus group discussion, the majority of farmers believed that family relations improved as a result of adopting 'Push-Pull' technology. In the absence of food and the presence of malnutrition, family relations become strained. Many male farmers who recognized a change in family relations said that they are less stressed because there is now enough food to feed everyone in the family and there is no longer fighting between their wives.

Farmers indicated that through 'Push-Pull' technology, they are now able to produce enough maize to last throughout the year, at least until the next harvesting season. This was a major problem before in which farmers said that their family struggles the most during the spring and summer months when they are planting and growing their crops. However, this problem has decreased significantly after adoption.

Climate change is a major constraint on the productivity of small-scale farmers in Eastern Africa. The loss of soil fertility, and drought wreak havoc and destroy crops resulting in poor yields. Farmers identified both issues as major problems that had a major impact on their household's food security before the adopted the 'push-pull' technology. However, after adoption, the farmers who said that their food security was negatively affected by climate changes believed that 'push-pull' assures them just enough yields to get through the year, and that the soil replenishes its nutrients.

Conclusion

When farmers were asked if they believe their household could prosper from just their 'push-pull' project, all responded with confidence. "Yes!" was their answer. Whether it is the facts that they are able access to more diverse and nutritional food, or they can achieve self-sufficiency, the impact of 'Push-Pull' technology has an immense impact on household nutrition and food security among small-scale farmers in Eastern Uganda and Western Kenya.

With 100% of the respondents saying that there are visible, nutritional benefits of adopting the technology, 'Push-Pull' has the potential to alleviate poverty throughout Eastern Africa and beyond. The eradication of Striga weed and stemborers is merely the tip of the iceberg. The access to high quality livestock fodder provides farmers with the opportunity to raise and reap the rewards of owning health livestock animals. The ability to produce a surplus of staple produce enables farmers to generate income without sacrificing the health or security of the family. The ability to afford to send children to school ensures a brighter and better tomorrow where poverty and food insecurity ceases to exist.

In addition to its impact on household nutrition and food security, 'Push-Pull' technology works to address the issues presented by climate. As climate change becomes more pressing issue, its impact on the agricultural productivity in Eastern Africa is a major reason why many people suffer from severe food insecurity. The loss of soil fertility and drought place a burden on small-scale farmers who are pressured to provide food for their family. Farmers who were interviewed and participated in the focus group discussion, for the most part, agreed that 'Push-Pull' technology promotes soil and soil biota conservation, increased soil fertility, and assures enough yields to prosper while traditional systems fail leave families with minimal results.

Nutrition is key to the success on a farm and to ending the cycle of poverty and food insecurity in the world. A balanced diet provides the body with the proper amount of proteins, carbohydrates, vitamins, and other micronutrients required to perform everyday activities. The opportunity costs of neglecting to maintain a balanced diet can be critical to the productivity on a small-scale farm. The time taken to care for family members who suffer from nutrition related illnesses could be used to harvest that last bag of maize before it spoils. The money needed to pay for hospital visits and drugs could have been used to save up for that heifer cow that would have enabled the household to produce milk. Small-scale farmer cannot afford to have unbalanced diets. The need to address this issue is now, not a few years in the future because malnutrition is not merciful.

Recommendations

Throughout the duration of my study, I proposed questions that were designed to analyze the impact of a technology on a problem, but when I was not asking questions I was making acute observations on other problems that were present that required immediate attention to ensure efficiency and the preservation of this novel technology.

