SECURING WATER FOR FOOD

Hydroponics Performance Evaluation Report

Hydroponics Innovation in Kenya

AUGUST 2019

SECURING WATER FOR FOOD: A GRAND CHALLENGE FOR DEVELOPMENT

USAID FROM THE AMERICAN PEOPLE

Government of the Netherlands

Sweden Sverige

science & technology Department: Science and Technology REPUBLIC OF SOUTH AFRICA

Prepared By: Brenda Binge, MSC Climate Change and Sustainability, Kenyatta University (Kenya)

The Kaizen Company | Contract #: AID-OAA-C-15-00011
www.securingwaterforfood.org | securingwaterforfood@gmail.com

TABLE OF CONTENTS

ABSTRACT

Many challenges hinder the prosperity of agricultural activities in developing countries, considering that it is the backbone of economic activity and contributes to food security and nutrition in most of these countries. The environmental problems caused by anthropogenic activities, such as deforestation and desertification, are increasing to meet food security needs through clearing to provide for arable land for cultivation. They are further exacerbated by the high population growth rate. Arable land loss is estimated at 30 to 35 times the historical rate. Agriculture also uses about 70 percent of the planet's available freshwater. This scenario is unsustainable in the long-run and requires renewed focus on efficient water use. Although 2.6 billion people depend directly on agriculture, only 52 percent of the land used for agriculture is moderately or severely affected by soil degradation.

Additionally, there are challenges of soil farming, including prevalence of pests and diseases; reliance on unpredictable rainfall; dependance on pesticides, fertilizers, and manure; and more labor hours and days weeding, among others. Hydroponics technology counters this by using less water, increasing the yield, using minimal space, reducing the cost of the value chain from the input, onfarm production, post harvest, and marketing. Hydroponics reduces incidences of pests and diseases that are common with conventional soil farming.

A performance evaluation of Hydroponics Africa was carried out, and 50 farmers were interviewed. Farmers were grouped into clusters and later randomized. Probability proportion to size (PPS) procedure was used to ensure that the probability of a cluster being selected was proportional to the size of the ultimate cluster, giving larger clusters a greater probability of selection and smaller clusters a lower probability. Systematic and simple random sampling techniques were used to identify the 50 sampled farmers. The interviews were recorded and, with the consent of the farmers, photos were taken.

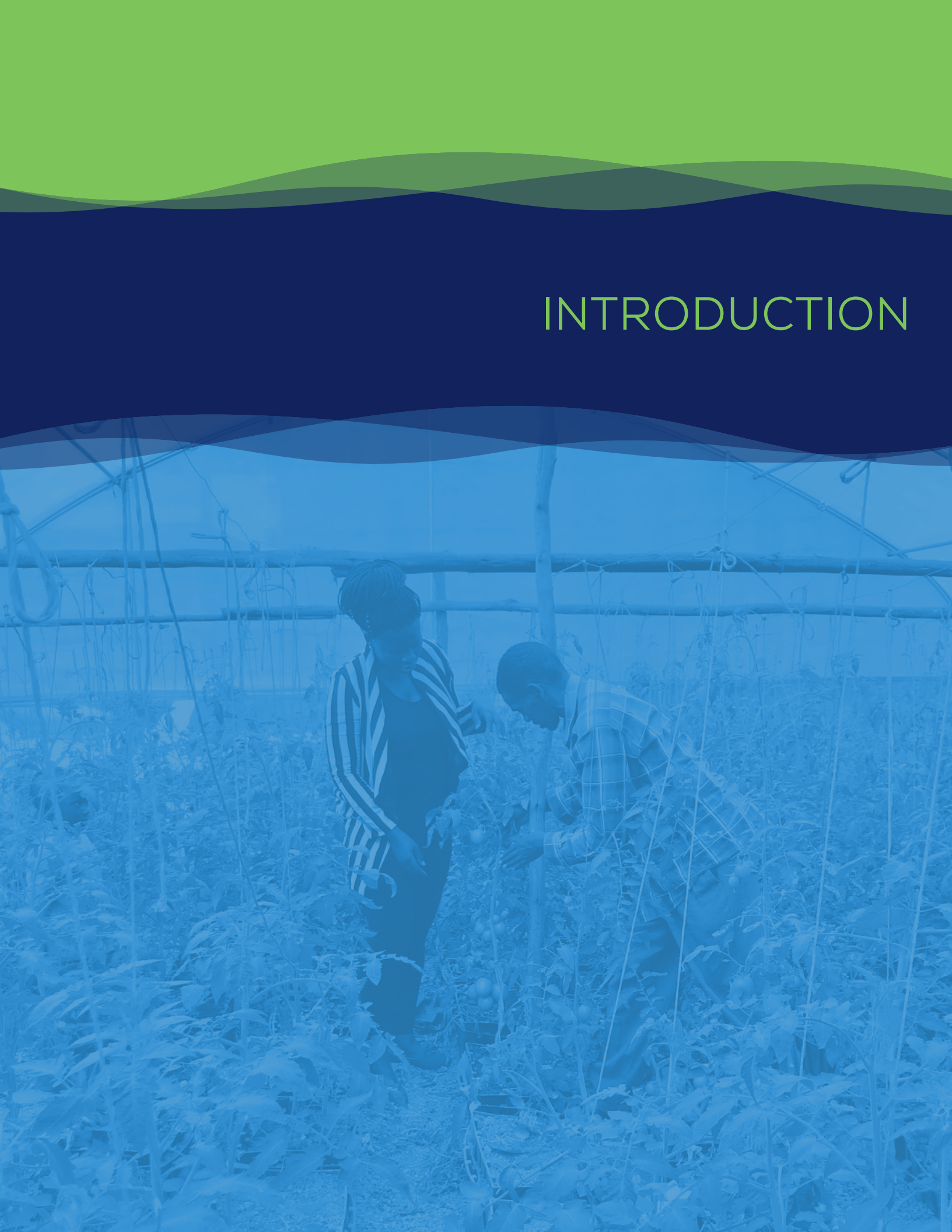
Seventy-eight percent of respondents interviewed were female, and 22 percent were male. Most of the farmers have not diversified their income, with the majority (50 percent) only having one source of income, 26 percent with two sources of income, and two percent with three sources of income. Females have an average of 0.4361 acre, whereas males have an average of 1.2617 acres. This is typical of African culture where men own more land than women. The average years of experience of hydroponics technology is 0.91 years, with little disparity when disaggregated by gender. Females and males have had the technology for 0.84 and 1.16 years, respectively. The average age of the respondents is 45 years. The correlation between age and experience, though positive, is very low at 0.01.

Farmers are spending less with the introduction of hydroponics technology. Before, the average amount spent in agricultural activity was Ksh. 21,297 per year. These costs include, but are not limited to, fertilizers, pesticides, water, labor, storage, and transportation. However, with the introduction of hydroponics, the average cost is Ksh.11,102 per year. The huge disparity is attributed to significant reduction of input supplies, such as pesticides, fertilizers, manure, reduced labor costs in weeding, pruning, and labor hours/days.

The majority of farmers engaging in hydroponics use it for subsistence with little or no surplus for sale. The main value chain includes kale (*sukuma wiki*), spinach, local vegetable (*kansira*), local vegetable African nightshade (*managu*), and Indigenous Amaranthus (*terere*). The few engaged in commercialization reported improved household income. The majority are continuing with hydroponics due to the benefits associated with the technology, such as reduced water use, involvement of women, increased crop yields, the ability to decide when to plant and which crops to plant, and the ability to diversify the crops.

For the success of the technology, there needs to be more distribution centers, training centers, technical support from the innovators, follow up to ensure sustainability of the technology, and increase in the percentage of success and uptake.

INTRODUCTION



Conventional agricultural practices can cause a wide range of negative impacts on the environment. Conventional or modern industrial agriculture historically has been defined as the practice of growing crops in soil, in the open air, with irrigation, and with the active application of nutrients, pesticides, and herbicides. Some of the negative impacts of conventional agriculture include high and inefficient use of water, large land requirements, high concentrations of nutrients and pesticides in runoff, and soil degradation accompanied by erosion (Guilherme, Lages et at 2015). These have adverse impacts on the finite natural resources, and sustainable development will not be achieved. Other serious challenges associated with soil farming include high prevalence of pests and diseases which is exacerbated further by climate variability. The use of a considerably high amount of water in soil farming, coupled with the unpredictability of the rainfall patterns[1] and the high cost of installation of irrigation facilities, makes it even harder for the farmers to participate in agriculture. Increased cases of perennial food shortages and food insecurity due to low productivity are associated with these factors. Consequently, these affect food security and have no guarantee of improved nutrition. This increases the cases of stunted and malnourishment among infants, especially in developing countries.

The high population growth rate that is experienced globally exacerbates environmental problems. Humans tend to clear forests so they can practice agriculture and meet their dietary needs. According to Tilman et al., 2002, the human world population will reach about nine billion by 2050. The high population strains the finite resources, such as land. Land is subdivided into small uneconomical divisions for agricultural activities, which hinders the prosperity of agricultural activities in developing countries where agriculture is the backbone of economic activity. The biggest challenge for global agriculture today is producing enough food to meet the demands of the world's exploding population. According to Venter Gert 2017, the primary global challenges include food insecurity, military defense issues, water and land scarcity, urbanization, and energy demands. Farmers will need to produce double the amount

1 Most of the farmers depend on rainfed agriculture.

of food with less water and land, using less energy while facing sharp increases in the cost of energy, labor, mechanization, and fertilizers.The fertilizers and pesticides, on the other hand, emit greenhouse gases, such as methane, carbon dioxide, and nitrous oxide and lead to the greenhouse effect and global warming that contribute to climate variability. Climate variability is a serious threat to the nations' achievement of their development goals. Many regions in Africa are already highly vulnerable to climate-related hazards, with temperatures and rainfall being sporadic and extreme (MoALF, 2017).

The wasteful way food is produced today relies on extracting finite resources, including phosphorus, potassium, and oil, to grow food in ways that harm the natural systems upon which agriculture depends. The damage includes the degradation of 12 million hectares of arable land annually, one-quarter of annual greenhouse gas emissions, and three-quarters of deforestation from 2000 to 2010 (Ellen MacArthur 2019).

Hydroponics offers a solution to these predicaments. In summary, hydroponics is a technology for growing plants in nutrient solutions (water and fertilizers) with or without the use of an artificial medium[2] to provide mechanical support. It is the process of growing plants without using soil.[3]

The principle advantages of hydroponic systems over traditional growing methods include high-density maximum crop yield and crop survival, more efficient use of water and fertilizers, minimal use of land area, suitability for mechanization, and disease control. The costly and time-consuming tasks of soil cultivation are unnecessary in hydroponic systems, and a rapid turnaround of crops is readily achieved. The net effect is an increased yield, increased time of production, increased crops

2 e.g., sand, gravel, vermiculite, rockwool, peat moss, coir, sawdust

3 Hydroponics is derived from greek words, it is an amalgamation of two words : hydro, meaning water and ponein, meaning to toil.

per unit, increased quality of harvest, and improved use of resources. A less wasteful approach to resource consumption means reduced waste, preservation of water stocks, and a diminished reliance on pesticides, fertilizers, and other potentially harmful materials. A multiple effect is increased family income (Jensen, Merle H, 2010).

Soilless cultivation represents a valid opportunity for the agricultural production sector, especially in areas characterized by severe soil degradation and limited water availability. Furthermore, this agronomic practice embodies a favorable response toward an environment-friendly agriculture and is a promising tool in the vision of a general challenge in terms of food security (Sambo, P., et al, 2019).

