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The Economic Effects of COVID-19 on Smallholder Farmers in Kenya

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The Economic Effects of COVID-19 on Smallholder Farmers in Kenya

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Abstract

Like many Sub-Saharan African countries, the Kenyan economy heavily relies on agriculture. Agriculture in Kenya accounted for 50% of the total workforce in 2019 and 70% of the rural workforce. Though reliant on agriculture for employment and subsistence, Kenya has been historically impoverished and malnourished. Kenya has been experiencing an economic recession since 2018, which was exacerbated by the COVID-19 pandemic. Relatively speaking to other African countries, Kenya managed to escape the worst health effects of the pandemic, but the economic effects were substantial. This study analyzes survey responses from 1,059 Kenyan smallholder agricultural producers on the economic impacts they experienced during the summer of 2020. The findings of this study showed differences among groups on the level of impact, namely heads of households being more likely to experience a high impact on agricultural activities and women more likely to experience a food shortage. The results also find what factors make these economic effects more likely to happen to a producer should they experience these factors, such as reduced income. These findings lead to policy implications that can be used to prevent harsh economic impact in the case of a future pandemic.

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Dedication

This thesis is dedicated to my father, Robert, who passed before this project was completed. He was my biggest supporter, and grammatical revisor, until the end.

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1. Introduction

Like most Sub-Saharan countries, the Kenyan economy heavily relies on the agricultural sector. Agriculture provided one-third of the country's gross domestic product (GDP) and half of all employment in 2019 (Nechifor et al., 2021). Kenya suffers from chronic food insecurity and poverty, where 26.1% of its population was classified as severely food insecure in 2020, and 36% lived below the international poverty line earning $1.90 USD or less per day. Food insecurity and poverty are exacerbated in rural areas, where 70% of rural living Kenyans were classified as food insecure (Kansiime et al., 2021), and 35.8% of the rural population live below the poverty line in 2021 (Nechifor et al., 2021).

Warah (2022) stated that Kenya was already in an economic downturn before the Corona Virus (SARS-CoV-2), now referred to as COVID-19, created a global pandemic. With 53% of the Kenyan population in 2018 being in multidimensional poverty, lacking income, access to healthcare, education, decent housing, and other essential services required for a sustainable life. The study also found that existing policies to address the multidimensional poverty had failed, adding to the economic strain.

Low-income countries with high poverty and food insecurity, such as Kenya, are more likely to be affected by exogenous economic shocks, such as COVID-19 (Paul Jr. et al., 2022; Warah, 2022). When COVID-19 arrived in Kenya in March 2020, the economic and socio-economic effects were likely to be felt the hardest by the rural agricultural population and the urban slum population, where the highest poverty levels exist (Nyariki & Wiggins, 1997; Kimani-Murage et al., 2014). In urban areas, 51% of residents live in urban slums, where there is a lack of durable housing, sufficient living spaces, and easy access to safe water or sanitation facilities, in 2020 (World Bank, 2020 & World Bank, 2017). Slum residents in Kenya were

already disproportionately affected by chronic poverty and thus were highly vulnerable to economic shocks like the COVID-19 pandemic (Kimani-Murage et al., 2014).

The Corona Virus (SARS-CoV-2), or COVID-19, was first reported in Wuhan, China, in December 2019. According to the Kenyan Ministry of Health, the virus was first reported in Kenya on March 12, 2020. When the virus first arrived, the Kenya Ministry of Health recommended washing hands, wearing face masks, and social distancing to mitigate its spread. Soon after the first reported domestic case in early March, non-essential workers began working from home as required by the government, borders were closed to noncitizens, and congressional meetings were banned, opting for online governmental meetings (McDade, 2020). Kenya then closed all private and public schools and higher learning institutions in March 2020, lasting until January 2021 (McDade et al., 2020). While a stay-at-home order was never implemented, a curfew was set in place on March 27th, in which all citizens had to return home by dusk and remain there until dawn, or 17:00-7:00, greatly affecting agricultural workers (McDade, 2020). The curfew was relaxed from 21:00 to 4:00 on July 7th. Public transit capacities were reduced to 50% of passenger capacity, limiting market and job access for citizens. Furthermore, travel in and out of the Nairobi metro area was banned, as well as movement between counties in Mombasa, Kilifi, Kwale, and Mandera affecting efficient food deliveries (McDade, 2020). As of March 7, 2023, Kenya reported over 340,000 confirmed cases and more than 5,600 related deaths (World Health Organization, 2023).

