AN ANALYSIS OF CLIMATE CHANGE AND ITS IMPACTS ON SMALLHOLDER 'PUSH-PULL' FARMERS IN WESTERN KENYA

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INTRODUCTION

Hunger impacts the world, not just the hungry. This fact was pressed into my mind, body, and soul with a force greater than any I could have imagined. Images of hunger and poverty are forever tattooed onto my soul, but so, too, are the smiles of my Kenyan friends, the unfailing strength of the African people, and the memories of a summer too impactful to describe.

Kenya left a deep impression on me—I imagine each child's handshake left a print on my heart. Hope and modesty were forever instilled in me upon seeing a schoolboy's eyes widen—with a matching smile—when offered a piece of American chocolate. I was humbled at seeing elderly widows, hardened by the perils of poverty, staying strong despite everything. The way passion and eagerness captivated the children as I taught them about science made me feel like a mentor, an inspiration. The Kenyan people became my family, and the villages were my home. I became a part of Kenya, and I was changed by my experience in ways I could never have imagined before. In Africa, I learned how to harness my potential and put it all toward making the world a better place. And that, truly, is an extraordinary feat.

The International Centre of Insect Physiology and Ecology

Founded in 1970 by renowned African entomologist Thomas Odhiambo, the International Centre of Insect Physiology and Ecology—or as it is more commonly known, *icipe*—aims to "help alleviate poverty, ensure food security and improve the overall health status of peoples 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," according to the Centre's mission statement.

The previously stated mission of *icipe* well describes the objectives of the organization. Objectives, indeed, that are becoming increasingly more relevant as insects continue to have a substantial influence—both positively and negatively—on agricultural, social, and economic development in Africa and around the world.

The Centre is headquartered in Nairobi, Kenya, and possesses several field research stations throughout the nation. Each campus of *icipe* is equally determined to make significant advances in its four divisions, namely Plant Health, Animal Health, Human Health, and Environmental Health. The Centre, since its founding over four decades ago, has attracted the attention of some of the world's foremost researchers in entomology and from other disciplines, and has compiled an array of articles, publications, programs, and presentations ranging in topic from commercial silk production to malaria vectors.

The influence of *icipe* among Kenya's subsistence farming population matches its prestige in the scientific community. Various programmes facilitated by the Centre are geared toward benefitting local smallholder farmers in the field as well as the household, including—to mention just a couple—the Bioprospecting Unit and the Commercial Insect Programme which encourages the involvement of farmers in the production and distribution of honey, silk, beeswax, and other products.

Thomas R. Odhiambo Field Station, Mbita Point

The Thomas R. Odhiambo campus of *icipe*, bearing the name of the Centre's founder and first Director General, is located on the shore of Africa's Great Lake—Lake Victoria—at Mbita Point, Kenya, approximately 400 kilometres west of Nairobi. The Mbita Point campus contains multiple

projects being conducted by research foundations, non-governmental organizations (NGO), and universities from all across the globe. In addition to the extensive, groundbreaking research efforts taking place on-site, the campus also houses an international primary school and a medical clinic.

Research teams in Mbita grapple with some of Africa's most pressing concerns: malaria vectors, agricultural sustainability, climate change—just to name a few. Institutions from around the world, such as the Nagasaki University Institute of Tropical Medicine, are stationed here tackling research questions that are becoming increasingly important for the future development of Africa and the world.

Push-Pull: A Novel Strategy for Africa and the World

The Push-Pull project, invented and directed by Dr. Zeyaur Khan from *icipe*'s Mbita Point Field Station in Mbita, Kenya, is "having a dramatic effect on entire rural communities and economies," according to a statement made by *icipe*'s current Director General, Professor Christian Borgemeister. Push-Pull is a revolutionary system that has made efforts to combat some of Africa's most devastating agricultural constraints—namely stem-boring insects, the parasitic *Striga* weed, and poor soil quality—immensely more efficient and effective for over 46,000 East African subsistence farmers to date.

Indeed, Push-Pull's incorporation of biological means of pest control is perfectly suited for East-African agriculturalists: it is simple, effective, and vastly more affordable than other means of control, such as the use of costly synthetic pesticides and fertilizers, which also can have substantial and devastating effects on the environment.

In these times of unprecedented climatic, economic, and environmental uncertainty, maintaining efficient, sustainable, and innovative agricultural operations has become a major concern for area farmers, and *icipe*'s promotion of Push-Pull technology has effectively begun to encourage agricultural success and food security among farmers.

Push Pull Technology employs two innovative plant species that, together, work in maize fields to eradicate stem-borer populations, improve soil conditions, and rid farmers of the aesthetically beautiful but devastating Striga weed. The team, under the direction of renowned entomological researcher Dr. Zeyaur Khan, has worked diligently toward perfecting the system, which increases maize yields in most cases by over 100% (Planting for Prosperity, *icipe*, 2011. http://www.push-pull.net/planting_for_prosperity.pdf). The strategy: intercrop maize and desmodium, a perennial legume and good quality livestock fodder that repels stemborers—the "Push"—and simultaneously eliminates Striga by the secretion of chemicals that discourage its growth.

The "Pull" aspect of the revolutionary system lies in another plant species, *Pennisetum purpureum*, or more commonly: Napier grass, which possesses a combination of qualities that are lethal to stemborer populations. The grass, which in the Push-Pull system is planted in border rows around maize plots, is more attractive to the pests than the maize itself, thus luring the borers away from the susceptible maize crop. What's more, the Napier grass offers farmers another, perhaps more substantial benefit. Namely, when the pests burrow into the Napier, the larvae face physical entrapment by way of an adhesive gum secreted by the grass, rendering them incapable of completing their life cycle.

In addition to the ability of Napier grass to attract and devastate stemborer populations in Push-Pull plots, it is useful also as livestock fodder—it is widely grown in the area already for that purpose. Desmodium and Napier grass jointly tackle four agricultural constraints that are among the most pertinent faced by lower-income, smallholder farmers in the area: stemborers, Striga, soil fertility, and the availability of livestock fodder.

icipe

African Insect Science for Food and Health

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ABSTRACT

The global climate is becoming an increasingly pertinent world issue. As the human population continues to increase, the demand for food, fuel, and other resources worldwide will balloon to extremes that society has never before experienced. What's more: meeting this demand is rapidly becoming very difficult, particularly in developing nations where utilization of sustainable agricultural pursuits is becoming less of a political focus. Increased population is inevitably coupled with an increase in Greenhouse Gas (GHG) emissions, which is a factor often considered one of the primary causes of climate change—a phenomenon that is proving to be a serious constraint to food production in places such as Sub-Saharan Africa, and thus a somber threat to food security.

This study, conducted in the Suba and Bondo Districts of western Kenya, analyzes and compares the perspectives of subsistence farmers regarding the impacts of climatic changes on agricultural productivity and family livelihood. Participating farmers utilized either traditional agricultural methods or Push-Pull Technology, a revolutionary system developed by the International Centre of Insect Physiology and Ecology that simultaneously eradicates three of the biggest constraints to productivity in the area: stem-boring insects, parasitic Striga weed that inhibit crop growth, and soil degradation.

INTRODUCTION

Climate Change is quickly becoming an issue of very relevant concern for agriculturalists around the world. According to an article produced by the secretariat of the United Nations Framework Convention on Climate Change (UNFCCC), an increase of temperature of just 1-2.5° C could result in decreases in yields, thus jeopardizing food security for millions of people worldwide. In the same article, the UNFCCC cites a very impactful prediction: "Over the next decades, it is predicted that billions of people, particularly those in developing countries, face shortages of water and food and greater risks to health and life as a result of climate change" (UNFCCC, 2007).

Climate change is an extraordinary topic, and it is not one that should be taken lightly. It is impacting many peoples, in many places, and in vastly different ways. A 2006 article also by the UNFCCC secretariat notes the increasingly real impacts and blatantly clear physical and social consequences of such drastic changes if no action is taken to combat it (UNFCCC, 2006).

Nyanza Province in Western Kenya, like many parts of Africa and the world, is already experiencing the wrath of shifting climatic patterns, and realizing the toll drought and heat can take on agricultural productivity, family livelihood, social behavior and morale, as well as financial security on the farm and in the home.

Agriculture in the region is suffering without large-scale methods for adaptation to climate change, and entire harvests are being lost as a result of drought conditions, fluctuating seasonal patterns, and soaring temperatures—thus posing a very real threat to food security and farm-family livelihood.

Adaptation is the necessary direction, and the dissemination of information is the key to sustainable agricultural development in that regard.

METHODOLOGY AND OBJECTIVES

Objectives

The first objective of this study is to assess the perceptions of smallholder farmers regarding changes in climatic trends, and their awareness of methods to combat those changes and adapt agricultural practices accordingly in order to ensure future farm success, financial well-being, and food security. Factors considered in this regard include the past and present levels of farm productivity, the perceived climate changes and their effect as observed by the farmers, social condition, and livelihood.