Hydroponics Africa Limited is a private company that has been in existence since 2013 as the pioneer initiator and leader of hydroponic farming systems in East Africa. Their main office is in Zambezi, Kiambu county in Kenya, and they have a branch in Rwanda. However, they have clients across Kenya, Rwanda, Uganda, Tanzania, and Somalia. The company enables farmers to achieve predictable and highly nutritious yields for vegetables and produce their own animal feed at limited cost. With hydroponics, the farmer is unaffected by seasons and adverse weather conditions. It uses up to 80 percent less water. This, therefore, guarantees food security and improved nutrition. Hydroponics Africa leverages use of locally available materials and provides products such as hanging garden, hydrocrates, greenhouse for commercial purposes, fodder, circular, and vertical and horizontal hydroponic systems. Currently, they use a plant physiology and chemistry technology in which plant roots release an exudate that chemically signals the drip tape to release water when the crop has insufficient water to meet evaporative demand. The chemically infused microporous tubing holds water and nutrients until root exudates are emitted to trigger the release of water.

An impact evaluation was performed through interviewing 50 farmers face to face using the Fulcrum mobile application. The interviews were recorded and later transcribed. Literature review, observation, and inferences data collection techniques also were used. Photos of the farmers were taken. A key informant interview was done with the Hydroponics innovator, Peter Chege. The purpose of this report is to give evidence that farmers are using hydroponic technology and to verify whether the farmers are realizing water benefits, producing more food with less water, and improving household income. It also studies how the use of hydroponics differs between women and men and the difficulties and challenges that farmers face with the technology and the market system. Further, it provides recommendations on how the technology can be improved based on the farmers' experiences. The farmers were grouped into clusters based on their agro-ecological zones[4] and later randomly selected.

4 According to the agricultural potential.

BACKGROUND

Farmers that participate in hydroponics cut across different agro-ecological zones and include both rural and urban farmers, women and men, young and old, and rich and poor farmers. A total population of 1,546 farmers in Year 1 and Year 2[5] was used. The sample clusters included[6] Buruburu, Dagoretti, Gacuthi, Githunguri, Kangemi, Kenyatta Road, Kikuyu, Kingeero, Kitengela, Mathare Slum, Muguga, Nairobi, Ruai, Ruaka, Ruiru, Uthiru, and Waginge.[7] Fifty farmers were interviewed, and their selection is discussed at length in the next section. This section describes the demographics, livelihoods, and agricultural and economic context of the respondents.

Interviews were conducted face to face by field evaluator Brenda Binge in English and Kiswahili. Where necessary, local dialect was administered with the help of an interpreter. The interviews were carried out using the Fulcrum mobile application and analysed using SPSS and Excel where descriptive statistic variables in the data were calculated, including summary of frequencies and proportions of categorical variables such as gender, and averages of the variables such as water use. Crop yields were determined and, where applicable, correlation was determined. The questionnaire tried to answer whether the sample of customers is experiencing water/yield/ income/hydroponics benefits and to determine how the hydroponics technology can be improved to maximize benefits for the farmers. It also tried to assess the market system and understand the technology based on the farmers' perspectives and testimonials.

Gender

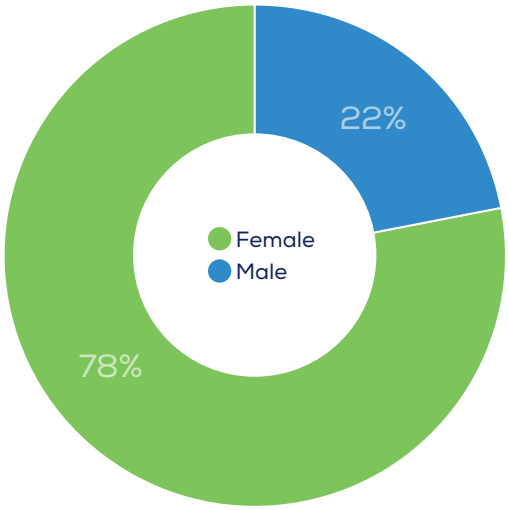
Seventy-eight percent of the respondents were female and 22 percent were male (Figure 1). Several factors tend to contribute to this disparity, among the most important is that male respondents are engaged in other income activities. Females are perceived to stay at home as the male engages in other off-farm activities. Women are now engaged in farming activities that once were perceived as a male dominant activity, which explains the high percentage of female respondents.

5 Y1 and Y2 were selected as these farmers had already harvested and thus could determine the objectives of the report. Y3 farmers had just began in May 2019 thus were difficult to assess the objectives of the report.

6 The number of participants in each cluster is available in the annex.

7 The calculation of the sample is in the annex.

FIGURE 1. GENDER OF RESPONDENTS (n=50)



Farm size

The land tenure system reported by the respondents include family tenure and individual (private) tenure. With the former, one is granted access to land on the basis of qualification as a family member. Respondents mentioned they had inherited the land. Individual tenure is where one owns land on more or less a permanent basis that is free from any claims from others. They are absolutely not answerable to anyone in the enjoyment of the land, including decisions on resource use and access. Land rates are paid to the county governments of their jurisdiction. A few farmers stay in rental homes and pay rent from as low as sh.2,000 per month in Mathare slums where the farmers basically do not have land or space for farming. The hanging bags technique has been used to counter the land space challenge, allowing them to farm from their walls. Maximum rent of Ksh.20,000 and 25,000 per month was reported by two respondents. One respondent was in an aggregation center where farmers aggregate their milk and sell collectively to avoid exploitation by middlemen,[8] and the other farmer was in a rental home.

The average farm size was 0.62 acres with huge disparity when disaggregated by gender (male 1.26 acres and female 0.44 acres). This disparity can be associated with the predominance of males in land matters, as they are the primary owners of the resources and women are less involved in the household decision making.

Four of the 50 respondents farm in school compounds and use the school utilities. The positive externality is earned by the pupils, as they are able to enjoy the feeding program and diversification of dietary needs.[9] Increasing school attendance with the assurity of food is a big challenge in areas

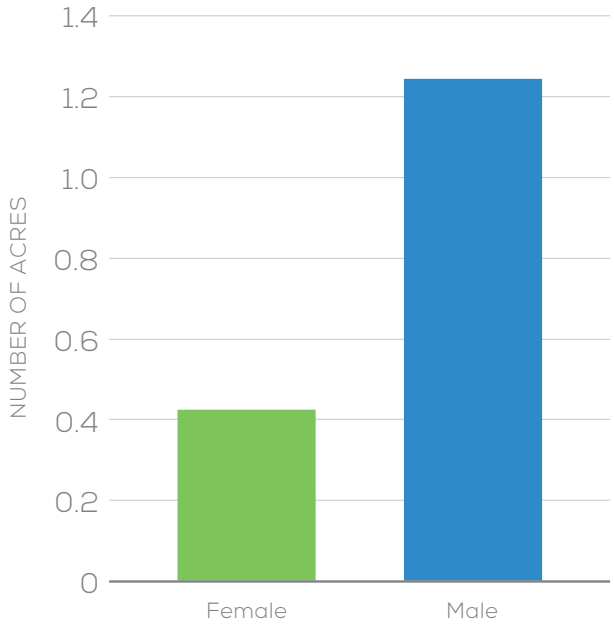
8 They have formed a farmers group to enjoy the benefits of collective action.

9 The crops include sukuma wiki, spinach, cowpea that are well spread in a feeding timetable.

such as Mathare slums; consequently, the farms improve the education system.[10] One respondent's farm takes care of the juveniles from the Kamiti Maximum Prison. This provides a spillover benefit with the reformation of the juveniles as they are engaged in agricultural activities to keep busy and limiting cases of crimes.

Figure 2 shows the size of the land in acres disaggregated by gender.

FIGURE 2: SIZE OF THE LAND IN ACRES DISAGGREGATED BY GENDER (n=50)



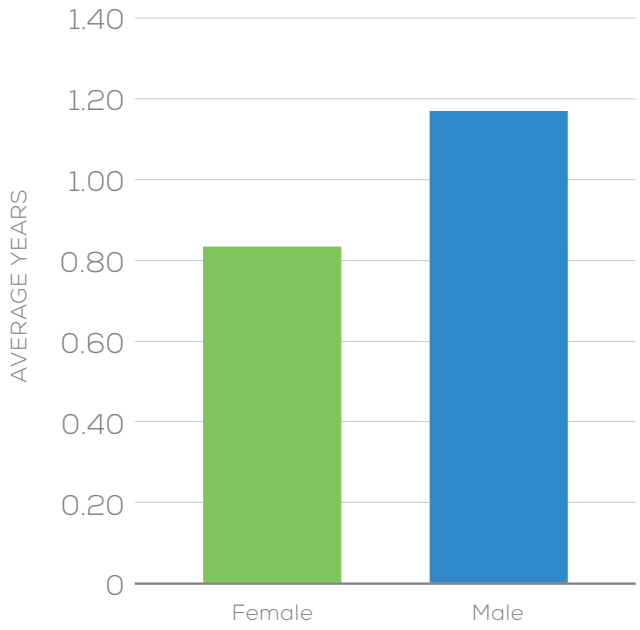
Farmer's experience and age

The average age of the farmers is 45 years. It is expected that as age increases, the experience with the technology increases; however, this is not the case with these respondents. The correlation between age and experience in years, despite being positive, is very low at 0.01.

The average years of experience is 0.91 years, with little disparity when disaggregated by gender. Females and males have had the technology for 0.84 and 1.16 years, respectively (Figure 3). Females tend to be less experienced in the technology, which can be associated with culture because in some regions farming is left to the husband as the head of the household while the wife is solely a homemaker.

10 Literacy level is improved.

FIGURE 3: AVERAGE OF YEARS EXPERIENCE (n=50)



Sources of income

The agriculture sector plays a significant role in household income despite the recurring challenges explained previously. Fifty-six percent of the respondents practice farming as their primary source of income. These include crop farming and livestock rearing. The main value chains[11] include vegetables such as *sukuma wiki,* spinach, local vegetables such as African nightshade commonly known as managu, cowpea (leafy) natively known as *kunde*, *kansira*, Indigenous Amaranthus (*terere*[12]), and fodder[13] for livestock feeds. There is a special preference of these vegetables because they are the best accompaniment to the staple food (*ugali*) and also attract higher prices, especially during the hot and dry seasons for farmers engaged in commercialization. Twenty-two percent of the respondents are employed,[14] 14 percent are engaged in small enterprises, such as owning a business. Six percent are wage laborers, and two percent are unemployed. The respondents engaged in wage labor are susceptible to vulnerability as they are not likely to be paid on a monthly basis and pay is normally low compared to their employed and small enterprises counterparts. The wage laborers include inter alia, tailoring, work on farm fields, and shops. For the small enterprises, some respondents had small businesses while some had enterprises that earned them more than Ksh. 720,000 per year. From these statistics, it is evident that the farmers are engaged in both on- and off-farm economic activities.

Figure 4 illustrates the respondents' economic activity (on- and off-farm economic activities).

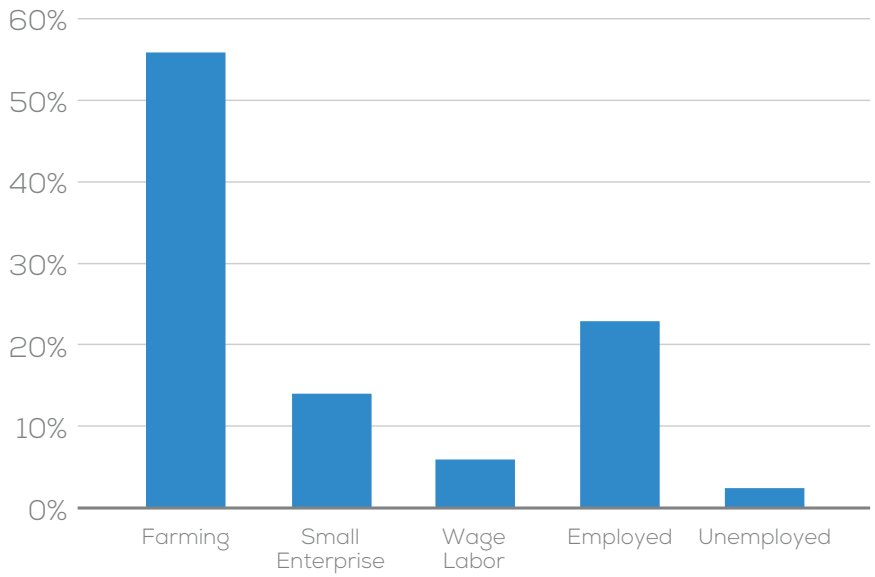
11 Other value chains that were also mentioned by respondents include, capsicum,celery, and parsley.