The Kenyan government provided little economic shelter from the covid pandemic. The only cash transfer program, which existed before the pandemic, allotted an additional $100 million USD to give to vulnerable people, such as the elderly and orphans, in cash payments of $19 USD per month (Center for Policy Impact, 2020). Kenya received outside funding to

mitigate the spread of COVID-19. Still, only 33% of all total funding went to economic relief, and none of that explicitly to agriculture, the backbone of the economy. The remaining 66% went to health response efforts and vaccinations/treatments (Center for Policy Impact, 2020).

Agricultural open-air markets, or "vibandas," where rural producers and consumers sold and bought food were allowed to remain open so long as "proper hygiene and distancing are observed" (Center for Policy Impact, 2020); many markets chose to shut voluntarily rather than continue to operate under the vague guidelines severely hampering agricultural commerce. While no laws were put in place for the operation of these markets, the Republic of Kenya's Ministry of Industrialization, Trade, and Enterprise Development published guidelines for businesses to operate under on June 2, 2020. For the open-air agricultural markets in rural areas, social distancing, random temperature checks, disinfection measures, and using credit as payment over cash were all encouraged (Republic of Kenya Ministry of Industrialization, Trade and Enterprise Development, 2020).

1.1. Pandemic History

Pandemics historically impact low-income countries hard (both in terms of economic impacts and mortality and morbidity) due to the lack of resources (medical infrastructure, communications systems, first responders, etc.) to effectively prevent spreading or off-set the negative economic impacts in the way that developed or high-income countries can (United Nations, 2020). Previous epidemics such as HIV in South Africa and Ebola in the Democratic Republic of Congo (DRC) have shown the unpreparedness of Sub-Saharan African countries to handle pandemics. HIV in South Africa was characterized by "denial, lack of political will, and poor implementation of policies and programs" (Karim et al., 2009), while the government during the 2018-2020 Ebola outbreak in the DRC was slow to implement previously successful

measures like burning possessions and spraying with chlorine. Though the DRC had experienced eleven previous outbreaks of Ebola, they were still grossly unprepared. The rich and business elites could afford and access proper protection. Those in poverty had to fend for themselves without preventative necessities (Mayhew et al., 2022).

By June 2021, it was reported that Kenya had escaped the worst health effects of the COVID-19 pandemic but was still reeling from the social and economic impact.. In poor rural areas of Kenya, citizens were not being tested or seeing high rates of infection or deaths, so they fear the government is overstating the severity of the pandemic to acquire outside relief funding. Previously, Kenyan Ministries and departments were implicated in corruption, so many Kenyans do not trust the government and were wary of following government mandates related to COVID-19 prevention (Warah, 2022).

1.2. Economic Effects

Unlike in high-income countries, where a high percentage of citizens are employed in the service industry and can work remotely, in Kenya, where agriculture employs 40% of the total workforce and 70% of the rural workforce, remote employment was not an option (International Trade Administration, 2022). 27.5% of Kenyan smallholder bean farmers surveyed in 2021 by Nchanji and Lutomia reported difficulty finding labor for hire, resulting in a loss of productivity, income, and food supply during the pandemic. Food price volatility also increased during the pandemic in Kenya, with price spikes in wheat flour, rice, sugar, cooking oil, eggs, and bananas in May 2020 (Kenya COVID-19 Economic Tracker, 2021). Cereals, a staple food group in Kenya, increased in price by up to 15% from March to December 2020 (Kunyanga et al., 2023). Two years later, in 2022, over 90% of Kenyans were still experiencing economic impacts from the pandemic via food price inflation (Sinha et al., 2022).