Another objective of the study is to assess the quantity and quality of adaptation-related information that has been made available to farmers by way of farmer meetings, field events, seminars, publications, and through various other forums. Also, the study sought to evaluate generally how frequently and effectively agricultural and adaptation-related information is being passed from one generation to the next.

Methodology

A questionnaire was used in the study to collect data on the perceptions of farmers regarding changes in climate. The document was meticulously designed and tested prior to official administration (see Appendix 2).

The study, which was conducted in the Suba and Bondo Districts of Western Kenya, involved 61 participant farmers. 31 farmers resided in the Suba District, and the remaining 30 in the Bondo District.

To ensure a reasonable amount of uniformity in the sample, the 61 farmers were divided as equally as was possible, regarding gender, sub-location, and System of Operation (SO). Of those 61 farmers, 31 were female and 30 were male. 16 female farmers were selected from the Suba District, and the remaining 14 were male. In the Bondo District, of the 30 surveyed farmers 15 were female and the remaining 15 were male.

Another level of comparison among participating farmers that was considered in the study was system of operation. Farmer participants fit into one of two systems either Push-Pull (those who utilized Push-Pull Technology) or Non Push-Pull (those who practiced traditional agriculture). In the Suba District, 16 of the 31 farmer participants were practicing Push-Pull, while the remaining 15 utilized a more traditional system. In the Bondo District, 15

farmers were selected from each system of operation, totalling 30 participants.

Each participant was subjected to an interview session of approximately 30 minutes, wherein the appropriate questionnaire fields were completed. All interviews took place on either the farmer's homestead or in an informal public setting. After data collection, participants' responses were compiled and entered into a statistical analysis program (Statistical Package for Social Science, version 11.5) for review. Data were then analyzed and considered on several levels, including comparison between systems of operation, location, gender, age, and level of education.

In addition to the individual surveys, two focus group discussions among Push-Pull farmers were facilitated by the study. These discussions involved a total of 100 Push-Pull farmers, and took place one each in the Vihiga and Kisumu Districts.

RESULTS

AGE DEMOGRAPHICS

Participant farmers ranged in age from 22-82 years, with the mean age of all participants being 48. Approximately 85 percent of all participating farmers had 60 years of age or less.

A higher number of male participants occupied the uppermost age brackets (61 years of age and older), with a ratio of 8 to 1. 60 percent of the male participants had at least 48 years of age, compared to 45 percent of females.

In the lowest age bracket (22-34 years), males accounted for 70 percent of the participants. The majority of female participants—about 87 percent—fit into the two median age brackets (35-47 and 48-60 years), compared to just 50 percent of all men.

The majority of all participants in the lowermost age brackets (22-34 and 35-47 years), regardless of gender, resided in the Suba District, making up 62 percent of those participants. Meanwhile, the remaining 38 percent of participant farmers in those age brackets were from the Bondo District.

100 percent of participants who had received some form of post-secondary education fit into the two median age brackets (35-47 and 48-60 years), though no other significant correlation between age and level of education was present in the sample.

EDUCATIONAL DEMOGRAPHICS

Fortunately, the lowermost tier of Education Level—namely, the absence of any sort of formal education—contained less than 10 percent of all participating farmers (9.8%). Women accounted for 100 percent of the participants in this tier. Two-thirds of participants who had received no formal education resided in the Bondo District, with the remaining portion in the Suba District.

Approximately 54 percent of farmer participants' educations culminated at the primary level. The distribution of farmers with Primary-level education between the two districts was relatively even, with 45.5 percent of participants in the Suba District, and the remaining 54.5 percent in the Bondo District.

At the Secondary level, participants had either completed secondary school ("O" Level), or had discontinued their secondary education before its finish, either at Form 1 or Form 2. 29.5 percent of participating farmers had reached the Secondary level of education, with a majority of those participants reaching "O" Level and completing secondary school, at 61.1 percent (see Table 1).

TABLE 1: *LEVEL OF EDUCATION*

Level	Frequency	Percentage
No Education	6	9.8
Primary	33	54.1
Secondary 1/2	7	11.5
Secondary "O"	11	18.0
Post-Secondary	4	6.6

Only 6.6 percent of participants in the study had received any sort of post-secondary education. Of that 6.6 percent, 75 percent were male, and the remaining 25 percent were female. 75 percent of participants with post-secondary education resided in the Bondo District, and the remainder in the Suba District.

Two-thirds of all participants that had not received any formal education whatsoever were not utilizing Push-Pull Technology on their farm, while

100 percent of participating farmers that had attended school at the post-secondary level were using Push-Pull.

SYSTEM OF OPERATION DEMOGRAPHICS

In total, two-thirds of the participant farmers that hadn't received any sort of formal education had not adopted Push-Pull Technology, but rather were utilizing a more traditional system. The results of this study show that 100 percent of the participants with post-secondary education were utilizing Push-Pull Technology. Also, over 81 percent of participants that had received formal education beyond the Primary level were practicing Push-Pull (see Table 2).

Of those participants that had adopted the Push-Pull SO, the average number of years since adoption was approximately 6.8. The majority (61.3 percent) of Push-Pull users had been using the technology for less than seven years, with the most substantial portion of the sample in the "4-6 Years" bracket, at 41.9 percent of all participants utilizing Push-Pull Technology (see Table 3).

TABLE 2: *EDUCATION BY SYSTEM OF OPERATION*

	Utilisation of Push-Pull	
	Yes	No
No Education	2	4
Primary	11	22
Secondary 1/2	6	1
Seconday "O"	8	3
Post-Secondary	4	0

When asked the number of maize sacks (90kg) that were harvested the season prior to the survey, farmers that utilized Push-Pull Technology in their maize plots generally harvested more maize than those who hadn't adopted the technology, with the average participant using Push-Pull Technology harvesting about 9.6 sacks of maize. On the other hand, the average farmer utilizing a traditional systemvbrought in less than half of that—only 4.6 sacks in the last season.

Only about 6.7 percent of farmers using traditional systems of operation harvested ten sacks of maize or more in the previous season, compared to 32.3 percent of farmers using the Push-Pull system. Of the Push-Pull farmers that had harvested ten sacks or more in the previous season, 70 percent of them had been using the system for at least seven years. Conversely, 73.6 percent of farmer participants that use Push-Pull and had harvested six sacks or less had been using the system for six years of less. Therefore, a positive correlation between the amount of maize harvested and the number years since the adoption of Push-Pull Technology is evident. This correlation is based solely on the number of sacks harvested, not the number of sacks per acre of cultivated land.

TABLE 3: *YEARS USING PUSH-PULL*

Years Using Push-Pull	Frequency	Percentage
1-3	6	19.4
4-6	13	41.9
7-9	3	9.7
>10	9	29.0

Analysis indicated that 83.3 percent of all of the farmers that brought in ten or more sacks of maize during the previous harvest had adopted Push-Pull. Furthermore, only one participant utilizing a traditional system had harvested twenty sacks or more (see Table 4).

TABLE 4: *SYSTEM AND MAIZE HARVEST*

Last Maize Harvest (90kg sacks)	Frequency	
	SYSTEM OF OPERATION	
	Push-Pull	Other
<1	1	3
1-3	14	14
4-6	4	10
7-9	2	1
10-19	5	1
20-29	3	0
>30	2	1

When asked to rate the impact level of problematic insects on the farm, the majority (60.7 percent) of all farmers that responded with "high" or "very high" impact levels were not utilizing Push-Pull. Therefore, the farmer participants utilizing Push-Pull Technology comprised only 39.3 percent of responses in those brackets. The highest percentage of all respondents, regardless of system of operation,

indicated that insect problems have an "average" impact on the farm—accounting for 52.5 percent of participants' responses.

The Striga weed—another very pressing constraint to agricultural productivity in the area—was rated as having a "high" or "very high" impact on farm productivity by approximately 82 percent of respondents, regardless of system of operation. Of those farmers that utilized a traditional system, 43.3 percent, and 61.3 percent of all farmers that utilized Push-Pull Technology rated Striga as a "very high" constraint to productivity, accounting for 52.5 percent of all the responses.

Though the majority of participating farmers rated Striga as having either a "high" or "very high" impact on productivity, a smaller portion of the sample rated Striga as an "average" or even a "low" level constraint. These responses in total accounted for approximately 18 percent of the sample. A miniscule 3.3 percent of farmers rated Striga as a "low" level constraint. 100 percent of farmers that gave that response had adopted the Push-Pull system of operation.