12 Other communities refer to the Indigenous Amaranthus as mchicha.

13 Barley was the common value chain reported by the livestock rearing farmers.

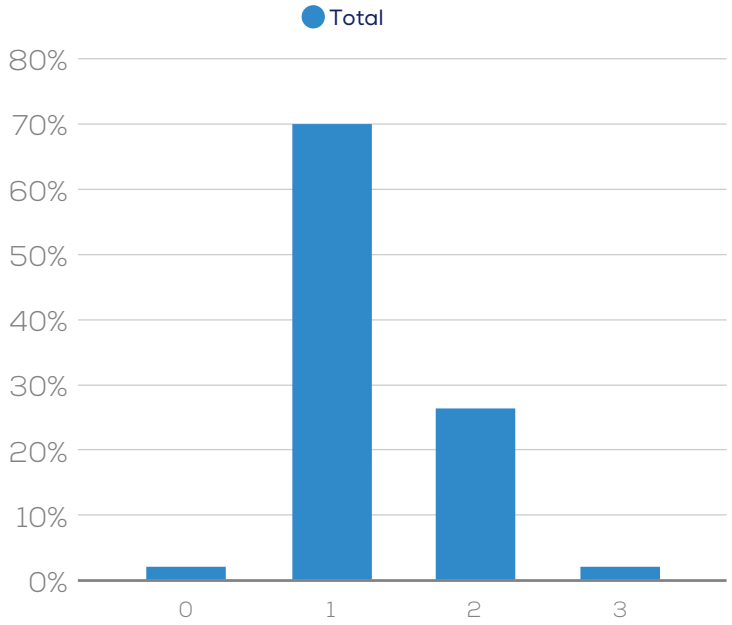
14 These include teachers, nurses among others.

FIGURE 4: RESPONDENTS ECONOMIC ACTIVITY (n=50)



The majority of the respondents (70%) have one source of household income. These respondents mentioned farming as their main economic activity.[15] The diversification of the income sources suggests likelihood of increased household income and thus less vulnerability. Only one respondent had diversified income of up to three sources of income, 13 of the 50 respondents had two sources of income, and one had no source of income.[16] Figure 5 shows the diversification of the income sources of the respondents.

FIGURE 5: DIVERSIFICATION OF INCOME SOURCES (n=50)



15 Some however do not engage in the sale of the surplus, they had other sources of income.

16 This respondent was only engaged in farming for subsistence with no surplus for sale.

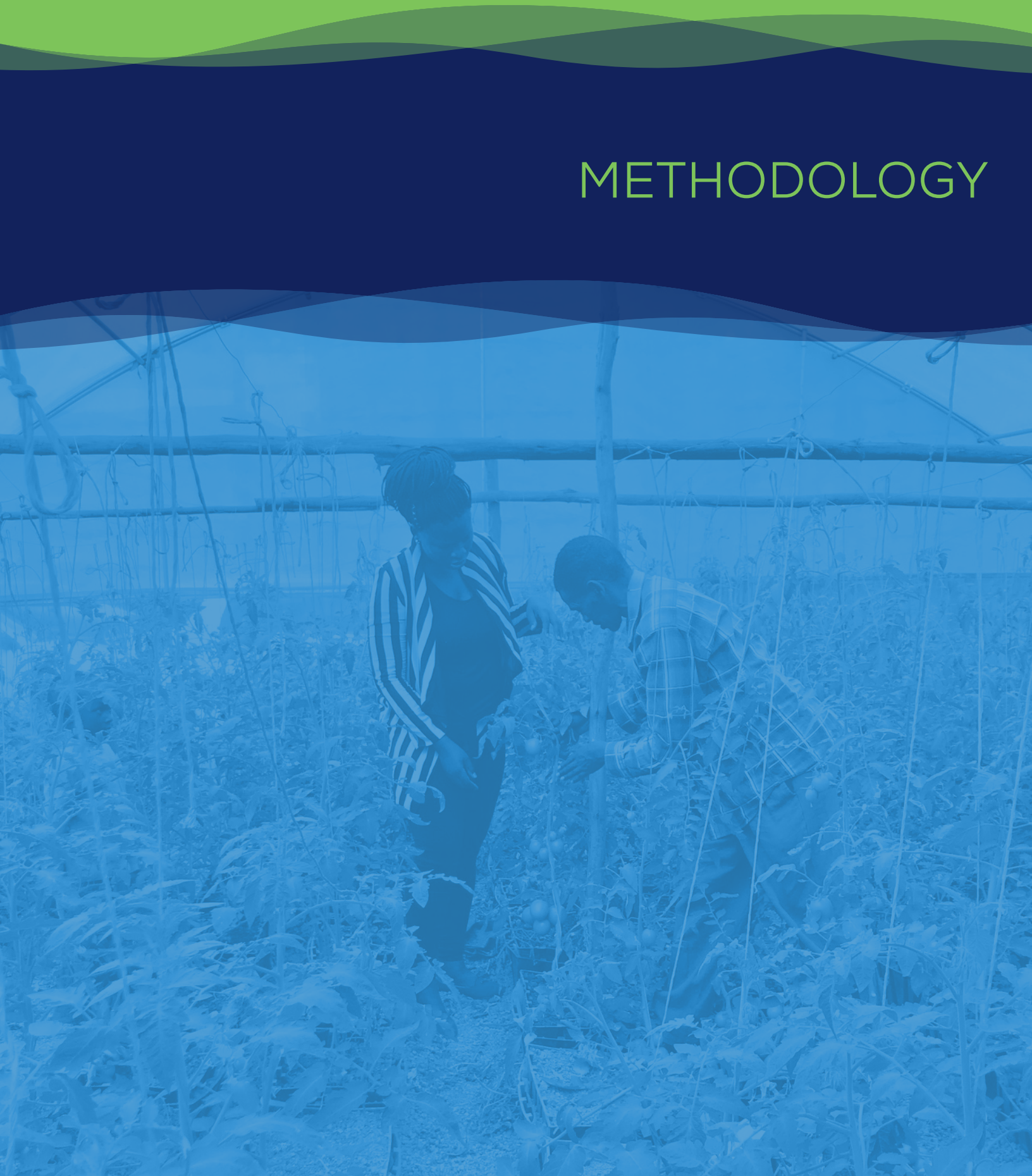
Family size

The average family size is four. This includes household members who share the same cooking pot methodology and is the nuclear family with a few incidences of external family, friends, and workers. There were male-headed households, female-headed households, and youth-headed households. The head of the household role includes, but is not limited to, decision making in resource use and access.

Two out of the 50 respondents had formed a group for women and a group for farmers, while three were engaged in the innovation in the schools where pupils benefited through the feeding programs. These schools included Kiboro Primary school and Destiny Junior, both in Mathare, and Moi Avenue Primary School in Nairobi. One respondent was in a children's home that cares for juveniles from the Kamiti Maximum prison.[17]

17 Currently, they take care of up to 15 boys.

METHODOLOGY



Sample selection

With the primary source of users list data from Hydroponics Africa, there was a total population of more than 1,500 farmers in Year 1 and Year 2 across 207 cluster villages. The farmers were characterised according to the various agro ecological zones (AEZ) in terms of agricultural potential. Farmers in the cold and wet regions are located largely in Kiambu county, Muranga, Embu, among other counties. These areas are in proximity with rivers and wetlands, such as River Njoro, Ruaka, etc. This is in contrast with farmers in the hot and dry areas of Kitengela, Athi River, Kamulu, Kakuma, Kitui, etc. Other counties with the hot and wet characteristic were grouped together, such as Kisumu, Mombasa. The farmers within the city were grouped together, since the hydroponics innovation does not require a large land space and is designed for easy adaption by urban farmers. Moreover, the evaluation also wanted to understand urban agriculture and the challenges they face. The sample selection involved clustering the farmers into cluster villages and later randomization to determine which farmers to interview. The sample clusters include: Buruburu, Dagoretti, Gacuthi, Githunguri, Kangemi, Kenyatta Road, Kikuyu, Kingeero, Kitengela, Mathare Slum, Muguga, Nairobi, Ruai, Ruaka, Ruiru, Uthiru, and Waginge. Literature review was carried out to research water use and farming practices of the farmers in the sampled areas, which was valuable in determining how to conduct the survey.

Probability proportion to size (PPS) procedure was used to ensure that the probability of a selected cluster is proportional to the size of the ultimate cluster, giving larger clusters a greater probability of selection and smaller clusters a lower probability. To ensure that all farmers in the population have the same probability of selection irrespective of the size of their cluster, each of the hierarchical levels prior to the ultimate level was sampled according to the size of ultimate farmers it contains, but the same number of farmers were sampled from each cluster at the last hierarchical level.

The number of farmers to be sampled from each cluster also was determined to ensure that all individuals in the population have the same probability of selection irrespective of the size of their cluster, the same number of farmers was sampled from each cluster. To determine the sampling interval (SI), the total population was divided by the number of clusters to be sampled.

Of the 207 clusters, 60 were considered for sampling based on convenience, easy to reach areas, time constraints, and budget constraints.[18] A random number between one and S1 was chosen through tossing of papers, and four was selected to determine the Random Start (RS) that was determined to be 11. The first cluster sampled contained the cumulative population, and the series went on until 20 clusters were determined.

A combination of simple random and systematic random sampling was then used to identify the individual farmers to be interviewed; 54 farmers were determined. These individual farmers were proportionally distributed by location in the same proportions as the overall population of farmers. However, with the challenges of the low response rate and missing specific attributes, the sample size was increased to 100 with over 200 farmers contacted. Fifty were available for interviews, and the results are discussed at length in later sections.

18 The characteristics are the same

In some instances, phone numbers and emails were not on the users list. Some were not willing to be part of the interview, others had not received their units and could not be evaluated, and still others were involved in other economic activities and had previous commitments. These farmers were replaced with new randomly selected users. Farmers sampled were not centralized, thus requiring more time because the farmers were spread across Nairobi, Kiambu, and Kajiado counties.

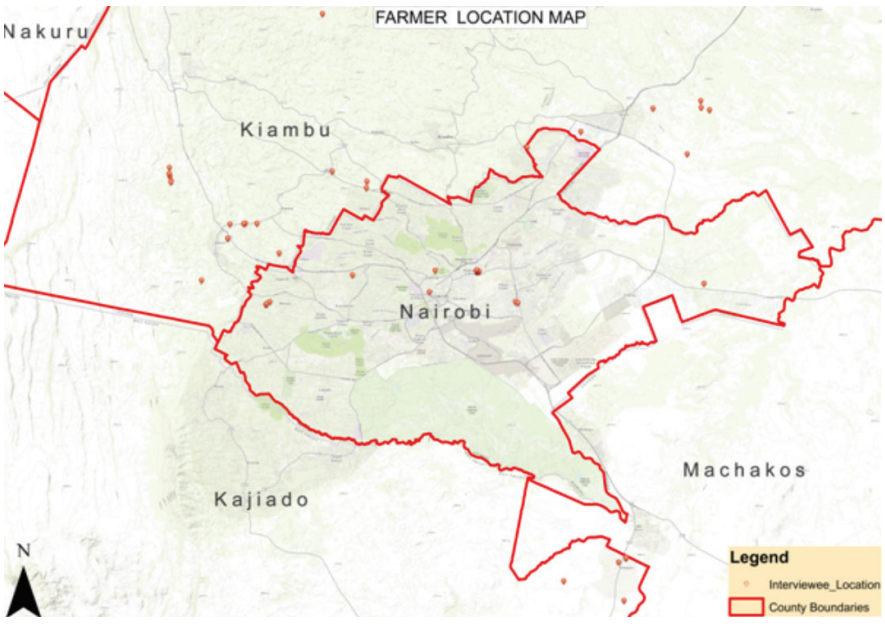
The field evaluator explained the purpose of the evaluation and sought consent to engage in administering the questionnaire. Participants verbally consented to engage in the interview. If they did not wish to respond to a particular question, they were asked to notify the evaluator and the particular question would be skipped.