1) **Creating markets for livestock fodder:** One of the most profound benefits of adopting 'Push-Pull' technology is the access to high quality livestock fodder. Livestock can consume only a certain amount of fodder, and once their limit is reached farmers often are left with surplus fodder produce. Often, farmers will choose to sell their fodder produce at local markets to diversify their household's income; however, many farmers stated that there is not a profitable market for the 'push-pull' fodder produce now. In parts of Northwestern Kenya, the demand for livestock feed is essential due to the lack of grazing land, but this issue is not present in the areas of Uganda or Kenya where this study took place. Measures should be taken to expand this market for 'push-pull' farmers in order expand the technology's profitability and influence.
2) **Promoting networks and partnerships among 'push-pull' farmers:** When asked about the benefits of 'Push-Pull' technology in a focus group discussion, farmers agreed on several important expected benefits such as increased yields, and the eradication of Striga weed and stemborers. In additions to these advantages, farmers also came to a consensus that adoption established a sense of unity among 'push-pull' farmers. The creation of partnerships among 'push-pull' farmers will encourage the exchange of ideas about expansion and adaptation of the technology, open the possibility for farmers to source inputs in bulk to generate more income and decrease the opportunity costs of having multiple farmers going to the market. It would additionally inhibit farmers from feeling left behind or neglected as expansion occurs, which was a concern among farmers during the focus group.
3) **Combating misconceptions about the technology:** My initial perception on why farmers do not easily adopt 'Push-Pull' technology was because of cultural reasons and the refusal to abandon traditional agriculture methods; however, the responses of the farmers in the focus group indicated that it is because of attitudinal reasons. Farmers feel that the required labor-intensive establishment phase does not provide a return on investment. Measures need to be taken to falsify these misconceptions in order efficiently expand the technology's adoption and influence.
4) **Creating a livestock acquisition plan for farmers:** The adoption of livestock is crucial to the success and efficiency of 'Push-Pull' technology. A successful livestock project wields to capability to lift farmers above the poverty line and bring about food security. This trend was seen throughout the extend of this study in which farmers who owned livestock animals, most notably milk producing cows, were better off than those who did not own any. One farmer's story highlights this idea perfectly. This 'push-pull' farmer from Tororo County, Uganda mentioned how she was initially unable to afford to own even a local cow, so she started a rabbit project feeding them desmodium from her 'push-pull' plot. Rabbits can reproduce at faster rates compared to other livestock animals such as goats, or pigs. Thus, they prove to be a "quick and easy" way to generate income. The establishment of a concrete methodology modeled after how she obtained a dairy cow,

could ensure ‘push-pull’ farmers access to both meat and milk, both of which are key to a balanced diet.

5) **Expanding field extension services and education:** All the preceding recommendations share one theme: education. Without education, both the expansion and the current influence of ‘Push-Pull’ technology would eventually fail. Therefore, it is important to provide farmers with education opportunities to enrich their understanding of the technology and what it provides them. This can be done with the expansion of field officers and stations to provide aid to current ‘push-pull’ farmers, and to expand the technology’s reach. Education about nutrition is also a necessity. Increasing awareness will help to eliminate current habits that inhibit balanced diets.

In the end, it is up to the farmer to decide how he or she wants the stability, health, and future wants to be. With aid from organizations, researchers, and their community, they can achieve self-sustainability and prosperity. Africa wields tremendous agricultural potential to become the solution to the global food crisis, but the right measures must to be taken to ensure productivity and stability.

Personal Experience

I was exposed to the world's diversity at a very young age. I grew up listening to my dad tell me stories about his experiences working in the Peace Corps in Mali and Chad during the 1980s. I played on a travel soccer team composed of players from Ecuador to Liberia to Jamaica to China. I attended a high school in which most students were first generation Americans. Thus, I developed an acute awareness to the numerous religions, cultures, and ethnicities of the world without leaving Florida. Despite my globalized upbringing, my experience in Kenya and Uganda opened my eyes to an entirely new perspective on the world, its inhabitants, as well as its future.

I graduated from my high school the evening of June 12th, and I was on a plane to John F. Kennedy International Airport the morning of June 13th. I did not have much time to prepare for my departure, to say goodbye to my lifelong friends who would be in college by the time I returned home, or to compose myself for the journey that I was about the embark on. To be honest, how could I truly prepare myself for such a formative and enriching experience? I merely had a theoretical background in scientific knowledge and research. In high school, I spent years learning about the application of science in the real world, but never had I applied my knowledge to anything meaningful, or impactful. Not to mention the fact that I would have to start college immediately after my return to Florida. All these concerns and questions, among other things, swirled around in my head throughout the flights to Nairobi. However, as soon as I stepped onto the tarmac at Jomo Kenyatta International Airport, I accepted the notion that two months from then I would be an entirely different person.