90 percent of all participants in the study rated the level of soil fertility on their farm as "low" or "average," with a relatively even distribution between systems of operation. Approximately 4.9 percent of respondents rated the soil fertility as "high," 3.3 percent rated "very low," and the remaining 1.6 percent—comprised only of Push-Pull Technology users—rated their level of soil fertility as "very high."

USAGE OF LAND AND RESOURCES

73.7 percent of participants own six acres of land or less. Of the remaining 26.3 percent, 68.8 percent of participants had less than twenty acres of land in their possession. In total, only 3.3 percent of farmer participants owned more than 30 acres of land, and the average acreage per farmer was approximately 6.6 acres (see Table 5).

Farms wherein Push-Pull was being utilized accounted for 81.8 percent of all of the farms that were comprised of ten acres or more. The majority of farms (65.6 percent) that were comprised of three total acres or less belonged to farmers that were not utilizing Push-Pull Technology.

82 percent of all farmer participants cultivated six acres of land or less, and the average number of cultivated acres per farm was 3.6. The lowest percentage of cultivated acreage reported was 14 percent, while several farmers claim to cultivate 100 percent of usable land on their farm. On average, farmers that participated in the study cultivated approximately 71.46 percent of their total acreage.

Table 5: *TOTAL ACREAGE*

Number of Acres	Frequency	Percentage
<1	3	4.9
1-3	29	47.5
4-6	13	21.3
7-9	5	8.2
10-19	6	9.8
20-29	3	4.9
>30	2	3.3

No farmer that utilized Push-Pull Technology cultivated less than 20 percent of their usable land, and only 4.9 percent of all participating farmers cultivated less than 30 percent of their property. The majority of farmers (64.3 percent) that cultivated over 90 percent of their total acreage did not utilize Push-Pull Technology. This is likely due to the fact that the average total acreage for farmers using traditional systems in the study was significantly less than those using Push-Pull.

92.8 percent of farmers that had cultivated over 90 percent of their total acreage owned no more than six acres. Two-thirds of farmers that owned less than one acre in total had cultivated over 90 percent. Similarly, two-thirds of all farmers that cultivated 30 percent or less of their total acreage owned thirty acres or more. No farmer that owned thirty acres or more cultivated over 30 percent of their property. This suggests that as total land area increases toward the maximum in the sample, the percent of land being utilized for agricultural production decreases, and vice versa.

Regarding education, there were no farmers from either system that owned more than six acres without having attended school at the Primary level. As for the relationship between level of education and maize harvest, farmers that participated in the study who hadn't received any formal education whatsoever did not exceed the "4-6 sacks" bracket. Thus, a positive correlation between obtaining *some*

level of formal education and the quantity of maize harvested is evident. No other significant correlations between the levels of education and the number of sacks harvested were present in the analysis.

Maize, by far, was the most common crop, grown by 98.4 percent of all of the farmer participants. Other widely used crops among surveyed farmers included beans (88.5 percent), sorghum (72.1 percent), and vegetables (72.1 percent). Cassava, a traditionally drought-tolerant crop, was being used on 42.6 percent of farms.

Of those farmers that utilized Push-Pull Technology, 100 percent were currently using maize in their Push-Pull plots. Other crops used by farmers in Push-Pull plots included sorghum and beans, but those crops appeared in a significantly lower percentage of farms: 25.8 and 29 percent, respectively.

CLIMATE, PRODUCTIVITY, AND THE FUTURE OF AREA AGRICULTURE

In this study, 75.5 percent of surveyed farmers harvested no more than six sacks of maize. In total, less than ten percent (9.8) of participants reported a harvest of more than 20 sacks in the previous season. Accordingly, less than half of farmers indicated that their farm's production satisfies the needs of their family, at 45.9 percent.

Regarding system of operation, the distribution of farmers whose production meets the needs of their family and those whose did not was approximately equal. 45 percent of surveyed farmers using the Push-Pull system reported that their farm produced enough to satisfy their family's needs, and, accordingly, the remaining 55 percent of Push-Pull farmers stated that their needs were being met. Of farmers that were not utilizing Push-Pull Technology, 46.7 percent reported satisfaction of needs, while the remaining 53.3 percent of farmers reported the opposite.

Only 40.6 percent of farmers that possessed a total acreage of three or less stated that their farm's production satisfied their family's needs. A slight majority (55.5 percent) of participants that cultivated over 80 percent of their total acreage reported that their farm's production was not enough to satisfy their family's needs. This is likely because, according to the results of this study, farmers that owned fewer acres generally cultivated a higher percentage of their land. No other relationship was evident between the percent of cultivated land and the satisfaction of needs.

When asked to compare recent harvests to harvests five years ago, 82 percent of respondents stated that yields have reduced as a result of drought, or other weather-related constraints. 8.2 percent of the remaining farmers had noticed increased yields in their Push-Pull plots, but significant decreases in plots where Push-Pull Technology was not being utilized. Another 6.6 percent noticed an increasing trend in harvests, solely due to the use of Push-Pull Technology. Only 1.6 percent noted a general increasing trend as a result of other measures, and the remaining 1.6 percent were not primarily involved in agricultural pursuits five years ago.

An outstanding majority of participating farmers had heard of climate change, comprising 95.1 percent. Most respondents had heard of climate change on the radio (72.1 percent of all participating farmers). The second most popular source of information regarding climate change were baraza meetings—public, community gatherings instigated by village officials for the purpose of attentive discussion—with 24.6 percent. Farmers also reported hearing about climate change in farmer group meetings, church services or burial ceremonies, conversations with fellow farmers, field events, extension efforts from the government or ICIPE, publications, and seminars. A small percentage (about 4.9 percent of all participating farmers) had not heard of climate change whatsoever (see Table 6).

TABLE 6: *WHERE HEARD OF CLIMATE CHANGE*

Where heard of Climate Change	Frequency	Percentage
Radio	44	72.1
Meeting	4	6.6
Baraza	15	24.6
Church/Burial	3	4.9
Fellow Farmer	8	13.1
Field Event	7	11.5
Government/ICIPE	6	9.8
Publication	1	1.6
Institution/Seminar	5	9.2
Hasn't heard	3	4.9

Two-thirds of the surveyed farmers that hadn't heard of climate change were not utilizing Push-Pull Technology. Similarly, two-thirds of the farmers that hadn't heard of climate change resided in the Bondo District.

In total, 73.8 percent of all the farmer participants had first heard of climate change no more than three years ago. Considering only participants that had heard of climate change (95.1 percent of the entire sample), that figure is elevated to 77.6 percent. Of the participants that had heard of climate change, only about 8.6 percent had first heard of it more than ten years ago. 86.9 percent of the entire sample had first heard of climate change no more than six years ago (or 91.4 percent, if considering only those participants that had indeed heard of climate change) (see Tables 7 & 8).

There did not appear to be any relationship between the number of years ago farmers had heard about climate change and age, gender, district, or system of operation.

TABLE 7: *WHEN FIRST HEARD OF CLIMATE CHANGE (ALL PARTICIPANTS)*

Years Ago	Frequency	Percentage
1-3	45	73.8
4-6	8	13.1
7-9	0	0.0
10+	5	8.2
Hasn't heard	3	4.9

All respondents, whether they had heard of climate change or not, had noticed changes in climatic trends. 100 percent of all participants reported decreases in rainfall. A majority of the surveyed farmers (60.7 percent) had first noticed changes in rainfall in the past three years. 82 percent of respondents had noticed rainfall changes no more than six years ago. The remaining 18 percent had noticed rainfall changes more than ten years ago. Of the participants that had noticed changes in rainfall more than ten years ago, 90.9 percent resided in the Bondo District. Conversely, the Suba District was home to a majority of those participants that had first noticed rainfall changes within the past three years, at 62.2 percent.

TABLE 8: *WHEN FIRST HEARD OF CLIMATE CHANGE (ONLY INCLUDING PARTICIPANTS WHO HAD HEARD OF CLIMATE CHANGE)*

Years Ago	Frequency	Percentage
1-3	45	77.6
4-6	8	13.8
7-9	0	0.0
10+	5	8.6

98.4 percent of the farmers reported noticing increases in temperature, and only the remnant 1.6 percent noticed no temperature change whatsoever. Like the rainfall statistics, only 18 percent of surveyed farmers had noticed the change more than ten years ago. 62.3 percent had first noticed temperature changes within the past three years. Similar to rainfall, a majority—80.3 percent—of participating farmers had noticed the change within the past six years. The Suba District was home to a majority of the farmers who had first noticed changes in temperature within the past three years, at 63.2 percent. The Suba District was also home to all the applicants who hadn't noticed any change in temperature whatsoever (which totalled only 1.6 percent of the responses). The Bondo District was home to 90.9 percent of respondents that reported having noticed temperature changes more than ten years ago.