The farmers were interviewed through face to face using the Fulcrum mobile application, the interviews were recorded and later transcribed, and photos with the farmers were taken. However, two respondents did not wish to be recorded so notes were taken.

In some instances, observation technique was used to lessen the burden and to validate interviewee responses as accurately as possible. In instances where the farmer did not know the answer or did not wish to provide a response, the evaluator asked related questions and used observations to determine and estimate. A conversion excel was generated that converted the various variables and is available in the annex section. The raw data was later analyzed using SPSS and excel. Descriptive statistics were analyzed for water use and crop yield; income mean, median, and averages were calculated; summary of frequencies and proportions of categorical variables such as gender was developed; and disaggregation of the various variables with gender and region\ where there was applicable correlation, was determined.

Figure 6 below illustrates the geographical location of the interviewed farmers.

FIGURE 6: GEOGRAPHICAL LOCATION OF THE 50 RESPONDENTS



RESULTS

EXPERIENCE WITH INNOVATION

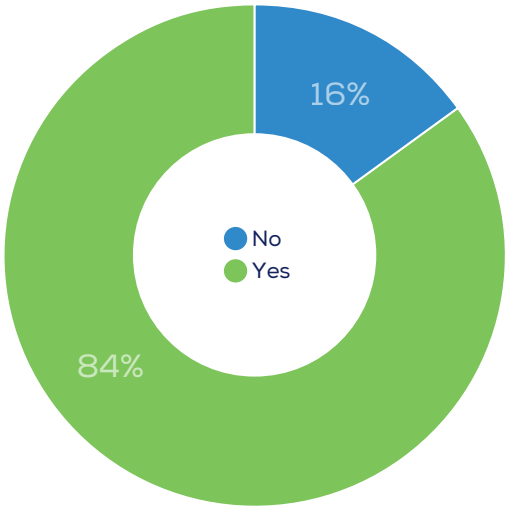
Farmers perceived the hydroponics technology as their "savior" in agricultural activities. They have been able to change their farming practices by reducing water use. Since they do not depend on the rainfall, they can now decide when and which crops to plant. They also reduce labor as there are less weeds. They spend less labor days and hours on the farm and engage in other economic activity to improve their household income. Female respondents feel the innovation is less labor intensive and "the market is at their doorstep" as they do not have to go to the market. With the scarce resource of water, hydroponics uses less water so they can allocate the water use in other domestic activities, reducing the distance and time in fetching water.

With the ongoing debate of the increased genetically modified foods in the market, farmers are happy that through hydroponics they now know what they are consuming and growing since they are involved in the agricultural activity decision making. Some attest they had health issues while they were purchasing food, but now can diversify their meals and improve their nutrition and dietary needs because they know the foods they are consuming.

With little or no use of pesticides, farmers are happy. They link the use of fertilizers and pesticides to the increased incidences of cancer. Some would say they are now "safe from cancer as they are no longer using these inputs."

Figure 7 illustrates whether the farmers will continue using the innovation in five to 10 years. Eighty-four percent of the respondents will continue with the innovation, while 16 percent said they will not. For the majority (84 percent), the decision is based on the benefits of hydroponics mentioned previously, while the 16 percent had the contrary opinion based on challenges they have experienced with the innovation.

FIGURE 7: RESPONDENTS USE OF HYDROPONICS AGAIN IN THE FUTURE (5-10 YEARS) (n=50)



All males will continue with the innovation, whereas 79 percent of females will continue and 21 percent will not. From the farmers' testimonials, their logic is based on the challenges they experienced. This included pests, diseases, water shortage, water scarcity, and high rates of evaporation. Some could not really tell why their crops failed. For instance, some of the farmers in Kitengela had the challenge of water shortage, resulting in crop failure. They could not understand why their crops failed since the demonstrations and training by the innovator showed they should have survived. These farmers initially depended on the rainfall for farming; but with the introduction of hydroponics, they are now buying water from vendors and prices would go up during the dry spells. This was a limiting factor in the success of the innovation and posed challenges to their farming.

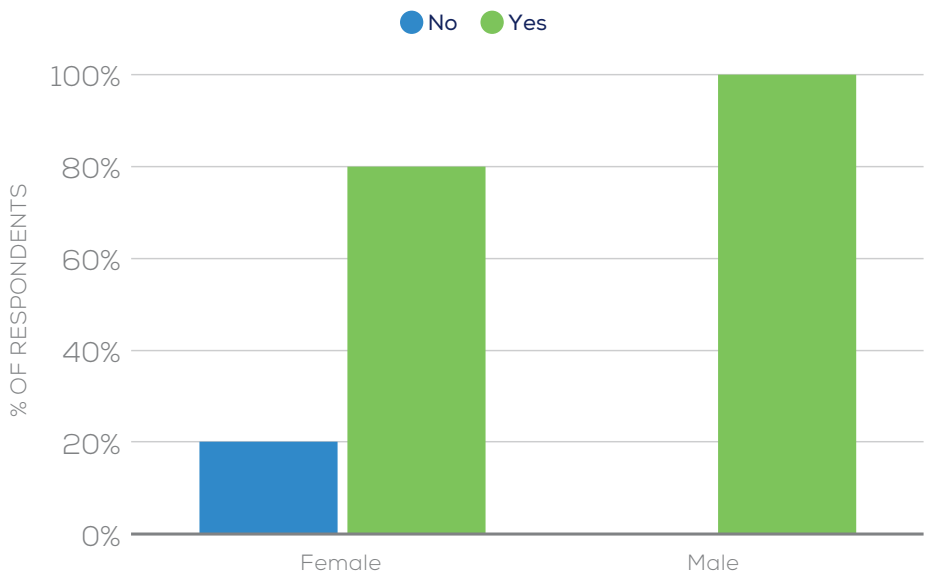
Some farmers reported they will not continue with the innovation using the hydrocrate technology (with rock wool material).[19] They cited shortcomings including increased temperature and high rates of evaporation causing the rock wool to harden and leading to crop failure, and it also degrades after one year. Some of the farmers in Dagoretti cited "skin irritation" and felt it may not be safe to use.

There were few concerns with the nutrients because farmers do not know the components of the nutrients. They want to be trained more on the components so as to limit the uncertainty surrounding the nutrients.

Figure 8 illustrates whether the farmers will continue to use the Hydroponics Africa innovation five to 10 years in the future, disaggregated by gender.

19 Farmers in Kitengela, Ruaka and Dagoretti had the hydrocrates with rock wool material that did not do well in all three areas.

FIGURE 8: RESPONDENTS USE OF HYDROPONICS FIVE TO 10 YEARS IN THE FUTURE, DISAGGREGATED BY GENDER (n=50)



BENEFITS OF INNOVATION

Agricultural activities benefits

The respondents interviewed engaged in a variety of value chain commodities (VCC) from vegetables to fruits. The five main VCCs are kale (*sukuma wiki*), spinach, local vegetable (*kansira*), and local vegetable African nightshade (*managu*) and *terere*.

Looking at the value chain in totality from the inputs, on-farm production, post-harvest, and market, farmers spend less money with the introduction of the hydroponics innovation. Before, the average amount spent in agricultural activity was Ksh. 21,297 per year. These costs include, but are not limited to, fertilizers, pesticides, water, labor, storage, and transport costs. However, with the introduction of hydroponics, the average cost is Ksh.11,102 per year.

The main inputs reported by respondents include water, fertilizers, pesticides, manure, and labor days/hours. In conventional farming, 11 farmers mentioned they applied fertilizers with an average cost of Ksh. 16,677.5 per year to increase the crop yields. With the introduction of hydroponics, none of the farmers reported the use of fertilizers. They only associated it with the nutrients that they purchase with the hydroponics system. Six farmers reported using pesticides input before the use of hydroponics with an average cost of Ksh.3,069. After the adoption of hydroponics, only one respondent mentioned using the pesticides at a cost of Ksh.2,880 per year. Twelve respondents reported purchase of water from vendors with conventional farming.

The majority of respondents depended on rain water, streams, rivers, and underground water that was free of charge since water is a public good and free for all. However, 12 respondents did not enjoy this water service and had to purchase water from the vendors at an average cost of Ksh 21,299 per year. With the adoption of hydroponics, the cost is expected to drop; however, the average cost of water per year reported by 23 respondents is Ksh.24,008.93. This is associated with the high price of water, especially during the hot and dry season. Additionally, before the introduction of hydroponics, most farmers relied on rainfall that in most cases was unpredictable. With the introduction of hydroponics, they do not depend on the uncertain rainfall pattern, suggesting that most will now have to buy the water from vendors to continue with the agricultural activity. This is evident with the increase from 12 to 23 respondents who incurred water costs. The other farmers reported use of groundwater, rain water harvesting, rivers, and streams that they enjoyed free of charge.

For labor, the farmers gave labor hours/days where they depended on family labor with only one farmer giving the labor expense to employ someone. This is the labor used in on-farm and post-harvest. They mentioned that with hydroponics, they spend less time in the fields as compared to conventional soil farming. Three farmers mentioned they spent on average Ksh.4,000 on manure

with conventional farming while others could get the same on farm[20] and at no cost. However, with hydroponics, none of the farmers reported use of manure input.

For the transport and market costs, they did not spend much because the market is at their doorstep. Only two farmers mentioned transport costs as more people and middle men come to the farms to buy.

These results are indicative but not accurate as the objective was to compare before and after the innovation. However, some farmers were not engaged in farming before the introduction of the hydroponics system but have become involved in farming since the introduction. This is an advantage because some are now engaged in farming, which is an economic activity to improve family income and, consequently, reduce poverty. This also leads to food security and improved nutrition.

When disaggregated by gender, females spent Ksh 2,750 before the innovation and ksh. 4,485 per year after the innovation. This disparity is associated with the water input cost. Before, most of the females depended on rainfall for farming, but with hydroponics they have to purchase water to ensure sustainability of the system. As water is a limited, expensive, and scarce resource, it tends to be expensive with exacerbated prices during the hot and dry season that is prolonged with the climate variability.[21] The rate from the Nairobi water and sewerage company that supplies and distributes water indicates 0 to 100 liters is Ksh.43 per unit.[22] Males, however, spent Ksh.87,055 per year before hydroponics and Ksh. 34,562 per year after hydroponics. Several factors contribute to this disparity, with the most important being the significant reduction of water use by hydroponics technology meaning less water costs, little or no usage of pesticides and fertilizers, and reduced labor costs in weeding, pruning and labor hours.