Janssens et al. (2021) found that Kenyans' income decreased by an average of 33% between December 2019 and April 2020 due to the pandemic. During this time, food prices were rising, with the highest increase in March of 2020, when the costs of staple commodities increased by 35% (Kunyanga et al., 2023). From June 2020 to June 2021, food and beverage prices increased by 8%, transportation costs increased by 14%, and housing, water, and electricity increased by 4% (Warah, 2022). Unlike high-income countries, where governments had stimulus packages and programs to help offset income reductions and price increases, Kenya, like most other low-income countries, provided little economic assistance to employers and employees affected by the pandemic. With income decreasing and food prices and other necessities increasing, Kenyans struggled with national and household food insecurity. The financial relief that the government offered came in the form of tax cuts, with a 5% decrease in personal income tax, a 2% decrease in value-added tax (VAT), and a 2% decrease in turnover taxes for small and medium-sized businesses (Center for Policy Impact, 2020). In May 2020, the International Monetary Fund (IMF) allotted $739 million USD to Kenya to address the impact of the pandemic and planned to ensure proper use of the funding by performing a post-crisis audit of the expenditures and publishing the report. This report and what resulted from the IMF funding is still yet to be seen (Zhang, 2020).

The COVID-19 impact cut deeper than simply a reduction in income and national GDP as it disrupted the global supply chain. Most agricultural chemicals and fertilizers in Kenya are imported, importing just under $260 million USD of fertilizer in 2019 and 2020 (Trading Economics, 2023). Agricultural producers are heavily reliant on imported chemicals and fertilizers as farms in Kenya are already of low productivity relative due to a lack of inputs (International Trade Administration, 2022). The reliance on fertilizer was further proven when

fertilizer imports in 2021 increased, albeit in a pandemic, by almost $100 million USD (Trading Economics, 2023). With these imported inputs, Kenyan producers grow coffee, cut flowers, black tea, and vegetables, all leading exports in Kenya. Tea, one of the leading exports, resulted in $1.1 billion USD in 2021, and horticulture, including vegetables and cut flowers, amounted to $1.4 billion USD in exports (Statista, 2021). Both tea and horticulture exports in 2021 were up from 2020, when imported inputs were more difficult and expensive to access.

Disrupted supply chains led to reduced access to inputs such as fertilizer and pesticides for agricultural production, higher food prices, and slowed deliveries of imported foods. A reduction in inputs also comes with a decrease in outputs and slowed production Fertilizer, a popular imported agricultural input, encourages consistent yields despite severe droughts and floods (Sibiko & Qaim, 2020). If access to agricultural inputs is reduced and food delivery is slowed, Kenyans have few options for obtaining proper nutrition as they can neither produce a sufficient amount (given reduced imports) of food nor access it in markets (given price increases associated with a decreased supply and market restrictions imposed by the government).

1.3. Food Insecurity

Kenya has historically been a food-insecure country, with growth stunting in children and undernourishment prominent in the rural areas where 20-32% of the population is undernourished and 25-41% of children show evidence of stunting (Global Hunger Index, 2022). Kenya's Global Hunger Index score of 23.5 in 2020 is considered “serious.” In a study by Kansiime et al. (2021), food insecurity was estimated to increase by 38% in Kenya during the pandemic. Kenyans’ diets contain mainly cereals, potatoes, chicken, beans, rice, and bananas (Muyanga et al., 2005, Vila-Real et al., 2022). Of these staple food items, cereals, chicken, and beans import quantity and value in USD dropped in 2020 and 2021 compared to 2019, pre-

pandemic, leaving less staple food available for purchase leading to higher domestic prices (FAO, 2023).

1.4. Study Objectives

This study utilizes a robust dataset to analyze how smallholder agricultural producers coped with the pandemic's higher food prices, labor shortages, and other negative externalities. The first objective was to determine which groups of people were the most affected (in a general sense) by the impact of COVID-19. We analyzed differences between genders, people 41 years or older versus 40 years or younger, heads of households, and rural inhabitants. We hypothesize that rural inhabitants were more likely to experience economic shocks, such as those from COVID-19, like increasing food prices, than urban inhabitants who are historically more affluent. Analyzing this data set can give insight into the magnitude of the impact of COVID-19 on the rural inhabitants.