88.5 percent of surveyed farmers believed that climate change has influenced general changes in pest and weed populations. 8.2 percent of participants were unaware of the influence of climate change on such populations, while a miniscule 3.3 percent of farmers believed that climate change has had no effect whatsoever on the pest and weed populations.

Of the 8.2 percent that were unaware of the effects of climate change on the pest and weed populations, 80 percent resided in the Bondo District. Regarding the level of education, all farmers that had stated that climate change had no effect whatsoever on pest and weed populations had received no formal education beyond the primary level, and 80 percent of the farmers that were unaware shared that same trait. All participants who had received education at the "O" Level or higher believed that changes in climate affect the pest and weed populations.

Regarding gender, 100 percent of the participant farmers who believed that climate change had no impact whatsoever on the pest and weed populations were female. The distributions of the two contrary responses were relatively equal between genders.

When asked about changes in the populations of insect pests on their farms specifically, 77.1 percent had noticed an increase: 70.5 percent noted an increase as a result of climate change, and the remaining 6.6 percent noted a general increase.

Only a small percentage of surveyed farmers—9.9 percent—reported a decrease in the number of insect pests on their farm. Of those farmers, two-thirds attributed the decrease to the use of Push-Pull Technology on their farm. The other one-third believed the decrease was the result of farm inputs or another form of intervention.

8.2 percent of the entire sample reported that the insect pest population had decreased in plots where the Push-Pull SO was being utilized, but had increased elsewhere. The remaining 4.9 percent had not noticed any change whatsoever in the insect population (see Table 9).

TABLE 9: *INSECT PEST POPULATION*

Response	Frequency	Percentage
Decrease with PPT	4	6.6
Increase with Climate	43	70.5
General Increase	4	6.6
Decrease with PPT, Increase otherwise	5	8.2
Decrease with input/intervention	2	3.3
No change	3	4.9

57.4 percent of all participating farmers reported an increase in the number of weeds on their farm. Of those respondents, 91.43 percent attributed the increase to changes in climate. The remaining 8.57 percent reported a general increase. 26.2 percent of the surveyed farmers reported that weed populations had decreased in Push-Pull plots, but increased elsewhere. 11.5 percent of participants noted a decrease in the number of weeds on their farm: 6.6 percent noted a decrease as a result of Push-Pull Technology utilization, and 4.9 percent noted a decrease because of farm inputs or another form of intervention. The remaining 4.9 percent had noticed no change in the weed population (see Table 10).

TABLE 10: *WEED POPULATION*

Response	Frequency	Percentage
Decrease with PPT	4	6.6
Increase with Climate	32	52.5
General Increase	3	4.9
Decrease with PPT, Increase otherwise	16	26.2
Decrease with Input/Intervention	3	4.9
No Change	3	4.9

A majority of surveyed farmers, when asked to rate the fertility of their farm's soils, gave "Average" ratings, at about 63.9 percent. In total, the percentage of farmers that rated their farm's soil fertility at "Very Low," "Low," or "Average" was about 93.4 percent. Just 4.9 percent of respondents rated their farm's soil fertility at "High," and only the remaining 1.6 percent gave their soil's fertility a rating of "Very High." 96.7 percent of farmers that participated in the study stated that changes in climate have resulted in decreased soil fertility.

An outstanding 98.4 percent of surveyed farmers were aware of methods for combating climate change. Moreover, 96.7 percent of the farmers had taken action to combat changes in climate. The most common action taken in order to adapt to climate change was the use of early-maturing (EM) crop varieties, which are better suited for less frequent, shorter rains. EM varieties had been adopted by about 67.2 percent of farmers. Another popular response among farmers was the reversion back to traditional crop varieties, which was noted by 32.8 percent of farmer participants. These crops include sorghum and cassava which are naturally drought-tolerant, and traditional maize varieties which can perform well in less rainy conditions.

Switching to new drought-tolerant varieties was also a common response: 31.1 percent of farmers reported adapting to climate change by making this

adjustment. Other actions taken by participants to combat climate change included planting trees, conservation agriculture, organic and inorganic farm inputs, certified or improved seed varieties, irrigation or the development of water resources, venturing to business for income, intensified weeding, timely agronomic practices, conservation of fodder and grain, and using greenhouse facilities. All of these responses, however, occurred in much smaller percentages of the sample (see Appendix 1).

98.4 percent of all respondents believed the government should take action to combat climate change and to mitigate its adverse effects on the agricultural sector. When the farmers were asked what sort of governmental intervention should be taken, 60.9 percent stated that the government should extend direct relief. Forms of desired relief that were noted by participants include: seeds, farm inputs or equipment, food, information, or financial assistance. Another common response was the development of water resources, which was given by 34.4 percent of respondents.

Several farmers (29.5 percent) believed that the government should promote and enforce conservation of the environment by providing seedlings, planting trees, regulating deforestation, or enforcing reforestation. One farmer participant, a female resident of the Suba District who was not utilizing Push-Pull Technology, stated that the government should not intervene. She stated instead that the government has no power in this regard, and that only God can intervene (see Table 11).

TABLE 11: *DESIRED GOVERNMENTAL ACTION*

Desired Governmental Action	Frequency	Percentage
Water Resources	21	34.4
Conservation	18	29.5
Inputs/Equipment	16	26.2
Seeds	15	24.6
Food Relief	8	13.1
Research	6	9.8
Provide Info	3	4.9
Financial Aid	3	4.9
No Action	1	1.6

86.9 percent of farmers stated that they had lost livestock as a result of climate change. The remaining 13.1 percent reported no change in the number of livestock on their farm. No participants believed that changes in climate had influenced an increase in the number of livestock on their farm. 96.4 percent of participants who owned milk-producing animals reported that they had experienced a decrease in milk production as a result of insufficient quantities of fodder, unavailability of water, or livestock loss—all primarily due to prolonged drought, abnormal temperature patterns, and other changes in climate.

When the farmers were asked if they had communicated with other farmers about dealing with climate change, an outstanding majority of 85.2 percent of the participants reported that they had indeed communicated with other farmers. The most common forums for communication about climate change among farmers were farmer group meetings or trainings, conversation with fellow farmers, and chief's barazas.

When asked about the impact of drought conditions on productivity, not a single participant gave a rating below "Average." Additionally, 93.4 percent of farmers rated its impact as either "High" or "Very High," with a vast majority of farmers that participated in the study responding with "Very High," totalling 83.6 percent of the sample.

Of the farmers that responded to that prompt with an "Average" rating, three-fourths resided in the Suba District. Similarly, three-fourths of those farmers were female. What's more, three-fourths of the farmers that had given such a rating were utilizing the Push-Pull SO.

93.4 percent of surveyed farmers stated that climate change will have a "Very High" impact on the future development of agriculture in the area. The remaining 6.6 percent stated that it would have a "High" impact.

CLIMATE AND LIVELIHOOD

When asked to list the most significant impacts of climate change on their family, 80.3 percent of all farmers that participated in this study reported that climate change has negatively impacted food security. Other common responses were financial insecurity, decreased farm output, and increases in illnesses and diseases as a result of climate change, at 27.9 percent, 24.6 percent, and 19.7 percent, respectively. Several respondents noted

that climate change has resulted in increases in social tension or weather related discomforts—an interesting observation, though only noted by a small percentage of the surveyed farmers (9.8 percent).

88.5 percent of farmers stated that climate change has negatively impacted water availability or quality. The remaining 11.5 percent reported no negative impact as a result of climate change. 100 percent of those farmers that reported no negative impact on water availability or quality resided in Central Asembo, a village in the Bondo District, wherein more substantial development of water resources had taken place.

A majority of respondents (78.7 percent) believed that climate change has resulted in increases in mosquito populations. Of those farmers, 27.1 percent noted that mosquitoes become abnormally populous during wet conditions, and the remaining 72.9 percent stated that climate change has resulted in a general increase in mosquito populations. 11.5 percent of farmers noted a decrease in mosquitoes as a result of climate change, 4.9 percent believed that climate change has had no effect on mosquito populations. It was also stated by 3.3 percent of farmers that changes in climate have made mosquito populations unpredictable. The remaining 1.6 percent were unsure if climate change could be attributed to changes in the mosquito population.

An outstanding 96.7 percent of farmers that participated in the study had taken some action to combat mosquitoes. 95.1 percent had been utilizing mosquito netting—which was, by far, the most common response given by the farmers. Other methods for combating mosquitoes that occurred in much smaller percentages (ranging from 4.9 percent to 24.6 percent) included clearing brush from the homestead, burning natural or traditional repellent substances, using commercial repellents, removing stagnant water sources that could serve as mosquito breeding sites, and using chemical insecticides.

When asked about Nutrition-Related Illnesses (NRI) in the area, a majority—59 percent—of farmers had noticed an increase. In Lambwe East, a village in the Suba District that has been highly impacted by drought, 3 times as many respondents had noticed an increase in NRIs in the area. There were no other significant relationships between residence and NRI incidences.