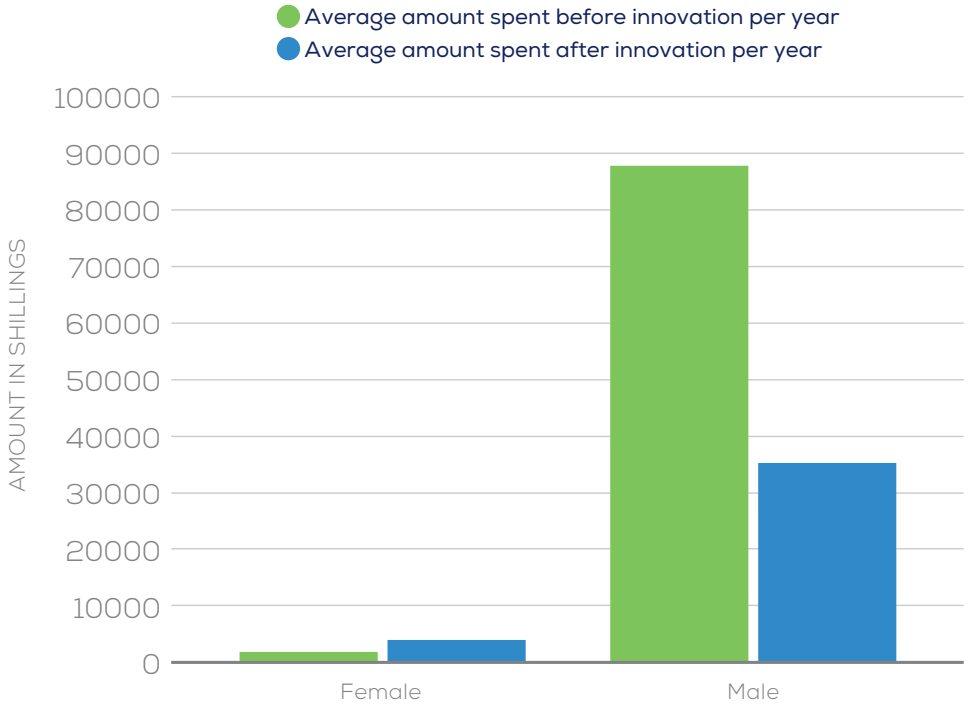
Figure 9 illustrates the average amount spent per year in agricultural activities before and after the innovation, disaggregated by gender.

20 These farmers engaged in mixed farming and thus could get the manure on farm.

21 For instance, the 20 liter jerry can can go as high as 50sh during the dry season as mentioned by farmers in Mathare slums.

22 There are other charges such as meter reading.

FIGURE 9: AVERAGE AMOUNT SPENT PER YEAR IN AGRICULTURAL ACTIVITIES BEFORE AND AFTER THE INNOVATION, DISAGGREGATED BY GENDER (n=50)



With the introduction of hydroponics, the number of harvests has increased along with increases in the quality of harvest and the time of production. Most of the farmers harvest vegetables weekly or biweekly, including *sukuma wiki*, spinach, capcicum, tomatoes, onions, and local vegetables such as cowpea-leafy (*kunde*), African nightshade (managu), *terere*, *kansira*. For the fodder, barley takes six to seven days to mature which has direct proportional impact on yields. The households are guaranteed meals providing food security and improved diet. For the livestock, health and milk production are improved. For instance, one dairy goat in Githunguri is fed 2 kilograms of fodder produced hydroponically and can produce up to 3 liters of milk per day.

Water benefits

The main source of water in agricultural activities reported by the farmers includes ground water, rainfall, tapped/piped water, and rivers. As a public good, water is scarce and expensive. This affects agricultural activities and, consequently, food security.

Prior to the introduction of hydroponics, many farmers relied on rainfall farming, which is tied to the challenges of climate extremities. Reliance of rainfall as their primary source of water poses a challenge in quantifying how much water was used before the technology,[23] however, it was easy for some farmers to compare their water use before and after the technology.[24] These farmers used the same source of water, making it easy to compare what they used before and after the introduction of hydroponics. With the challenge of change in water source, the use of statistical tests such as T-test is limited. However, an average amount of water used after the innovation was determined.

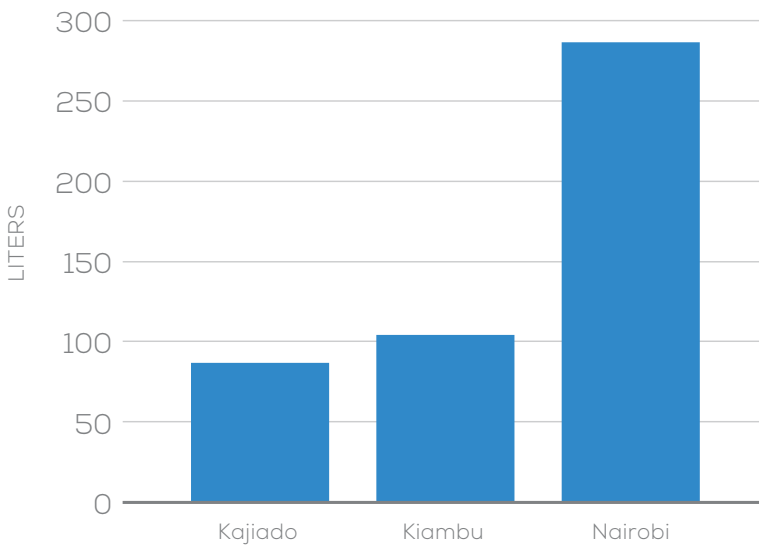
23 It was hard for them to measure the rainfall used in farming.

24 For those who did not depend on rainfall farming

With the introduction of hydroponics farming, farmers do not have to rely on the unpredictable rainfall and are unlikely to be affected by climatic shocks such as heat stress, increased and extremely low temperatures, and the prolonged drought. Each of these has negative impact on water access and availability and, ultimately, food security. With hydroponics, farmers can go on with their farming practices. The average amount of water used by hydroponics is 173 liters per week with huge disparity when disaggregated by gender. Females use an average of 154 liters, and males use 242 liters. This disparity can be associated with several factors including that females are known to be the ones fetching water so they know the challenges such as distance to the water source, water scarcity, unavailability, and unreliability. This means they tend to use it more economically than their male counterparts. Males also tend to have invested in water harvesting techniques such as ground water, rain water, and piped water. It is worth noting that the water benefits are confounded by the size of the land.

Figure 10 below disaggregates amount of water use per week in liters by region.

FIGURE 10: DISAGGREGATION OF AMOUNT OF WATER USED PER WEEK IN LITERS BY REGION (n=50)



Kajiado is in the hot and dry agro ecological zone and has challenges with water access, reliability, and availability. Water is a scarce resource which limits its use. The average water use per week is 84 liters compared to farmers in Nairobi and Kiambu who use 285.2 and 103.9 liters per week, respectively. Kiambu is in the cold and wet agro ecological zone, so the farmers engage in rain water harvesting techniques and incur high water use. Relatively, farmers in Nairobi have boreholes and piped water provided by the Nairobi city county, which can also be associated by the wasteful nature of the people in the city.

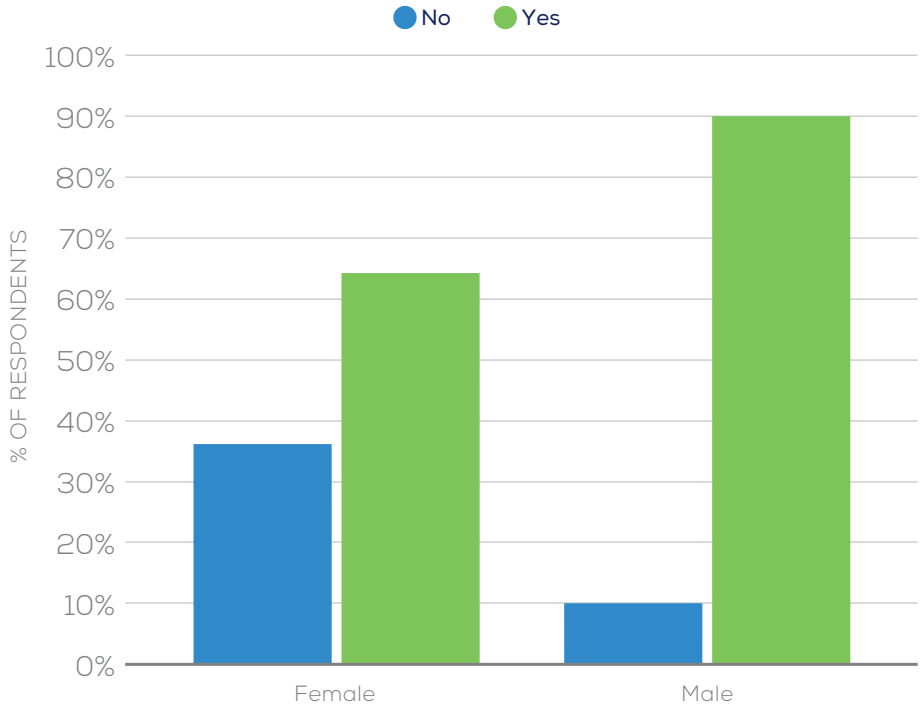
Crop benefits

Some of the farmers engaged in summer crops like maize, beans and other crops before the innovation . However, with the introduction of hydroponics, they now can engage in horticultural crops that are perceived to be expensive to maintain due to the high costs of associated inputs. This poses a challenge in comparing yields before and after the innovation since the crops before hydroponics are different from the crops produced after adoption of hydroponics. Some of the farmers, however, engage in the same crops before and after innovation.

With hydroponics, there are incidences of crop survival compared to soil farming, as crops evade the soil borne diseases that are common in the tropics and farmers do not have to depend on the climate that is characterised by high incidences of prolonged drought, reduced rainfall, flood, increased temperatures, and other related climate extremities. Seventy-seven percent of the respondents' crops survived, whereas 23 percent did not survive. When disaggregated by gender, 90 percent of male farmers' crops survived and 10 percent did not survive. As for females, 64 percent said their crops survived and 36 percent did not survive. This can be associated with males engaging in better agricultural practices compared to females and the barriers that limit females such as water access and reliability.

Figure 11 below illustrates whether the crops of the respondents survived, disaggregated by gender.

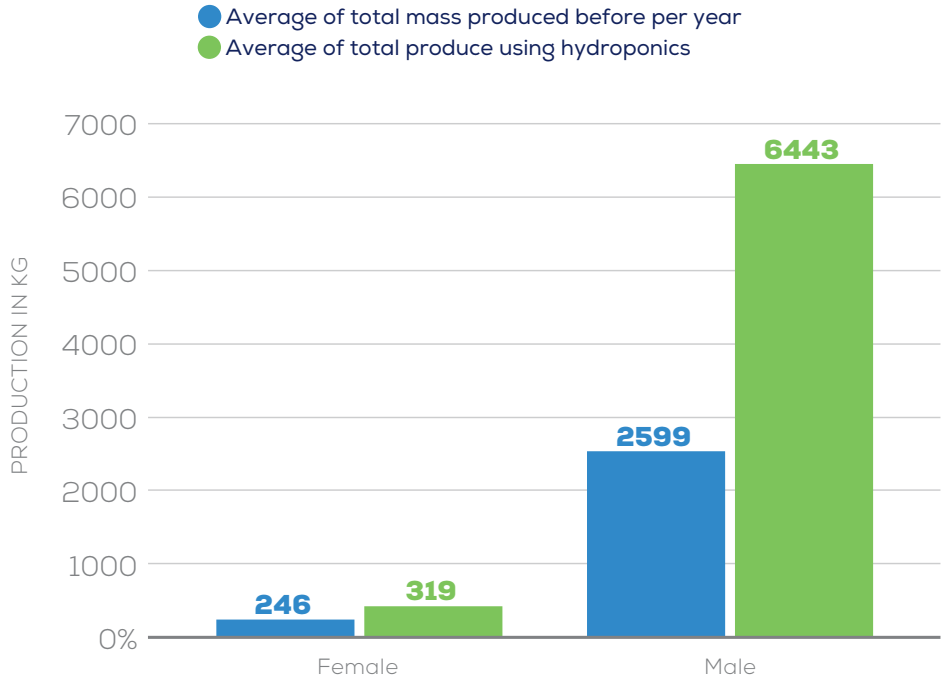
FIGURE 11: WHETHER THE CROPS OF THE RESPONDENTS SURVIVED, DISAGGREGATED BY GENDER. (n=50)



The average crop production in kilograms per year before the use of hydroponics was 750 kilograms while hydroponically the production significantly increased to 1,632 kilograms. This can be associated with the benefits alluded to hydroponics that increase crop yields through timely forecasts.The farmers do not need to rely on the uncertainty of the weather and can have increased yields. Hydroponics increases the time of production per year, the number of crops per unit, and the quality of harvest while weeds and pests are limited. When disaggregated by gender, females produced 246 kilograms per year before the innovation and 319 kilograms per year after the innovation. Similarly, males reported significant increases in production from 2,599 kilograms per year before hydroponics to 6,443 kilograms after.[25] Several factors tend to contribute to this huge disparity, including the female farm unit size is smaller than the male farm unit, females are less involved in decision making about resource use, and they have limited access to farm inputs such as water as compared to their male counterparts.