The second objective was to determine which groups of people were most likely to experience a food shortage because of COVID-19 and the resulting economic shocks and supply chain disruptions and who was expected to implore coping mechanisms due to a potential food shortage. As reported by participants, the food shortages were due to a lack of availability, resources, or consuming fewer meals. We hypothesize that the effects were heterogenous regarding food shortages and coping strategies used as income dispersion between urban and rural Kenyans were diverse. We focused on the heterogenous impact on women, elderly people, heads of households, and rural inhabitants versus urban or peri-urban inhabitants. Previous research has shown that women are more susceptible to food insecurity than men (Ingutia & Sumelius, 2022).

The third objective was to determine the cause of a "high impact" on agricultural activities, such as farming and raising livestock, due to COVID-19. We queried participants as to what kind of agricultural-related impacts they experienced, whether it be a reduction in agricultural activities, higher demand for products, reduced availability of labor, reduced family labor availability, reduced income for investment, reduced access to inputs, difficulty selling produce, or any combination of these impacts. Participants were also asked if they had difficulty accessing agricultural markets, acquiring agricultural inputs and if they had reduced access to sellers and buyers during the pandemic.

The final objective was to assess the causes of food shortages during the pandemic. Participants were surveyed on if they experienced an increase in food prices, the impact level of COVID-19 on agricultural activities, reduced income, and reduced access to agricultural sellers, buyers, and markets. Previous research alludes to food insecurity increasing during the pandemic, but the causes of food insecurity during the pandemic are nebulous (Kansiime et al., 2021; Siche, 2020).

The impetus of this study is to shed light on how COVID-19 impacted the Kenyan agricultural industry, both from a supply and demand side, during COVID-19. Even though the pandemic may be over, future pandemics, or macroeconomic shocks, will likely affect the Kenyan agricultural markets. This study provides insight to policymakers in Kenya about the impacts of the pandemic and if there are hotspots in the supply chain that could preemptively be addressed before the next widespread economic shock. While the next pandemic cannot be predicted in terms of timing or severity, this study provides a roadmap of how Kenyans tried to cope during the pandemic to better prepare for the next pandemic and its potential impacts.

2. Data & Methodology

2.1. Data

The data were collected via an online survey, distributed using iShamba. This agricultural call center allows for text messages or short messaging services (SMS) to be sent to Kenyan farmers to gather information. The Nairobi office of the International Center for Tropical Agriculture (CIAT) conducted the survey. Respondents were Kenyan agricultural producers across the country.

The data set used in this study was part of three rounds of surveys conducted by CIAT. The first round, utilized here, was collected from June 22, 2020, to July 17, 2020, around four months into the pandemic in Kenya. The first round collected 1,069 responses from producers across Kenya. The survey questions and possible answers used within the study, which range from demographics to economic effects, are illustrated in Table 1.