While much of my experience was spent either interviewing farmers in villages throughout rural parts of western Kenya and eastern Uganda, and within the walls of the icipe compound in Mbita, I would spend my weekends observing both countries through the lens of a tourist and a "local". From Ruma National Park where I stood within one-hundred meters of a giraffe, to Sipi Falls where I stood behind the cascading waters of a waterfall, I never ventured anywhere without my camera. However, there is more to the region than just tourist hotspots. I discovered that the time I spent taking pictures and walking about the town of Mbita was the most memorable and fulfilling. I could capture the emotions of children returning home after a long day at school, the communication between a farmer and his client, the relationship between Lake Victoria and the community, as well as the looks I received by everyone as I strolled down the street.

Although I was a foreigner living in a strange land, one thing brought my closer to the people of Kenya: our shared love for soccer. Most evenings, I spent my time playing soccer with children, teens, and adults from the Mbita township. It was by far the most rewarding part of my journey. Not only did I establish a personal relationship with twenty-two unique individuals, but I further developed an appreciation for the sport that I love, and the resources that I had at my disposal growing up that my teammates in Kenya did not possess: multiple soccer balls, goal nets, a level playing surface. I remember searching for plastic water bottles, candy wrappers, and paper towels to use instead of cones to outline

the pitch. The last night I spent playing soccer was emotional. I had spent two months building a strong relationship with people who I would more than likely never have the opportunity to see again. Walking back to the guest house, I took one looks back at my teammates who were standing there waving at me, and yelling “Good bye my friend!”

I boarded my plane to Nairobi as an eager, anxious, and inexperienced recent high school graduate about to embark on the journey of a life time. Throughout my time in both Kenya and Uganda, I experienced a great deal of personal growth. My transition from high school graduate to college freshman was facilitated by this experience. I had developed an unimaginable amount of maturity, responsibility, and confidence that I did not have coming out of high school. I find it difficult to express my gratitude to those who made this experience possible for it has changed how I perceive the world, and has made me a more global citizen.

Analysis of Push-Pull Technology on Household Food Security and Nutrition

Date of interview: _____ Name: _____ Age: ____
Gender/Sex: ____ Village: _____ Country: _____ Sub County: _____ County: _____ How many years of push-pull practice: _____

Section A: Household Characteristics:

1. How many males: _____ How many females: _____ How many in household: _____
2. How many children (under 12 years of age): _____
3. Marital status: _____
4. Education (Place a √ in the corresponding box):

None	Non-formal	Primary	Secondary "O" level
Secondary "A" level	College	University	

5. Total land acreage (in acres): _____
   i. Total acreage devoted to push-pull technology: _____
6. Do you have an occupation other than farming? Yes / No
   i. (Please specify): _____
   ii. If yes, were you able to have this occupation before you adopted push-pull technology? Yes / No

Section B: Benefits of Push-Pull Technology and Produce

7.	**Before 'Push-Pull'**	**After 'Push-Pull'**
Amount of maize seeds used (kg)		
Yields (kg)		
Number of cobs per stem/size		
Type of fertilizer/manure used		
Intercropped produce		
Fodder produce		

8. If applicable, what do you do with the surplus produce
   a. Sell the surplus b. Share with neighbors/family c. Feed to livestock d. Other (please specify): _____

Section C: Benefits of Push-Pull Technology and Livestock

9.	**Before PPT**		**After PPT**			
Type of livestock	#	Quantity (lts)	Type of livestock	#	Quantity (lts)	Health of livestock animals

   i. If you did not own livestock before you adopted push-pull technology, briefly explain why: _____
10. Before you adopted push-pull technology, did your livestock animals suffer from any fodder

insufficiency? Yes / No / Not applicable

ii. If yes, which animals? _____

11. What types of animal products do you produce (select all the apply):
    a. Milk b. Meat c. Eggs d. Manure e. Other (please specify): _____
12. What do you do with your animal produce (select all that apply)?
    a. Consume b. Sell c. Share with neighbors/family d. Use as fertilizer
    f. Other: _____
13. How did you obtain feed for your livestock before you adopted push-pull technology?
    _____

i. What combination of feed do you use as fodder for your livestock now?
_____

Section D: Push-Pull Technology and Income

14.	**Sales of Cereals (kg)**	**Sales of Milk (liters)**
Quantity Consumed Before 'Push-Pull'		
Quantity Sold Before 'Push-Pull'		
14.	**Sales of Cereals (kg)**	**Sales of Milk (liters)**
Quantity Consumed After 'Push-Pull'		
Quantity Sold After 'Push-Pull'		