Figure 12 below illustrates the total production per year before the innovation and after the innovation, disaggregated by gender.

FIGURE 12: TOTAL PRODUCTION PER YEAR BEFORE THE INNOVATION AND AFTER THE INNOVATION, DISAGGREGATED BY GENDER. (n=29)



25 a conversion excel is available at the annex. several farmers could associate the production to bunches, bucket, basin. The conversion excel has converted this to kilograms.

Income benefits

The majority of the farmers engaging in this innovation use it for subsistence with little or no surplus for sale. Eight of the 50 farmers are engaged in the sale of their surplus produce. Six of the eight are engaged in the sale of vegetables, and two are engaged in the sale of milk. The average income earned per year from the sale of their surplus as a result of hydroponics is Ksh. 24,233 for the six farmers and Ksh. 158,400 for the two farmers. The high numbers involved in subsistence and not sale of surplus can be associated with the high cost of the system. Thus, they can afford a small unit area. They wish to upscale and commercialize the farming, but capital is the limiting factor. Some farmers noted since they are not purchasing, they are saving and improving their household income.

Farmers involved in fodder are also involved in the commercialization of the milk and improving their household income because they produce more income when they feed their livestock with fodder produced hydroponically as compared to feeding the napier grass, hay, maize stalks, etc. Using the previous example of the Githunguri dairy goat producing three liters of milk, the gross margin per day per goat is Ksh. 360,[26] less the daily expense per goat of Ksh. 60, making the net income per day per goat Ksh. 300. Similarly, a respondent within a children's home in Nairobi-Kahawa West reported an increase in profit margin with hydroponics because they are able to sell more milk when farming hydroponically. This scenario is similar to the farmers engaged in the production of horticultural crops that allude to the improved household income such as celery, parsely, tomatoes, and others.

26 Given that the price per liter for dairy goat is Ksh.120.

Poverty reduction benefits

The poorer households have smaller unit systems than their rich counterparts so few are engaged in the sale of their surplus. However, they try to sell the surplus, and most desire to upscale their farming and commercialize, but are limited by capital and space. Most of these poor farmers live in densely populated areas such as mathare slums, or farmers' lands have been fragmented into very small subdivisions due to the high population growth rate.

For the few respondents who engage in the sale of the surplus, there is evidence of improved household income and, consequently, poverty reduction. Some farmers also argue that they can now save more since there is no purchasing of the farm produce – the food comes from their farm as opposed to purchasing from the market. However, income is the same since they are not involved in selling.

DISCUSSION

Before the innovation, some of the farmers relied on rainfall for their agricultural activities so it is difficult for them to determine how much water they used. Similarly, for crop production before the innovation, previously planted crops are different from crops planted hydroponically, therefore limiting the use of statistical tests such as t-test. However, averages were determined.

The majority of the farmers are engaged in hydroponics to boost their home consumption with little remaining for market sales, so they are involved in other occupations off-farm. This presented a challenge in reaching the respondents. Farmers sampled were not centralized, which required more time, and some were not reachable. Others did not wish to have the interviews because it would take too much time and there was no compensation provision for time lost due to participating in the survey. Despite the challenges, the survey was successful and the target respondents achieved.

Usage/Availability

The majority of the farmers are continuing with the hydroponics innovation due to the benefits associated with it, such as reduced water use, involvement of women, increased yield through timely forecasts, the ability to decide when and which crops to plant, the ability to diversify crops,[27] and reduced farming activities costs. With the success of hydroponics, some have been able to start small scale commercialization of crops so as to enjoy the economies of scale.

Contrary, some of the farmers discontinued farming hydroponically due to pests and diseases, water shortages, crop failure, distance to the collection or distribution centers. Some farmers said this posed a challenge in their production and, consequently, affected their farming practices. Some wished to upscale their farming but are challenged by space and cost implications of the installation.

27 increasing their dietary needs.

Crop yield/survival

Conventional farming requires active application of farm inputs such as fertilizers, pesticides, and herbicides. With their prohibitive prices, very few people[28] can afford inputs which leads to crop failure. This is because crops cannot survive in such an environment and there is reduced crop yields and/or crop failure. Similarly, the poor land tenure systems leads to fragmentation and reduced farming land affects the yields. Climate variability pose serious threats in farming, scarcity of water, increased temperatures, and very low temperatures because frost affects crop production. These problems have an adverse impact on crop yields. The challenges associated with soil farming, such as soil borne diseases, are common in the tropics.

Hydroponics revolutionizes crop farming through less water use, decreased input use and costs, reduced pest population, little or no weeding, increased quality of harvests, and increased in production time, all of which have a positive impact on crop yields.The artificial intelligence system, for instance, is able to respond in real time to plants' needs and changing weather conditions. The farmers testified that with hydroponics, they are not affected by climate variability and, thus, their produce is guaranteed. They are able to increase their yield through timely forecasts and for the livestock because the fodder improves livestock health and milk production.

Farmers report increased yields because of the hydroponics technology. With a small unit area, they are able to produce much more than compared to previous use of soil farming.

Most of the farmers report increased crop survival. For instance, the respondent in Nairobi-Kahawa West engaged in hydroponics during the dry spells[29] as the fodder grown hydroponically will survive, giving a continuous supply of food for the livestock.

Some farmers have access to project water that is a county government initiative to distribute water to its residents. This means the cost of water is reduced, and water is available which increases crop yield.

Changes in income

Most of the respondents were within the extreme poor bracket, earning Ksh 0 to 240,000 per year. The majority undertake farming as their primary occupation whereas respondents who diversified their sources of income were within the 240,001 to 480,000; 480,001 to 720,000; and 720,000 and more per year brackets.

Most farmers' motivation for adopting the hydroponics innovation is to boost home consumption with little for market sales. Thus, there is little or no change in income for most of the farmers although they are able to save more as they reduce the cost of purchasing and transporting food. Farmers who are selling their surplus and engaged in the commercialization report a significant increase in household income.

Looking at the significant reduction in the cost of farming above, farmers save and improve their household income. These monies can be allocated in other budgetary needs, such as health and education, and improve the well being of the respondents and their families altogether.

28 This is due to the high poverty rates

29 However, during the rainy season, they engage in hay, maize stalk as they depend on rainfed farming.

The majority of the respondents report no increase in family income because the household consumes the additional yield. A few farmers (10) provided evidence of the somewhat, significant and very significant increase in the family income attributed to hydroponics. Of those, seven are within the extreme poor bracket of farmers earning Ksh 0 to 240,000 per year. This, therefore, suggests an increase in family income.[30] It means if the farmers were to commercialize on their farming, there will be an increase in family income.

Gender differences

Both male and female farmers experience benefits from hydroponics. This included reduction in water use, increase in crop yields/survival through timely forecast, reduction in farming inputs costs, and help deciding which crops to plant and when to plant. With the poor land tenure systems, there are challenges with land access. Females benefit more from the land challenge; culturally, males own more land than females who are also less involved in decision making of the use of the land resource. With hydroponics, it is possible to engage in farming with a small land space, thus making a special effort to include in farming women who are limited by land space due to cultural restrictions.

Hydroponics is also less labor intensive and makes it possible for females to engage in farming like their male counterparts.

30 10 out of 50 farmers is a small representation to provide an average of increase in income as a result of the technology.

Within water use benefits, women faced greater barriers in accessing water input and spend more accessing water from vendors. Also, the prices increase with the dry season prolonged by climate variability.

Males tend to benefit more than females due to several factors, including but not limited to land size, access to farm inputs, affordability of the innovation, and education/literacy levels.

Affordability

Most of the farmers are comfortable with what they pay currently because of the benefits of hydroponics. They feel it is economical and the payment plan makes the innovation affordable. However, many feel the innovation should be free simply because they cannot afford it. Some of the respondents interviewed mentioned they received the innovation for free[31] and wish to upscale their production to enjoy the economies of scale.

The majority wish to upscale their farming, but the limitation is the installation cost which is expensive to most of them. This explains why most of the respondents are engaged in subsistence farming.

The respondents whose crops did not survive have a contrary opinion on the same. They feel they have not been able to break even and make profits from farming. They feel they have had losses and have wasted time with the technology that otherwise could be channelled into other activities.

Impact on poverty

Most of the respondents are engaged in subsistence farming, which is attributed to the costs associated with the installation of the hydroponics innovation. Therefore, most can only afford a small unit size for home consumption. They wish to upscale their farming and increase their family income. However, it can be assumed that since they are purchasing from the market there is an increase in financial savings. This, therefore, means the poverty level is reduced.

Benefits of hydroponics on community

With the hydroponics innovation, farmers have come together to form farmer groups. They believe that when they come together, they are able to benefit more and learn from each other. A women's group in Mathare slums came together and engaged in farming as a result of the education they received from their children. Similarly, farmers in Githunguri came up with an aggregation center to aggregate their produce as a result of hydroponics farming. This leads to food security for the community, reduced cost of food,[32] and, ultimately, improved health and nutrition of the community.

Other farmers land have served as a demonstration space where neighbors and relatives learn about hydroponics. The farmers are also willing to share the skills they have learned with others.