CLIMATE AND PUSH-PULL TECHNOLOGY

All of the farmers that participated in the study and were utilizing the Push-Pull SO were planting maize in their Push-Pull plots. 25.8 percent of Push-Pull farmers were using Push-Pull Technology in sorghum plots as well. Beans were also being incorporated into Push-Pull plots by approximately 29 percent of Push-Pull farmers. No other crops were reported as being used in Push-Pull plots by the participant farmers. A majority of farmers—83.9 percent—have always used the same crops in their Push-Pull plots. The Suba District was home to 66.7 percent of farmers who had incorporated beans into their Push-Pull plots. 62.5 percent of the farmers who had reported the use of sorghum in their Push-Pull plots also lived in the Suba District.

This tendency for more diverse, drought-resistant Push-Pull crops like sorghum in the Suba District may be a result of the decrease in area rainfall totals in recent years. Several farmers in the Bondo District stated that, though rainfall has reduced, rains are still mostly sufficient for agriculture—which may explain the fact that a higher percentage of Bondo agriculturists continue to use only maize in their Push-Pull plots.

Another factor that may have contributed to this response is the difference in the history of the Push-Pull SO between the two districts. The technology reached farmers in the Suba District in 1997, while farmers in Bondo were not exposed to the technology until 2005. This difference may justify the fact that a higher percentage of Bondo farmers continue to only use maize in their Push-Pull plots, because the system is newer to them and they have not yet considered adaptation strategies that involve altering such components of the technology.

60 percent of farmers in the Bondo District stated that the Push-Pull system had been affected by climate change, compared to just 37.5 percent in the Suba District. In total, less than half (48.4 percent) of farmers that were utilizing Push-Pull Technology believed climate change had affected the system.

Of the farmers that had reported an effect of climate change on the Push-Pull system, 66.7 percent believed its primary impact was crop dehydration. Of farmers that had given that response, 60 percent stated specifically that the desmodium intercrop had been drying, while the remaining 40 percent noted a

drying trend throughout the entire system. 75 percent of the farmers that had specifically reported dehydration of the desmodium intercrop in their Push-Pull plots resided in the Bondo District. Smaller percentages of farmers noted that changes in local climate had resulted in slowed or inhibited desmodium development in newly-established Push-Pull plots, increases in damage done by grazing livestock, and excess water absorption by the desmodium intercrop.

When the farmers were asked if they had made any adjustments to the Push-Pull system to respond to changes in climate, only 41.9 percent reported that they had made an adjustment. 61.5 percent of farmers that had made an adjustment to the Push-Pull SO resided in the Bondo District—a statistic that may relate to the fact that a lower percentage of surveyed farmers in the Bondo District had been using naturally drought-resistant cereals like sorghum in their Push-Pull plots.

Regarding education, all Push-Pull farmers that had received some form of post-secondary education had reported making adjustments to Push-Pull Technology to respond to climate change. Conversely, none of the Push-Pull farmers who hadn't received any formal education whatsoever had made adjustments to the technology.

The most common adjustments made by farmers to adjust their Push-Pull systems to respond to climate change was the implementation of new cereal crop varieties and regular trimming of the desmodium intercrop. Other responses included adjustments in water use or system intake, adjustment of farm inputs, and adjustments in crop spacing.

83.9 percent of all farmers that utilized Push-Pull Technology believed that *icipe* should modify Push-Pull Technology to respond to changes in climate. The most common aspect in need of modification, according to Push-Pull farmers that reported a need for modification, was drought resistance in the desmodium intercrop.

Another common response was the need for implementation of new drought-resistant cereal crop varieties. There were several other notable responses that occurred at much lower frequencies, including improvement of water management in the system, improved *icipe* outreach and expansion efforts, further development of early-maturing (EM) crop varieties, and development of new strategies for weed resistance.

Of the farmers that were not utilizing Push-Pull technology on their farm, a majority (63.3 percent) had heard of the technology. The most frequent response given by these farmers was that they had heard of the technology in conversation with other farmers. Several other farmers who had heard of the technology had heard of it at a field event. These two responses combined accounted for 63.2 percent of cases.

Other notable sources of hearing about Push-Pull Technology that occurred significantly less frequently included farmer group meetings, barazas, governmental or *icipe* extension, and church or burial services. Though it is important to state that a majority of farmers who weren't utilizing Push-Pull Technology had heard of the system, it must also be noted that the most frequent single response given by farmers using traditional systems of operation was that they hadn't heard of the technology (see Table 12).

TABLE 12: *WHERE TRADITIONAL SYSTEM USERS HAD HEARD ABOUT PUSH-PULL*

Forum	Frequency	Percentage
Fellow Farmer	7	23.3
Field Event	5	16.7
Group Meeting	2	6.7
Baraza	2	6.7
Extension	2	6.7
Burial/Church	1	3.3
Hasn't Heard	11	36.7

Farmers in the Bondo District that did not use Push-Pull Technology on their farm were far less aware of the technology than their counterparts in the Suba District. Only 40 percent of those farmers in the Bondo District had heard of the system, compared to 86.7 percent in Suba.

Though a majority of the farmers that were not utilizing Push-Pull had heard of the technology, many of them did not understand the technology or its benefits. 68.4 percent of the Non Push-Pull farmers that had heard of the technology reported that they had no understanding of it whatsoever.

A miniscule 15.7 percent of farmers had a full understanding of the technology and its benefits. 15.7 percent of the farmers who had heard of the

technology had a partial understanding, as well. Not a single farmer in the Bondo District who wasn't utilizing the Push-Pull system had any understanding of the technology.

DISCUSSION

In Western Kenya, the impact of changing climatic trends is unmistakable. Entire fields of cereal crops lie in distress—stunted by drought, pummelled by soaring temperatures, and unable to produce grain. This impact on the crops in turn impacts the farm families that depend on good harvests for food security, financial stability, and maintenance of a decent living standard. Devastated harvests, therefore, are devastating African farmers—and adaptation is the needed remedy.

Every farmer that participated in the study had realized the impact of climate change on their farms and their society, which indicates the ripeness of area agriculturists for change, for taking action to rectify their livelihoods, and for working together to mitigate the adverse effects of climate change on subsistence agriculture.

The adverse effects of climate change, I might add, are many—and combating them is not a simple task. Along with the more blatant changes in climate like decreases in rainfall and increases in temperature, farmers noted such things are differences in cloud cover, sun intensity, wind pattern, soil condition, et cetera, each having diverse and profound impacts on productivity and livelihood on many Kenyan farms. Of course, the resultant adversities from these issues complicate the matter even further, influencing harvests, income, morale, social tendencies, physical wellbeing, and a plethora of others. Needless to say, climate impacts all of society—its behaviour, therefore, is a vital concept to comprehend.

Comprehension, though, is only the first step. The next: assertion. If the damaging impact of climate change on smallholder agriculturalists is going to be reversed, they must realize the need for assertive action. Fortunately, the data compiled in this study suggests that farmers in Western Kenya are heeding the call, and taking action to combat climate change, and in doing so improve productivity and livelihood. Over 96 percent of participant farmers stated that they had already taken some form of action to respond to climate change, or are planning to do so. Furthermore, an even greater percentage of the surveyed farmers were at least aware of methods for adaptation. In addition, it was purported by all farmers that participated in the focus group discussions that they had experienced some degree of success in their adaptation endeavours. These figures are indeed very promising.

However, trends in area harvests are still decreasing drastically. Over 90 percent of farmers reported some degree of decrease in yields as a result of changes in climate, further suggesting the need for development of improved, effective, and practical tactics for coping with less rainfall, higher temperatures, et cetera on the small-scale farm. The farmers know that something must be done, but many do not have the knowledge, resources, or ability to implement successful, sustainable adaptation initiatives.

Many participating farmers had incorporated early-maturing and drought-tolerant crop varieties on their farms, hoping to negate the devastation of drought and other climate changes. Others had reverted back to hearty, traditional crop species that are naturally designed to withstand drought, and to mature at rapid rates. Several farmers had taken advantage of water resources by utilizing roof catchment schemes, small-scale or bucket irrigation systems, or making strategic adjustments to water flow in their plots—but these measures are costly and, thus, are unavailable to many farmers.

An interesting consensus was reached at the focus group discussion that took place in the Vihiga District. At the meeting, all farmers reported having adjusted the ratio of fertilizer application by favouring organic fertilizers such as farmyard manure and compost, because in drought conditions the inorganic fertilizers can scorch the crops.

Such actions and several others have been reported, and farmers in the area are actively working to make necessary adjustments to their agricultural operations. Communication among farmers is also vital for capacity-building in agricultural communities.