Table 1: Survey Questions and Responses

	Question	Responses	Response Type	Used in Model
Q1	What is your gender?	Male Female	Choose one	1, 2, 3, 4
Q2	What is your age?	Below 20 Between 20 and 40 Between 41 and 60 Above 60 Don't know or don't want to say	Choose one	1, 2, 3, 4
Q3	Are you the head of the household? (main breadwinner, main decision maker)	Yes No	Choose one	1, 2, 3, 4
Q4	Which of the following best describes your location?	Urban Rural Peri-urban	Choose one	1, 2, 3, 4
Q5	Is the impact on agricultural activities low or high?	Impact is low Impact is medium Impact is high	Choose one	1, 5, 6
Q6	How has COVID and measurements taken by your govenrment impacted your agricutlural activities?	There is no reduction on my agricultural activities until now There is higher demand There is reduced avaialbility of hired labor for farm activities Me and my family have less time available to invest in agricultural activities I have less money available to invest in agricultural activities I have reduced access to inputs (seed, fertilizer, pesiticides, etc) It's harder to sell or get agricultural producce	Multiple	5
Q7	Have you faced difficulty in accessing the market?	Yes, curfew Yes, roadblock/restriction Yes, less transport No	Multiple	5, 6
Q8	Are agricultural inputs (seed, fertilizer, pesticides, etc) harder to get?	Yes, because of restricted access to market Yes, because of less availability of inputs No, there is no difficulty to access input	Choose one	5
Q9	Did you directly access the seller/buyer without going to market?	No Yes, word-of-mouth Yes, by telephone, messages Yes, by Facebook, websites	Multiple	5, 6
Q10	Do you have less income (farm/off-farm) during the time when measurements are taken due to COVID?	Yes, I have lost my job Yes, I work less due to measurements I'm getting less remittances from off-farm sources No, my income has increased because higher demand My income did not change	Multiple	6
Q11	During the last weeks of the COVID crisis, did the cost of food increase for you and your family	Yes No	Choose one	2, 6
Q12	During the last week, did your household experience shortages of food?	No, there was no shortage in food during the last weeks Yes, worried that we would not have enough food available Yes, ate a limited variety of food due to a lack of resources Yes, ate fewer meals in a day due to lack of food	Multiple	3, 6
Q13	Since the COVID crisis started, has anyone in your household done any of these things?	Consumed less expensive food of the same type Stopped eating certain kinds of food Limited portion size or reduced meals Borrowed food or bought it on credit None of these	Multiple	4

From the survey questions in Table 1, six logit models were developed to answer the four study objectives. The objectives, found in Table 2, below,

Table 2: Objectives and Corresponding Variables

	Objective	Equation	Dependent Variable	Independent Variables
1	Determine which groups of Kenyan agricultural producers were most likely to be affected by economic shocks as a result of COVID	1	Impact on agricultural activities is high	Gender (x_1)(Q1) Age (x_2)(Q2) Head of Household (x_3)(Q3) Location (x_4)(Q4)
		2	Experienced an increase in food prices	Gender (x_1)(Q1) Age (x_2)(Q2) Head of Household (x_3)(Q3) Location (x_4)(Q4)
2	Determine which groups of producers were most likely to experience a food shortage and implore coping mechanisms to deal with a food shortage	3	Experienced a food shortage	Gender (x_1)(Q1) Age (x_2)(Q2) Head of Household (x_3)(Q3) Location (x_4)(Q4)
		4	Implored coping strategies for a food shortage	Gender (x_1)(Q1) Age (x_2)(Q2) Head of Household (x_3)(Q3) Location (x_4)(Q4)
3	Determine the root causes of experiencing a high impact on agricultural activities as a result of COVID	5	Impact on agricultural activities is high	Reduction on agricultural activities now (x_1)(Q6) Higher demand for agricultural products (x_2)(Q6) Reduced availability of hired labor (x_3)(Q6) Reduced availability of family labor (x_4)(Q6) Less money to invest in agricultural activities (x_5)(Q6) Reduced access to inputs (x_6)(Q6) Harder to sell or buy agricultural products (x_7)(Q6) Difficulty in accessing the market (x_8)(Q7) Agricultural inputs are harder to access (x_9)(Q8) Directly accessing the seller/buyer without going to the market (x_{10})(Q9)
4	Determine the root causes of experiencing a food shortage during the pandemic	6	Experienced a food shortage	Increase in food prices (x_1)(Q11) High impact on agricultural activities (x_2)(Q5) Less income during COVID measurements (x_3)(Q10) Accessing sellers/buyers via word-of-mouth (x_4)(Q9) Accessing sellers/buyers via technology (x_5)(Q9) Difficulty in accessing the market (x_6)(Q7)

* Question numbers (e.g., Q1) correlate to Table 1.

are to; 1) determine which groups of Kenyan agricultural producers were most affected by the economic shocks, such as experiencing a high impact on agricultural activities and an increase in food prices, as a result of covid, 2) determine which groups of agricultural producers were most likely to experience a food shortage and implore coping mechanisms to deal with a food shortage, 3) determine the causes of being classified as having experienced a “high impact” on

agricultural activities as a result of the pandemic, and 4) to determine the underlying causes of food shortages during the covid pandemic in Kenya.