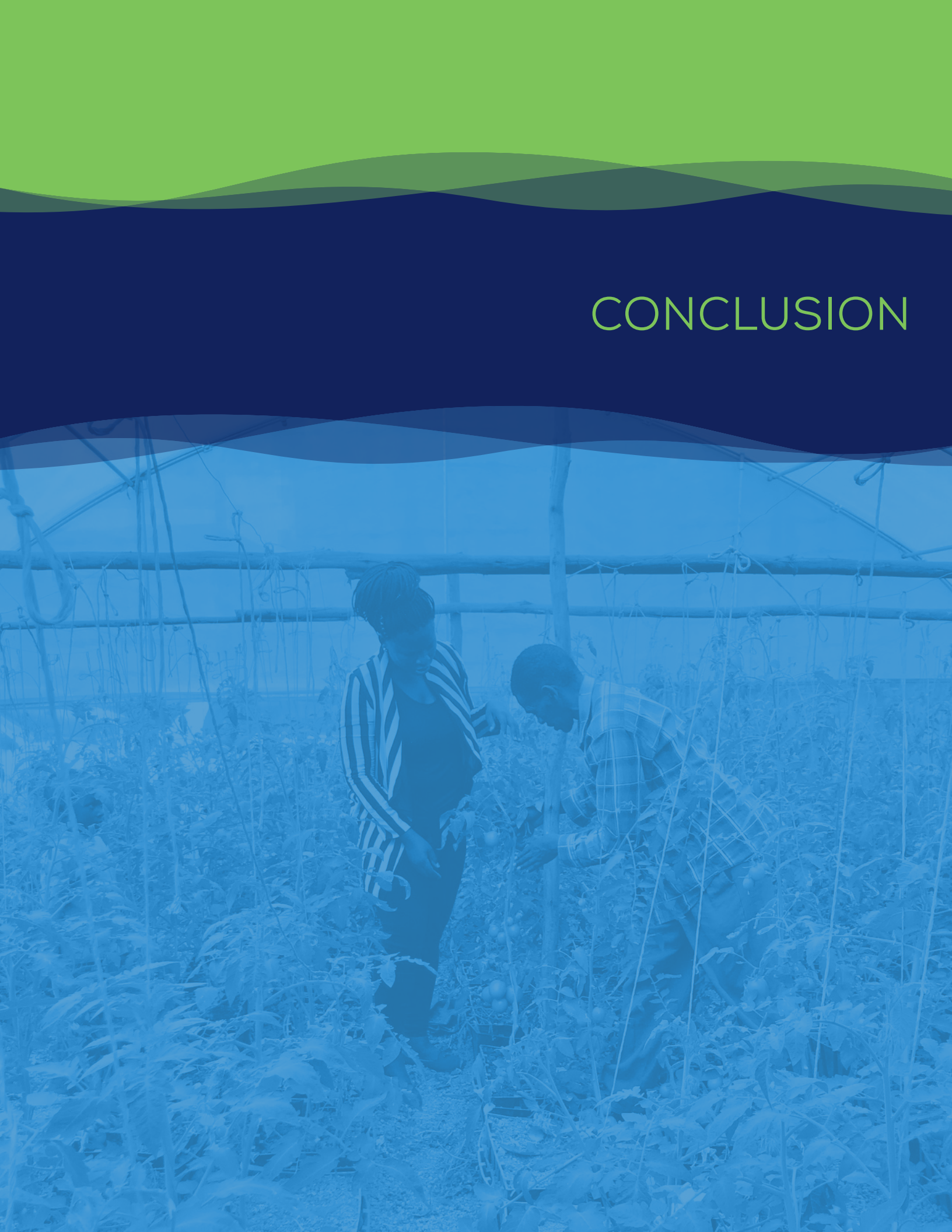
31 They were very pleased with the technology and, more so, with having the technology for free.

32 With the increase in the production of the crops and milk, reduced cost of the agricultural activities (production), the net effect is reduced prices of these commodities.

Comparison of latest innovator M&E statistics with latest SWFF M&E statistics

From the innovator data, the approach was different in determining whether the farmers realize water and yield benefits, but the results are similar and indicate that with hydroponics, farmers tend to use less water and experience an increase in agricultural production.

CONCLUSION



Most of the farmers' motivation for adopting the Hydroponics Africa innovation is to boost their home consumption for food security and guarantee the dietary needs. However, there is the urge to upscale their farming, but the challenge lies in the initial capital associated with the installation and the land space. Water input cost also is seen as a challenge in the success of hydroponics. If barriers associated with water are solved, then most of the farmers will enjoy the benefits associated with the innovation.

The majority of the respondents have benefited from the water/yield/cost of production benefits. These benefits lead to reduced prices of produce to the community, a spillover effect that is crucial to the community as it ensures food security and affordability, consequently improves nutrition.

For the farmers with challenges of land access and availability, they can be encouraged to consider crops requiring very little space such as peppermint, spearmint, and other herbs. These crops attract very high prices per batch, with the range of Ksh 20 to Ksh 40 where other vegetables such as sukuma wiki costs Ksh 18 per kilogram. This can lead to improved household income and, consequently, reduced poverty.

With 77 percent of the respondents positively impacted by the hydroponics, the innovation is important in agricultural activities. The number is likely to rise if the challenges and barriers experienced by the farmers are addressed. The female respondents are seen to be vulnerable as much as they are working toward benefiting from the innovation. If the stumbling blocks are addressed, they will be up against their male counterparts.

Farmers can be advised to practice staggered farming with crops such as celery and parsley so that when they have harvested there is less time to wait for the next harvest, a climate smart agriculture technique that is sustainable and guarantees the farmers' food prosperity.

REFERENCES

Ellen MacArthur , 2019, World Economic Forum, Our food system is no longer fit for the 21st century, Here are three ways to fix it. available at https://www.weforum.org/agenda/2019/01/how-to-build-a-circular-economy-for-food/

Guilherme Lages Barbosa et al., 2015, Comparison of Land, Water, and Energy Requirements of Lettuce Grown Using Hydroponic vs. Conventional Agricultural Methods, 12(6): 6879–6891. Available at https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4483736/Jensen, Merle H, 2010. Hydroponics Worldwide-A technical Overview, University of Arizona School of Agriculture Tucson, Arizona 85721. Available at: https://pdfs.semanticscholar.org/d4a7/1ef04b4d174d00d65fc4238629db99f9bd1a.pdf

MoALF, 2018. Climate Risk Profile for Kisumu County, Kenya County Climate Risk Profile series. The Kenya Ministry of Agriculture, Livestock and Fisheries (MoALF), Nairobi, Kenya. Available at: https://ccafs.cgiar.org/publications/climate-risk-profile-kisumu-county-kenya-county-climate-risk-profile-series#.XVW1RjcvN6x

Sambo, P., Nicoletto, C., Giro, A., Pii, Y., Valentinuzzi, F., Mimmo, T., Cesco, S. (2019). Hydroponic Solutions for Soilless Production Systems: Issues and Opportunities in a Smart Agriculture Perspective. *Frontiers in plant science, 10*, 923. doi:10.3389/fpls.2019.00923

Tilman D., Cassman K. G., Matson P. A., Naylor R., Polasky S. (2002). Agriculture sustainability and intensive production practices. Nature 418, 671–677. 10.1038/nature01014.

United Nations Sustainable Development, 2019, Forests, Desertification and Biodiversity available at https://www.un.org/sustainabledevelopment/biodiversity/

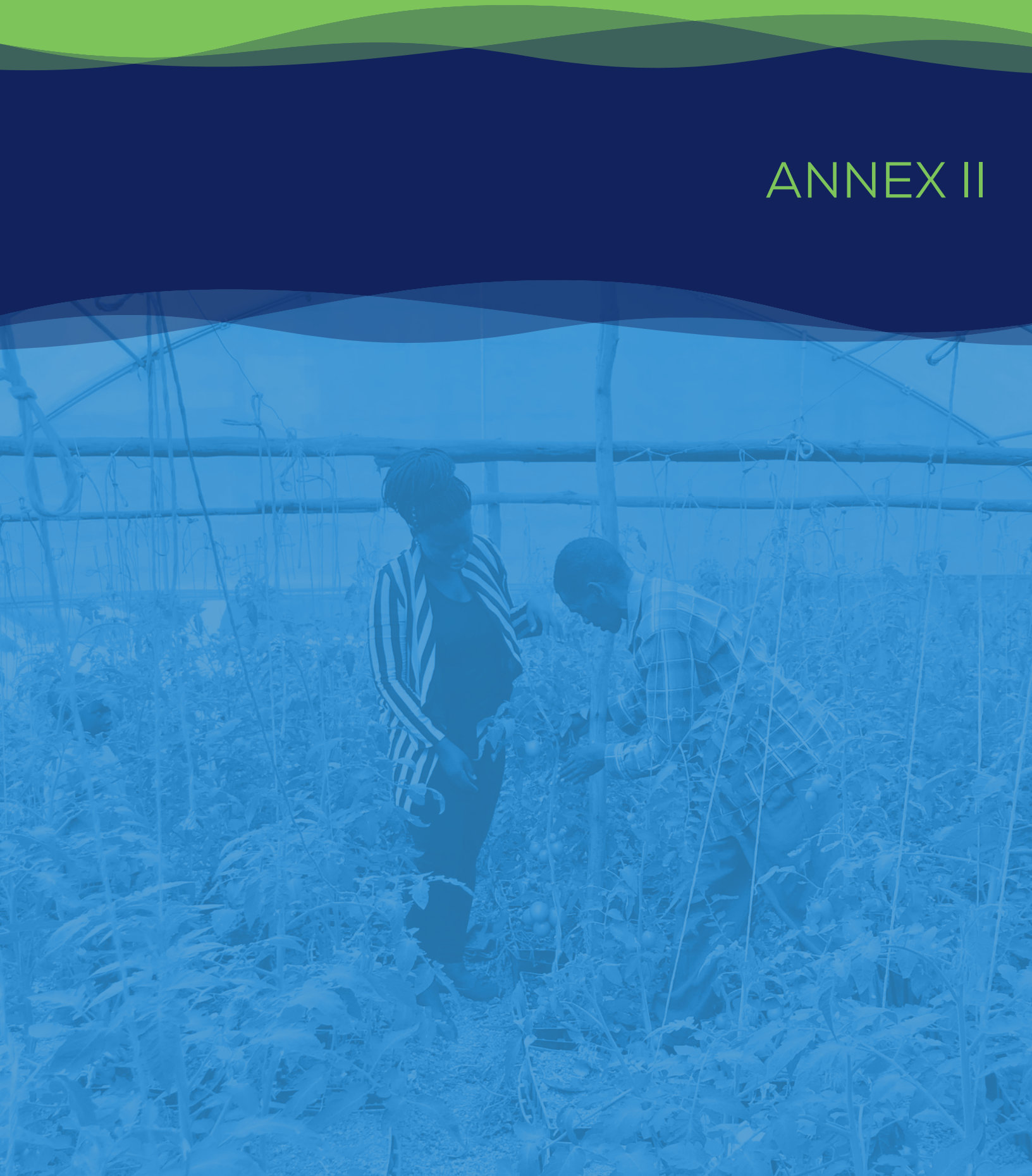
Venter Gert 2017, Is hydroponics the answer to global food challenges? Available at; https://www.farmersweekly.co.za/agri-technology/farming-for-tomorrow/hydroponics-answer-global-food-challenges/

ANNEX I

CONVERSION

DESCRIPTION OF THE CONVERSION	FROM	TO			QUANTITY
size of the land from meter squared to acres	m2	acres	1m2	0.000247 acres	
size of the land from feet to acres	sq.foot	acres	1sq.foot	0.00002296 acres	
distance in minutes/hours to km	minutes	kilometres	15minutes	1km	
pesticides applied from grams to kilograms	grams	kilograms	1000g	1kg	
pesticides applied from liters to grams	litres	grams	1l	1000g	
pesticides applied from milliliters to liters	milliliter	liter	1l	1000ml	
pesticides applied from liters to kilogram	liters	kilograms	1l	1kg	
manure applied from sacks to kilograms	50kg sack	kilograms	1sack	30kg	1sack
manure applied from buckets to kilograms	bucket	kilograms	1bucket	20kg	1bucket
manure applied from pickup to kilograms	pickup	kilograms	1pickup	900kg	1pickup
labour days from people and days to days	people/days	days	people*days	people*days	1labor day
buckets of maize output to kilograms	bucket	kilograms	1bucket	20kg	1bucket
sack of maize to kilograms	50kg sack	kilograms	I sack	50kg	1sack
buckets of beans to kilograms	bucket	kilograms	1bucket	20kg	1bucket
sack of beans to kilograms	50kg sack	kilograms	1sack	50kg	1sack
buckets of fertilizer to kilograms	bucket	kilograms	1bucket	20kg	1kg
bucket of potatoes to kilograms	bucket	kilograms	1bucket	20kg	1bucket
bucket of sukuma wiki to kilograms	bucket	kilograms	1bucket	5kg	1bucket
sack of sukuma wiki to kilograms	50kg sack	kilograms	1sack	30kg	1sack
pieces of avocado to kilograms	1piece	kilograms	7pieces of avocado	1kg	1kg
bundles of grass to kilogram	bundle	kilograms	1bundle	20kg	1bundle
bundles of fodder to kilograms	bundle	kilograms	1bundle	20kg	bundle
pick up of napier grass to kilograms	pickup	kilograms	1pickup	500kg	1pickup
1 debe of manure to kilograms	debe	kilograms	1debe	2kg	1debe
debe of beans to kilograms	debe	kilograms	1debe	2kg	1debe
bunch of fodder to kilograms	bunch	kilograms	1bunch	20kg	1bunch
bucket of arrow roots to kilograms	bucket	kilograms	1bucket	25kg	1bucket
bunch of sukuma wiki to kilogram	1 bunch	kilogram	10 bunches	5kg	1kg

ANNEX II



FARMER INFORMATION

NAME _____

AGE _____

DATE _____ TIME _____

GROUP INTERVIEW? ❑ Yes ❑ No

GROUP INTERVIEW NOTES

_____

_____

_____

HOW MANY FAMILY MEMBERS SHARE WITH YOU THE SAME POT? _____

GENDER ❑ Male ❑ Female

WHAT IS YOUR PRIMARY OCCUPATION?