A majority of over 85 percent of surveyed farmers had utilized farmer group meetings, chief's barazas, field days, and an array of other forums to discuss the impacts of climate change and methods for dealing with it. It is this sort of communication that can lead to better yields, more effective

measures for combating climate change, as well as real breakthroughs in adaptation.

Livelihood and Health

The impacts of climate change are certainly not limited to farm productivity. In fact, drought, soaring temperatures, and other climatic extremes have had reported effects on health, societal behaviour, biodiversity, and a multitude of other aspects.

A majority of participants—particularly in the Suba District—noted increases in Nutrition-Related Illnesses (NRI), an undeniable consequence of drought-related food and water shortage. Another health-related concern noted by farmers regarded the population of mosquitoes—the dreaded vectors of the malaria parasite. Nearly 80 percent of farmers had attributed changes in climate to increases in mosquito population.

Another interesting suggestion made by a small percentage of farmers was the impacts of climate change on culture and behaviour. It was noted that, because of decreased yields and the resultant food shortage, farmers' ability to share goods and resources freely has become hindered, thus creating a certain degree of social tension in agricultural communities. This suggestion was reinforced by group discussions in neighbouring Vihiga and Kiumu Districts, wherein all of the 100 involved Push-Pull farmers reported that in order to increase income they had started selling farm produce that they had previously given away freely.

Push-Pull Technology

In total, less than half of all respondents said that their Push-Pull plots had been affected by climate change. This suggests that the technology may naturally be resistant to the climate changes taking place in the area (i.e. drought, high temperatures, et cetera). This is further supported by the results of the focus group discussions, wherein all farmers stated that climate change has not decreased the effectiveness of Push-Pull technology in eradicating Striga, repelling and trapping stem-boring insects, or maintaining soil fertility. Additionally, all participants in both focus group discussions believed yields in Push-Pull plots have continued to increase, despite the climate change and a reported general decrease in plots where Push-Pull was not used.

Push-Pull Technology is truly a revolutionary agricultural innovation, but it is not immune to the adverse effects of climate change. Though many farmers believed that the system was not substantially impacted by climate change, there were a number of farmers that had noticed the system suffering as a result of drought, heat, and such related climatic adversities.

The most common effect of climate change on the Push-Pull system was crop dehydration, especially of the desmodium intercrop. Drying of desmodium was reported by the highest percentage of farmer participants, followed by total system dehydration. It was also mentioned by several farmers that, due to drought conditions and temperature extremes, development of desmodium in newly-established plots is very poor. Several other interesting claims were made as to the impacts of climate change on Push-Pull Technology, all of which occurred at much lower frequencies. These included an increase in damage done to the system by grazing livestock—which indicates a shortage of forages, undoubtedly as a result of drought conditions—as well as excessive water absorption by the desmodium intercrop.

At the focus group discussion in the Vihiga district, all of the farmers had attributed dehydration of the Napier Grass trap crop and increased incidences of Napier Stunt Disease to climate change, as well. Additionally, it was noted at the focus group discussions that the damage done by pests like moles and termites have been exacerbated by climate change.

Less than half of the Push-Pull farmers that participated in the study had made adjustments to the technology to respond to climate change. Of those who had made adjustments, however, the most common adjustment made was the use of new cereal crop varieties in Push-Pull plots.

One example of such an adaptation is the substitution of sorghum—a local, more drought resistant cereal grain—for maize in the Push-Pull plots. Data regarding this specific measure of adaptation was collected at the focus group discussions, wherein ten percent of the farmers reported using sorghum to combat climate change. The majority of these responses occurred at the discussion in the Kisumu District. Other adaptations

made to the Push-Pull SO in response to changes in area climate included adjustments in system water intake, input usage, and crop spacing, though these occurred much less frequently.

A Sincere Need for Adaptation

It is clear that agriculturists in the region need to take action to adapt to changes in climatic trends. Climate changes impact the lives of everyone, regardless of gender, SO, level of education, et cetera. Western Kenya has been drastically impacted by climate change, and farmers in the region are ready to experience real success in adaptation. They merely require the resources for doing so.

CONCLUSION

In a 2006 article by the UNFCCC entitled *Technologies for Adapting to Climate Change*, a very serious point is brought forth. The article states that "on the whole, agricultural systems are fairly flexible so if farmers have access to the right information and tools they should be able to make many of the necessary adaptations on their own" (UNFCCC, 2006).

It is a most relevant point, indeed. Farms are very versatile entities, and farmers surely have the capacity to make adjustments and to successfully adapt to changes in climatic trends. Such adaptation, however, cannot occur if communities are bereft of the necessary resources.

Many of the farmers that participated in the study emphasized this during the interview: they want to adapt, but they cannot do it alone. Climate change is a monstrous being, and can only be tackled using an equally sizable amount of knowledge and resources.

Accordingly, an outstanding majority of over 98 percent of all respondents believed that the government should take action to assist smallholder farmers. The highest percentage of farmers called for the development of one of the area's most precious—and at times, scarce—resources: water. The two districts surveyed by this study, namely Bondo District and Suba District, have a quite ironic geographical trait: although situated on the shores of Lake Victoria, the largest tropical lake in the world, these two districts remain dry.

Farmers in this region traditionally rely on rain-fed agriculture. Accordingly, less than 15 percent of participants reported the utilization of irrigation systems or other techniques for the development of water resources. Because such a high percentage of farmers depend so wholly on rainfall, drought conditions can be devastating to crop yields—and thus can be devastating to financial stability, livelihood, and food security.

Another governmental intervention called for by a high percentage of participating farmers was the enforcement of reforestation efforts and environmental conservation. Many surveyed farmers noted changes in vegetation cover, and they attributed soil fertility, rain, and ultimately agricultural production to the presence and prevalence of trees and native vegetation. Hence, it was widely suggested by participants that the government should enforce stricter conservation policies, thus encouraging rainfall and environmental health.

Water resource development and environmental conservation are just two of the several desired governmental actions that were noted by participating farmers (See Table 11). Many farmers also noted the importance of non-governmental institutions in adapting Push-Pull Technology to changes in climate, such as Non-Governmental Organizations (NGO), and research centers like *icipe*.

Farmers, indeed, possess the capacity and desire required for successful adaptation to climate change, but they do not have the resources to do it alone.

Recommendations

The direct effects of drought conditions and increased temperatures on the farm in turn affect financial stability, food security, and quality of life. It is undeniable that farmers in Western Kenya have been negatively impacted by climate change, and it is very probable that climatic conditions will continue to approach new extremes—extremes to which area farmers have never before been forced to adapt.

Fortunately, the results of this study suggest that a majority of farmers in the area are aware of methods for combating climate change. Furthermore, many have begun practicing these

methods on their farms, and have experienced some success. Such initiatives are indeed present, as was shown by the results of this study: a very high percentage of farmer participants had been informed about climate change. Even so, it should be noted that no farmer reported that they had been totally successful in their efforts to mitigate the impacts of climate change. It is clear: a discrepancy exists between the adaptation methods currently available to farmers and those needed to experience total success.

The gap that lies between partial success and total success in adaptation can be filled only through sincere efforts from all parties involved: the government, the researchers, the consumers, and the farmers themselves. Hence, in order for agriculture in the region to persist and thrive sustainably, it is necessary for agriculturists to take real action to mitigate the adverse effects of climate change, and to exploit any potential advantages. In order to do so, several things are required:

1. First and foremost, farmers need to be continuously informed. Without knowledge, no successful, sustainable adaptation can take place. Therefore, dedicated capacity building and expansive outreach initiatives regarding adaptation are necessary in order to achieve total, large scale success in adaptation. The most effective means for the dissemination of adaptation strategies should be utilized widely to maintain an ideal level of local awareness on climate-related issues and appropriate measures for adaptation. These most common channels for outreach, as observed by this study, included radio broadcasts, barazas, farmer group meetings and field days, as well as farmer-to-farmer conversations (see Table 6).

2. Continuation of agricultural research is an absolute necessity for adaptation. As climate changes continue to effect farms, research will continue to be of vital importance—especially considering the rising global population, and the resultant increase in demand for agricultural goods.

3. The development of infrastructure must precede any successful, sustainable protocol for adaptation on the long term. In Western Kenya, where for years the road network has been of very poor quality, the lack of basic infrastructure has delayed the development of resources such as irrigation systems and has acutely limited market access among the smallholder farmer population—both of which are to be critical in assuring a successful future for Kenya's agricultural sector.

4. Sustainable adaptation to climate change may only occur after the establishment of sustainable agricultural practices. Therefore, it is of utmost importance that the government, researchers, and other development organizations teach farmers to incorporate sustainable, environmentally-considerate technologies and resources in their SO. Such incorporation might include the adoption of Push-Pull Technology, implementation of no-tillage or other sorts of conservation agriculture, et cetera.