2.2. Econometric Models

Equation 1 uses a Logit model to identify which causes are most likely to affect a Kenyan agricultural producer to be "highly" impacted (self-identified) by the pandemic. If the respondents answered, "impact is high" to Q5 on Table 1, "Is the impact on agricultural activities low or high?", they were deemed to be highly impacted by the pandemic and assigned binary variable 1; if not high, highly impacted (low or medium impact), 0.

$$Y = \beta_0 + \beta_1 x_1 + \beta_2 x_2 + \beta_3 x_3 + \beta_4 x_4 + u$$
$$\text{with } P(Y = 1|x_1, x_2, x_3, x_4) = \phi(\beta_0 + \beta_1 x_1 + \beta_2 x_2 + \beta_3 x_3 + \beta_4 x_4) \quad (1)$$

where β_0 represents the intercept, $\beta_1$represents the coefficient for a respondent being male, β_2 is the coefficient for a respondent being 41 years or older, β_3 is the coefficient for a respondent being head of household, and β_4 is the coefficient for a respondent living in a rural area. The variable x_1 corresponds to Q1 in Table 1. If a respondent answered "male", they were coded a binary variable 1, while "female" was 0. The variable x_2 corresponds to Q2 in Table 1. If the respondent answered below 20, or between 21 and 40, they were assigned binary variable 0, else a 1. Age was originally reported in brackets by decade, but for simpler interpretation they were grouped into 40 or younger and 41 or older. The variable x_3 is 1 if the respondent answered "yes" to being head of household in Q3, and 0 if "no". The variable x_4 takes on binary variable 1 if a respondent answered "rural" to Q4 in Table 1, and 0 if "urban" or "peri-urban"."u represents the error in the model.

$$Y = \beta_0 + \beta_1 x_1 + \beta_2 x_2 + \beta_3 x_3 + \beta_4 x_4 + u$$

$$\text{with } P(Y = 1|x_1, x_2, x_3, x_4) = \phi(\beta_0 + \beta_1 x_1 + \beta_2 x_2 + \beta_3 x_3 + \beta_4 x_4) \quad (2)$$

Equation 2 estimates the likelihood of increased food prices for participants. The dependent variable in Equation 2 uses responses from Q11 on Table 1, "During the last few weeks of the COVID crisis, did the cost of food increase for you and your family?" Thus, the dependent variable was a dummy for "yes" or "no". Like equation 1, x_1 corresponds to Q1 in Table 1, where "male" was reported as 1 and female as 0. The variable x_2 corresponds to Q2 and was assigned 1 if 41 or older, and 0 if 40 or younger. x_3 corresponds to Q3 in Table 1, which asks if a respondent is head of household, has "yes" being 1 and "no" being 0. The variable, x_4, is 1 if the answer to Q4 is "rural", and 0 if urban or peri-urban. β_0 is the model's intercept, and $\beta_1, \beta_2, \beta_3, \beta_4$ are the coefficients for the variables x_1, x_2, x_3, x_4, respectively. u represents the error in the model.

$$Y = \beta_0 + \beta_1 x_1 + \beta_2 x_2 + \beta_3 x_3 + \beta_4 x_4 + u$$
$$\text{with } P(Y = 1|x_1, x_2, x_3, x_4) = \phi(\beta_0 + \beta_1 x_1 + \beta_2 x_2 + \beta_3 x_3 + \beta_4 x_4) \quad (3)$$