- ❑ Farming
- ❑ Wage Labor
- ❑ Seasonal Migrant Labor
- ❑ Small Enterprise
- ❑ Other: _____

DO YOU HAVE ANOTHER OCCUPATION?

- ❑ Farming
- ❑ Wage Labor
- ❑ Seasonal Migrant Labor
- ❑ Small Enterprise
- ❑ Other: _____

WHAT IS THE NAME OF YOUR VILLAGE/TOWN? _____

SIZE OF FARM (ACRES) _____

HOW MUCH LAND DO YOU OWN? _____

HOW LARGE IS YOUR FARM/PLOT?

- ❑ Large
- ❑ Medium
- ❑ Small
- ❑ Very Small

HOW MUCH IS LAND RENT? _____

OTHER LAND NOTES

_____

_____

_____

HOW LONG HAVE YOU BEEN USING HYDROPONICS? _____

DID YOU PARTICIPATE IN AGRICULTURAL ACTIVITIES THIS YEAR? ❑ Yes ❑ No

HOW MANY MONTHS IS THE PRIMARY GROWING SEASON? _____

HOW MANY TIMES DO YOU HARVEST PER YEAR? _____

FARM INFORMATION

WHAT CROPS DO YOU GROW AS A RESULT OF HYDROPONICS? LIST FROM MOST IMPORTANT TO LEAST IMPORTANT:

1. _____

2. _____

3. _____

DID THE MOST IMPORTANT CROP BENEFIT ? ❑ Yes ❑ No

DID THE SECOND MOST IMPORTANT CROP BENEFIT ? ❑ Yes ❑ No

DID THE THIRD MOST IMPORTANT CROP BENEFIT ? ❑ Yes ❑ No

WHAT IS THE WATER SOURCE FOR YOUR IRRIGATION OF CROPS?

- ❑ Own pond
- ❑ River
- ❑ Groundwater
- ❑ Innovation Source
- ❑ Other _____

WHAT IS YOUR METHOD OF IRRIGATION?

- ❑ Drip feed
- ❑ Flooding
- ❑ Hand watering
- ❑ Rainfed
- ❑ Other _____

HOW MUCH HAS YOUR WATER USAGE CHANGED SINCE USING HYDROPONICS? _____

_____

USING Hydroponics HAS YOUR ACCESS TO WATER:

- ❑ Had no change
- ❑ Improved
- ❑ Fundamentally improved (Improved a lot)
- ❑ Other: _____

PREVIOUSLY GROWN CROPS

MASS OF PRODUCE: WHAT YIELDS DID YOU HAVE FOR YOUR FIRST CROP ? _____

_____

MASS OF PRODUCE 2: WHAT YIELDS DID YOU HAVE FOR YOUR SECOND CROP? _____

_____

USING HYDROPONICS HAVE YOU

- ❑ Used more water
- ❑ Had no change in water use
- ❑ Used less water
- ❑ Other: _____

USING HYDROPONICS HAVE YOUR CROP YIELDS (ASK FOR EACH CROP):

- ❑ Declined
- ❑ Remained the same
- ❑ Increased
- ❑ Substantially increased

IS THERE A DIFFERENCE IN THE SURVIVAL RATES OF YOUR CROPS DUE TO HYDROPONICS?

❑ Yes ❑ No

HOW MUCH OF YOUR PRODUCE DID YOU CONSUME IN YOUR HOUSEHOLD? (BUCKET, BUNCH, KG)

_____

HOW MUCH OF EACH OF THE FOLLOWING INPUTS DID YOU USE BEFORE HYDROPONICS?

FERTILIZER _____ (KG)
PESTICIDE _____ (KG)
HERBICIDE _____ (L)
CHARCOAL _____ (KG)
WATER _____ (TOTAL)
LABOR _____ (DAYS)
OTHER _____

HOW MUCH DID YOU SPEND ON EACH OF THE FOLLOWING INPUTS BEFORE HYDROPONICS?

FERTILIZER _____ (KG)
PESTICIDE _____ (KG)
HERBICIDE _____ (L)
CHARCOAL _____ (KG)
WATER _____ (TOTAL)
LABOR _____ (DAYS)
OTHER _____

HOW MUCH OF EACH OF THE FOLLOWING INPUTS DO YOU USE AFTER HYDROPONICS?

FERTILIZER _____ (KG)
PESTICIDE _____ (KG)
HERBICIDE _____ (L)
CHARCOAL _____ (KG)
WATER _____ (TOTAL)
LABOR _____ (DAYS)
OTHER _____

HOW MUCH DID YOU SPEND ON THE FOLLOWING INPUTS AFTER HYDROPONICS?

FERTILIZER _____ (KG)
PESTICIDE _____ (KG)
HERBICIDE _____ (L)
CHARCOAL _____ (KG)
WATER _____ (TOTAL)
LABOR _____ (DAYS)
OTHER _____

HOW MUCH DID YOU SPEND ON EQUIPMENT DUE TO HYDROPONICS? _____

_____

HOW MUCH DID YOU SPEND ON TRANSPORT AND STORAGE BEFORE AND AFTER HYDROPONICS? _____

OTHER FARM NOTES (OPTIONAL).

_____

_____

_____

INCOME AND EXPENDITURES

WHAT IS YOUR ANNUAL HOUSEHOLD INCOME?

- ❏ 0-240,000 EXTREME POOR
- ❏ 240,001-480,000 LOW INCOME
- ❏ 480,001-720,000 MIDDLE INCOME
- ❏ 720,000+ UPPER INCOME

HOW MUCH INCOME DID YOU MAKE BEFORE HYDROPONICS? _____
AFTER HYDROPONICS? _____

HAS HYDROPONICS IMPROVED YOUR FAMILY INCOME? _____

WHAT PERCENTAGE OF YOUR INCOME DO YOU GET FROM NON-FARM SOURCES? _____

HOW MUCH PRODUCE DID YOU SELL? _____

_____

WHAT IS THE PRICE PER KILO YOU RECEIVED FOR EACH OF YOUR CROPS FOR THE LAST SEASON?

_____

_____

USING HYDROPONICS HAS YOUR ACCESS TO CREDIT:

- ❑ Not improved
- ❑ Improved
- ❑ Improved and have been able to repay over a short period

HOW DO YOU CURRENTLY FINANCE AGRICULTURAL ACTIVITIES?

- ❑ Own savings
- ❑ Credit and savings scheme
- ❑ Other credit

HOW MUCH DO YOU PAY FOR HYDROPONICS? _____

HOW MUCH ARE YOU WILLING TO PAY FOR HYDROPONICS?

- ❑ Nothing
- ❑ Hydroponics is free
- ❑ The same as what I pay now
- ❑ 50% less
- ❑ 50% more
- ❑ Other: _____

HOW HAVE YOU SPENT YOUR NEW INCOME?

- ❑ N/A (if no new income)
- ❑ Send children to school or keep children in school
- ❑ Social functions (like weddings)
- ❑ Investment in farming
- ❑ Improving house
- ❑ Other: _____

OTHER INCOME NOTES (OPTIONAL)

_____

_____

_____

PERCEPTIONS OF HYDROPONICS

WILL YOU USE HYDROPONICS IN THE FUTURE (5 TO 10 YEARS)? ❑ Yes ❑ No

PLEASE ELABORATE: _____

_____

HOW, IF AT ALL, HAVE YOU CHANGED YOUR FARMING PRACTICES DUE TO HYDROPONICS?

- ❑ No change
- ❑ Introduced new crops
- ❑ Changed irrigation system
- ❑ Reduced water usage
- ❑ It helps me decide when to plant
- ❑ It helps me decide which crops to plant
- ❑ Other: _____

HAVE YOU FACED ANY DIFFICULTIES OR PROBLEMS USING HYDROPONICS? ❑ Yes ❑ No

HOW CAN HYDROPONICS BE IMPROVED? _____

_____

HOW DID YOU HEAR ABOUT HYDROPONICS?

- ❑ Wealthy farmer
- ❑ Neighbor
- ❑ Innovation personnel
- ❑ Extension worker
- ❑ Other: _____

WHAT FACTORS INFLUENCED YOU TO TRY HYDROPONICS?

- ❑ Demonstration from neighbor's farm
- ❑ Innovation is free from extension services
- ❑ No alternative water source
- ❑ Other: _____

DO YOU SHARE YOUR KNOWLEDGE SKILLS FROM HYDROPONICS WITH OTHERS? ❑ Yes ❑ No

IF SO, HOW? _____

_____

_____

WHAT DO YOU FEEL ARE THE BENEFITS OF HYDROPONICS? _____

_____

_____

HOW HAS HYDROPONICS HELPED YOU? PLEASE RANK THE TOP 3 AND EXPLAIN POSITIVES/ NEGATIVES.

☐ Makes water reusable _____

☐ Helps women farmers as well as men _____

☐ They made a special effort to include women farmers _____

☐ Helps in producing more of our most important crop _____

☐ Increases my yield through timely forecasts _____

☐ Helps by lowering cost of inputs _____

☐ Improves health and strength of livestock _____

☐ Helps reduce labor _____

☐ Reduces crop wastage _____

☐ Helps me decide when to plant _____

☐ Helps me decide which crops to plant _____

☐ Other: _____

WOULD YOU RECOMMEND HYDROPONICS?

❑ No
❑ Yes
❑ Yes, would strongly recommend

ARE THERE NEGATIVE IMPACTS FROM HYDROPONICS IN THE COMMUNITY? ❑ Yes ❑ No

IF YES, PLEASE EXPLAIN. _____

_____

_____

IF THERE HAVE BEEN ANY NEGATIVE IMPACTS, HAVE EFFORTS BEEN MADE TO RESOLVE THEM?
❑ Yes ❑ No

EXPLAIN. _____

_____

_____

DO YOU HAVE PROBLEMS FINDING A MARKET TO SELL YOUR CROPS IN? ❑ Yes ❑ No
EXPLAIN. _____

_____

_____

DO YOU HAVE PROBLEMS GETTING YOUR CROPS TO THE MARKET? ❑ Yes ❑ No
EXPLAIN. _____

_____

_____

HAVE CHANGES IN RAINFALL OR TEMPERATURE AFFECTED YOUR FARMING PRACTICES OR CROP YIELDS COMPARED TO HISTORICAL RAIN/DRY SEASON PERIODS? ❑ Yes ❑ No

OTHER

INCOME/POVERTY NOTES

_____

_____

GENDER OBSERVATIONS

_____

_____

QUESTIONS/REQUESTS

_____

_____

OTHER NOTES

_____

_____

_____

SECURING
WATER
FOR FOOD:
A GRAND CHALLENGE
FOR DEVELOPMENT

Securing Water for Food has sourced and invested in a portfolio of innovative solutions that aim to help farmers use water more efficiently and effectively, improve water storage for lean times, and remove salt from water to make more food. Our cohort of innovators are helping people in 35 low-resource countries with tools they need to produce more food with less water.

To learn more about Securing Water for Food,
visit www.securingwaterforfood.org.