15. Has push-pull technology enabled your household to diversify its income? Yes / No
    i. Briefly explain your answer: _____
16. Have there been economic costs cut by push-pull technology? Yes / No
    i. If yes, please explain: _____
17. What do you do with your extra income? _____
    _____

Section E: Push-Pull Technology and Nutrition

18. Are there any visible, nutritional impacts of adopting push-pull technology? Yes / No
    i. Briefly explain your answer: _____

19.	**Before Push-Pull**	
	Meals per days	**Typical Meal Combination**
Breakfast		
Lunch		
Supper		

19.	**After Push-Pull**	
	Meals per days	**Typical meal Combination**
Breakfast		

Lunch		
Supper		

Section F: Push-Pull Technology and Health

20. What types of health problems/nutrition related illnesses were prevalent among children in your household before you adopted push-pull technology?
    _____
    i. How did your household address these problems?
    _____
    ii. What was the indicator? _____
21. Before you adopted push-pull technology, during pregnancy and breastfeeding, do you feel you were, or do you feel your wife had a balanced diet? Yes / No
22. Do you feel that nutrition related illnesses among children have increased in frequency, have decreased in frequency, or have similar frequencies since you adopted push-pull technology?
    _____
23. How have family relations changed since you adopted push-pull technology? _____
    _____
24. Do you believe your household could prosper from just your push-pull project? Yes/ No
    i. Please explain your answer: _____

Section G: Push-Pull Technology and Food Security

25. Before you adopted push-pull technology, during which months did you not have enough food or did you have to buy staple produce? _____
    i. After you adopted push-pull technology, during which months did you not have enough food or did you have to buy staple produce? _____
26. Before you adopted push-pull technology, how did natural disasters affect your household's food security? _____
    i. How has this changed since you adopted push-pull technology? _____

Notes: _____
_____

Focus Group Discussion with Push-Pull Farmers

Research Objectives:

5. Assess the benefits of push-pull technology and its impact on crop production to promote household nutrition
6. Assess the benefits of push-pull technology on livestock production and health to promote household nutrition
7. Explore the relationship between push-pull technology and income to address household nutrition
8. Determine the impact of push-pull technology on health and food security

Objective: To obtain perceptions of push-pull practicing farmers on the relationship between push-pull technology and household nutrition.

1. Are there cultural hindrances that prevent the adoption of push-pull technology?
    a. *Decision maker*
    b. *Gender roles in farming*
    c. *Access to education*
    d. *Traditional farming methods*
2. Benefits of using push-pull technology
    a. *Yields*
    b. *Labor costs*
    c. *Soil fertility*
    d. *Income*
    e. *Damage of stemborers and Striga weed*
    f. *Home-grown feed for livestock*
3. As a result of adopting push-pull technology, how has your life changed?
4. How does an increased income from the push-pull technology contribute to household nutrition?
    a. *Increased food availability*
    b. *Additional income for investment*
    c. *Increased food accessibility*
    d. *Surplus money to buy other food items*
    e. *Quality of life*
5. Why is household nutrition key to the success of a farm?
    a. *Health benefits*
    b. *Various labor benefits*
    c. *Additional expenses*
6. Effects of push-pull technology on household nutrition and food security
    a. *Sustainable farming*
    b. *Steady income and safety net*
    c. *Address parasitic weed and stemborers*
    d. *Yields*

7. *How does Push-pull technology benefit both human health and animal health?*

    a. *More nutritious livestock fodder*
    b. *Benefits from increased income*
    c. *Increased milk yields*
    d. *More food available*
8. What are the benefits of a sustainable farm?
    a. *Economic independence*
    b. *Environment*
    c. *Social*