5. Unavailability of resources is another factor that discourages successful measures for adaptation. A change in farm methodology often requires a change in farm equipment, agricultural materials, inputs, or any number of things. Certainly, without many exceptions, adaptation requires capital, and therefore is a very challenging process for resource-poor smallholder farmers in the area. In order for agricultural adaptation to take place, farmers need to acquire sufficient resources. Many farmers have realized this need for capital in the process of adaptation to climate change: for example, all 100 farmers that participated in the focus group discussions reported that they had begun selling agricultural produce to increase farm revenue. Measures like this are indeed a vital prerequisite to resource accumulation.

However, resources also need to be provided more consistently and indiscriminately by governments, policy-makers, and other institutions of research and development. The participation of these institutions in efforts to mitigate the effects of climate change at the national and local level is very important: only they can reliably develop infrastructure, offer subsidies and incentives, facilitate effective and relevant capacity-building, secure farm insurance, et cetera.

Concluding Remarks

Climate change is, without doubt, becoming an increasingly dangerous threat to productivity and livelihood in Western Kenya, and is therefore an issue that must be diligently combated. Successful efforts to combat change, however, cannot occur without information, research, development of infrastructure, sustainable agricultural practices, and access to resources.

The key to adaptation truly lies in the farmers. Sustainable adaptation worldwide begins with mobilization at the local level. Area agriculturists have the capacity to develop and utilize successful strategies for adaptation, but that capacity must be enriched through dedicated cooperation on the community, national, and global levels.

Farmers, in a sense, are affected by climate change in much the same way as their fields: they have been hindered by drought, and without nourishment they cannot be fruitful. Nourishment must first come in the form knowledge, and its fruit: sustainable agriculture for an ever-changing world.

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PERSONAL EXPERIENCE

One evening shortly after my arrival at Mbita, upon returning to the *icipe* guest centre from a long walk around the village, I recorded this in my journal:

> The children can see what I see. The beauty: the lake, the hills, the grandeur of the day—they see it. The children see with their young eyes the same physical Africa that I have seen, they have walked upon the same soils, listened to the same birds hymning toward the setting sun. They are here in Kenya much the same way that I am, but it is different to them. To me, Africa is a part of the world—a beautiful, pure, valuable portion of our planet Earth, rich with culture and wrought by the wholesome traditions of wholesome folk. But it is still foreign to me. I am still a stranger here. To them, though, the children—Africa is more than that. Africa is home.

Somewhere on my journey from the United States to Kenya, I determined that one of my goals for the summer and for the rest of my life was to make the world my home. We—myself and the children that I referenced in the above excerpt—may have stood upon the same Kenyan road. We likely had looked toward the lake to see the same fleet of fishermen idling silently in the distance… but I was not yet a part of it. That, fortunately, was bound to change.

As time persisted, I started to truly feel Kenya. It was all around me—the sights, the sounds, the hills, the trees—I was enveloped by it, and I could only embrace it with passion and amazement. Also, though, I was obligated to embrace more than the beautiful sunsets and the unwavering Kenyan hospitality. I was the subject of a million stereotypes; I was the "Mzungu" who could promise a better life for the poor, and more food for the hungry, and more resources for those in need, et cetera. I witnessed poverty at its utmost extremes, and I felt the pain of widows and orphans that were desperate for a change and in need of something, anything at all. What's more outstanding, though, is that while in their sombre eyes could be seen the agony of poverty, in their smiles one could see their pride, their confidence in the African people and their sincerest hope for a better tomorrow.

I spent many hours over the course of my internship teaching science at the Mbita Point International School. However, I considered myself to be *their* pupil as much as they were mine. The children were unendingly eager to learn, whether in class or not, and through their enlightenment came my own. They thirsted for knowledge of the world, and forever will—much like me. As a result of their curiosity I learned much about myself, my abilities, and my relationship with the world. Whether we were entranced by fascinating scientific discussion, engaging in conversations about culture and history, by kicking a soccer ball on a dusty road, or by solving riddles and telling stories, the students and I were constantly learning together. Through countless lessons both inside and out of the classroom on a variety of subjects, I instilled new insight into their fresh minds, while through simple conversation, undisturbed interest, and passion for betterment they made me remember what freshness of mind felt like. I owe much to the children, because they, more than most, invited me to remember the power of belief, of hope, and of happiness. I will never forget what I learned from the children of Mbita—that, truly, one person can make an impact, and all of us together can change the world.

Another amazing thing about Kenya is its plant life. Not only the plants themselves—though some of them were undeniably magnificent—but their weight and influence in society. Kenya, like many countries, relies on plants for development and subsistence in one major form: agriculture. The role of agriculture in the lives of the people of Western Kenya is absolutely tremendous. Often, the heft of one's harvest alone determines the financial, social, physical, and emotional wellbeing of

entire families for months at a time. It was difficult to see entire maize crops that were stunted by drought and incapable of bearing grain, knowing that the result would be increased poverty, increased hunger, and, ultimately, increased hardship. That was perhaps the hardest reality for me to realize: that just a few sacks of maize can mean security and progress, or, just as likely, they can guarantee poverty, distress, sickness, or even death.

Indeed, plants are very important to Kenya and the world. Accordingly, I was determined to become better acquainted with their role in society while I was in Mbita. I did many things to accomplish this—through my research, my curious explorations, my conversations with farmers, et cetera—but one example is particularly vivid in my memory: the Jero Fruit Tree and Flower Nursery. I met a man in Mbita—a Kenyan, born and raised—with a passion for betterment very similar to my own. He and a small group of individuals from the village created a small fruit and flower nursery with the goal of improving the Lake Victoria region, and by instilling in its people the knowledge necessary to increase the standard of life. I was indeed drawn to this nursery, and did everything I could to make the community more aware of its presence and purpose: on several occasions I helped the group with advertising, and even created a website and E-mail address for the group. Of course, I also was very interested in the plants and made regular visits to the nursery, which was nestled pleasantly on the lakeshore. The self-help group was dedicated to their cause, as was much of the Mbita community. They—unlike too much of the modern world—haven't lost sight of the most basic human desire: the desire to make their world a place where all people can live happily. I noticed this passion everywhere in Kenya, and I was amazed by it.

There is another characteristic that I noticed in Kenya: that despite everything—be it underdevelopment, poverty, disease, food or water insecurity, or any other adversity—the people are strong. The strength of Kenya truly lies in the hearts and souls of its people. Furthermore, this strength is not the residue of disdain or the result of aggression, but rather it exists more simply as an instinct nurtured by time. Strength is a way of life, among those whose lives cannot possibly persist feebly. One July day, as I sat in deep thought by the lakeshore, I scribbled this into my journal:

> It is true, I've been in Kenya for only slightly over a month, but I can see that this sort of determination--this unshakable strength--has long been a part of society here. I've noticed its presence in every generation, be it the perseverance of working-age adults, the students' thirst for knowledge, or the aged, hardened elder, staying strong, because that is what must be done. This Kenyan strength is as much a part of the people as is their blood, their flesh, et cetera, and it is as much a part of me now as I could have ever imagined.

Indeed, my experiences in Kenya opened my eyes to reality, in the very best way possible. I learned much about myself through my work in Mbita, and much about the responsibilities of humanity in this ever-changing world. I learned that it is world-changers like me, fellow Borlaug-Ruan International Interns, and Norman Borlaug himself whose duty it was, is, and forever will be to hold the world's delicate hand and guide it into an era unexplored. As my internship came to an end, I knew that Africa was like home to me. I did it—that task I have forever longed to complete: I had made the world my home.

Appendix 1: "Collection Materials"

Questionnaire

1. Name: _____

Place of residence: _____Geographical Location: _____
Level of Education: _____ Gender: _____ Age: _____
Size of property: _____ Amount of cultivated land: _____

2. Crops grown: _____
3. Crop Usage: Home consumption: □ Production for sale: □ Livestock feedstuff: □
4. Number of animals and type: _____
   _____
5. Usage of animals: Meat Production for sale: □ Dairy Production for sale: □
   Home consumption of meat: □ Home consumption of dairy: □
6. How much maize/crop did you harvest last season? _____
7. How do recent harvests compare to harvests five years ago? _____
8. Does your farm generally produce enough to satisfy your family's needs? Y: □ N: □
9. Have you noticed an increase in nutrition-related illness in the area? Y: □ N: □
10. Have you noticed changes in rainfall intensity or pattern? Y: □ N: □
    Describe: _____
11. When did you first notice these changes? _____
12. Have you noticed changes in temperature intensity or pattern? Y: □ N: □
    Describe: _____
13. When did you first notice these changes? _____
14. Has there been any change in the cropping season? Y: □ N: □
    Describe: _____
15. Have there been changes in the types of crops grown in the area? Y: □ N: □
    Describe: _____
16. Do you grow the same crops today that you grew five years ago? Y: □ N: □
    Describe: _____
17. Have you experienced crop failure? Y: □ N: □ How many times in the past five years? _____
18. Have you noticed a change in the number of insect pests on your farm? Y: □ N: □
    How so? _____
19. What are you doing to manage insects on your farm? _____
    _____
20. Have you noticed a change in the number of Striga and other weeds on your farm? Y: □ N: □
    How so? _____
21. What are you doing to manage weeds and Striga on your farm? _____
    _____
22. Have you heard about climate change? Y: □ N: □
23. When did you first hear of it? _____
24. Where, and from whom did you first hear of it? _____
25. Have you noticed changes in climate apart from temperature and rainfall? Y: □ N: □
    What types of changes?_____
26. How does climate change affect you and your family? _____
    _____
27. Do you think changes in climate have affected the pest/weed population? Y: □ N: □
    _____
28. Do you think yield sizes have decreased as a result of climate change? Y: □ N: □

29. Do you think changes in rainfall or temperature have decreased soil fertility? Y: □ N: □
30. Are you aware of ways to combat climate change? Y: □ N: □
31. Have you taken action to combat climate change, or do you plan to do so? Y: □ N: □
32. What action have you taken, or are you planning to take? _____

OR Why haven't you taken action? _____

33. Has climate change negatively impacted water availability or quality? Y: □ N: □
34. Do you think climate change has impacted mosquito population or distribution? Y: □ N: □
    How so? _____
35. Have you done anything to combat mosquitoes? Y: □ N: □
    What have you done? _____
36. Do you think climate change has impacted the number of livestock on your farm? Y: □ N: □
    How so? _____
37. Has climate change affected milk production on your farm? Y: □ N: □
    How so? _____
38. Have you communicated with other farmers about dealing with climate change? Y: □ N: □
39. How and where did you communicate with them? _____
    _____
40. Have you talked to your children about changes in climate? Y: □ N: □
41. What do you think the government should do to combat climate change? _____
    _____
42. Have you received any information about climate change from extension officers? Y: □ N: □
43. Do you use Push-Pull Technology on your farm? Y: □ N: □

PPT Users:

44. Years using PPT: _____Where did you first learn about PPT? _____
45. What crops do you use under PPT? [maize, sorghum, et cetera] _____
46. Have you always used the same crops under PPT? Y: □ N: □
47. What species of desmodium do you plant under PPT? _____
48. Has PPT been affected by changes in climate? Y: □ N: □
    Describe the effects of climate change on desmodium: _____
    _____

    Describe the effects of climate change on Napier Grass: _____
    _____
49. Have you made adjustments to PPT to respond to climate change? Y: □ N: □
    What were those adjustments? _____
50. Do you think *icipe* should modify PPT to adjust to changes in climate? Y: □ N: □
51. What aspects of PPT need modification? _____

Non-PPT Users

52. Have you heard of Push-Pull Technology? Y: □ N: □
53. If you have heard of it, from where did you hear of it? _____
    _____
54. What is Push-Pull Technology, as you understand it? _____
    _____
55. Why haven't you adopted PPT, if you've heard of it? _____

Please respond by rating on a scale from one to five, one being minimum and five being maximum:

1: Very low/No	2: Low	3: Average	4: High	5: Very high/Yes

Prompt	Rating
56. How severely have drought conditions affected productivity on your farm?	

57. How severe are insect problems on your farm:	
58. How severely do weeds like Striga affect productivity:	
59. Rate the fertility of your farm's soil:	
60. How involved are your children on the farm?	
61. Rate the impact you think climate change will have on the future development of agriculture in the region:	

Focus Group Discussion

The primary objective of the Focus Group is to gauge farmers' awareness of and opinions on changing climatic trends, their strategies for mitigating climate-related agricultural constraints, and their ability to communicate ideas, suggestions, and information amongst themselves. Also, this Focus Group aims to specifically assess the perceived effects of climate change on Push-Pull Technology.

TYPES OF CLIMATE CHANGE AND IMPACT ON FARM

1. What sort of climate-related problems have you experienced recently on your farm?

Problem	**Total**			**Male**			**Female**		
	Yes	No	Unsure	Yes	No	Unsure	Yes	No	Unsure
Drought									
Increased Temperature									
Increased Striga									
Increased other weeds									
Increased stem-borers									
Increased other pests									
No Climate-related Problems									

Notes: _____

_____

2. How severely is climate affecting you, your family, and other farm families in the area?

Response	**Total**			**Male**			**Female**		
	Yes	No	Unsure	Yes	No	Unsure	Yes	No	Unsure
Food shortage									
Water shortage									
Increased disease									
Increased									

mosquitoes									

a. Have climate changes affected your farm's productivity?

Response	**Total**			**Male**			**Female**		
	Yes	No	Unsure	Yes	No	Unsure	Yes	No	Unsure
Decreased Production									
Increased Production									
Decreased production in non Push-Pull plots									
No effect									

Notes: _____

_____

b. Have you experienced crop failure? Have you lost livestock or noticed decreased milk production because of changes in climate trends?

Response	**Total**			**Male**			**Female**		
	Yes	No	Unsure	Yes	No	Unsure	Yes	No	Unsure
Crop Failure									
Livestock Loss									
Decreased Milk									

Notes:

_____

_____

COPING WITH AND ADAPTING TO CLIMATE CHANGE

3. What have you done to lessen the impact of climate change on your farms?

Action	**Total**			**Male**			**Female**		
	Yes	No	Unsure	Yes	No	Unsure	Yes	No	Unsure
Change in Crop Varieties									
Development of water resources									
Organic/inorganic inputs									
Nothing									

Notes:
_____

_____

a. Have you been successful in your efforts to combat climate change?

Response	**Total**	**Male**	**Female**
Yes			
No			
N/A			

Notes:
_____

_____

b. Have you sought after other sources for employment or income?

Response	**Total**	**Male**	**Female**
Yes			
No			
N/A			

Notes:
_____

_____

4. Have you learned strategies for dealing with drought conditions or other climate changes?

Response	**Total**	**Male**	**Female**
Yes			
No			

a. Where did you learn of these strategies?

Forum	**Total**			**Male**			**Female**		
	Yes	No	Unsure	Yes	No	Unsure	Yes	No	Unsure
Farmer meeting									
Field Event									
Radio									
Conversation with fellow farmers									
Baraza									

Notes:
_____

_____

FARM-TO-FARM AND GOVERNMENT-TO-FARMER COMMUNICATION

5. Have you talked with your neighbors about how changes in climate are affecting your farm?

Response	**Total**	**Male**	**Female**
Yes			
No			

Notes:
_____

_____

a. Are climate-related farming issues regularly brought up at farmer meetings?

Response	**Total**	**Male**	**Female**
Yes			
No			

b. Have you gotten any agricultural information from the government or from extension services recently?

Response	**Total**	**Male**	**Female**
Yes			
No			

c. Has any information you have received regarded climate change or methods for dealing with it?

Response	Total	Male	Female
Yes			
No			
N/A			

Notes:
_____

_____

FOR USERS OF PUSH-PULL TECHNOLOGY:

6. Have any aspects of Push-Pull Technology been negatively impacted by climate change?

Response	Total	Male	Female
Yes			
No			

a. Which aspects are being impacted?

Impact	Total			Male			Female		
	Yes	No	Unsure	Yes	No	Unsure	Yes	No	Unsure
Desmodium drying out									
Napier drying out									
Poor growth of desm. in new plots									
Less effective									

Notes:
_____

_____

b. Are yields decreasing in Push-Pull plots?

Response	Total	Male	Female
Yes			
No			
Unsure			

7. Have you done anything to alter Push-Pull Technology to make it better suited for changes in climate?

Response	Total	Male	Female

Yes			
No			

a. What have you done?

Response	**Total**			**Male**			**Female**		
	Yes	No	Unsure	Yes	No	Unsure	Yes	No	Unsure
New cereal crops									
New intercrops									
Changed water management									
Changes in inputs									
Nothing									

Notes:
_____

_____

b. Have your alterations been successful?

Response	**Total**	**Male**	**Female**
Yes			
No			
N/A			

c. Where did you learn about alteration strategies?

Forum	**Total**			**Male**			**Female**		
	Yes	No	Unsure	Yes	No	Unsure	Yes	No	Unsure
Farmer meeting									
Field Event									
Radio									
Conversation with fellow farmers									
Baraza									

Notes:

_____

_____

8. What aspects of PPT need to be improved to cope with climate changes?

Response	**Total**			**Male**			**Female**		
	Yes	No	Unsure	Yes	No	Unsure	Yes	No	Unsure
DR intercrops									
DR Napier									
Water management									
Insect management									
Striga management									
Maintenance of soil fertility									
DR Crops									

Notes:

_____

_____