Equation 3 estimates which Kenyan agricultural producers would likely experience a food shortage. The dependent variable in equation 3 uses Q12 in Table 1, "During the last week, did your household experience food shortages?". Regardless of the reason(s), was not enough food, not enough resources, or a reduction of meals eaten, if a respondent answered *yes* to any of the reasons, they were classified as having experienced a food shortage. Equation 3 addresses our second objective of determining which Kenyan agricultural producers were most likely to experience a food shortage of some capacity. The demographic questions Q1, Q2, Q3, and Q4 on Table 1 correspond to variables x_1, x_2, x_3, x_4 and are assigned binary variables depending on the response. x_1 being Q1 where males were assigned 1 and females 0. x_2 is Q2 and assigned 1 if the

answer is 41 years of age or older, and 0 if younger. x_3 corresponds to Q4 ,where the head of household respondents are assigned binary variable 1, and those who were not, 0. The last variable, x_4, is Q4 in Table 1 where rural inhabitants were assigned binary variable 1, and those who lived in urban or peri-urban areas were assigned 0.

$$Y = \beta_0 + \beta_1 x_1 + \beta_2 x_2 + \beta_3 x_3 + \beta_4 x_4 + u$$
$$\text{with } P(Y = 1|x_1, x_2, x_3, x_4) = \phi(\beta_0 + \beta_1 x_1 + \beta_2 x_2 + \beta_3 x_3 + \beta_4 x_4) \quad (4)$$

Equation 4 is related to the second objective of identifying which Kenyan producers were most affected by food shortages. More specifically, which groups were likely to implore coping strategies to deal with food shortages. If participants answered that they undertook any of the coping activities listed in the survey (consumed less expensive food of the same type, stopped eating certain kinds of foods, limited portion size or reduced meals, and borrowed food or bought it on credit) as answers for Q13 in Table 1, "Since the COVID crisis has started, has anyone in your household done any of these things?", excluding "None of these," they were classified of implementing a coping strategy. The demographic variables, Q1-Q4 from Table 1, were then used to see each group's likelihood of using a coping mechanism. Like the previous questions, Q1, is gender, in which male is 1 and female is 0. Q2, in which anyone answering that they are 41 or older is 1 and 40 or younger is 0. Q3 asks about being head of household, and if they are, they are assigned binary variable 1, if not 0. Q4 asks about the location of living where the answer "rural" is 1 and "urban" or "peri-urban" is 0.

$$Y = \beta_0 + \beta_1 x_1 + \beta_2 x_2 + \beta_3 x_3 + \beta_4 x_4 + \beta_5 x_5 + \beta_6 x_6 + \beta_7 x_7 + \beta_8 x_8 + \beta_9 x_9 + \beta_{10} x_{10} + u$$
$$\text{with } P(Y = 1|x_1, x_2, x_3, x_4, x_5, x_6, x_7, x_8, x_9, x_{10}) = \phi(\beta_0 + \beta_1 x_1 + \beta_2 x_2 +$$
$$\beta_3 x_3 + \beta_4 x_4 + \beta_5 x_5 + \beta_6 x_6 + \beta_7 x_7 + \beta_8 x_8 + \beta_9 x_9 + \beta_{10} x_{10}) \quad (5)$$

Equation 5 estimates the causes of experiencing a "high" impact on agricultural activities during the pandemic. The dependent variable was any respondent who answered they were experiencing a "high" impact on their agricultural activities due to COVID-19 (Q5 Table 1). From Q6 in Table 1, each response type was made into a separate binary variable. These are variables $x_1, x_2, x_3, x_4, x_5, x_6, x_7$ corresponding to responses from Q6 ("How has COVID and measurements taken by your government impacted your agricultural activities?") and coded as binary variables as follows; x_1 is those who answered "there is no reduction on my agricultural activities until now","x_2 is those who answered "there is higher demand" for their agricultural products, x_3 is those who answered "there is reduced availability of hired labor for farm activities", x_4 is those who answered "me and my family have less time available to invest in agricultural activities", x_5 is those who answered yes to "I have less money available to invest in agricultural activities", x_6 is those who answered "I have reduced access to inputs (seed, fertilizer, pesticides, etc.), and x_7 is those who answered, "it's harder to sell or get agricultural produce."

Then, respondents who answered with any response, including "Yes" for Q7-Q9 on Table 1, were transformed into binary variables. Q7 was "Have you faced difficulty in accessing the market?" Q8 was "Are agricultural inputs (seed, fertilizer, pesticides, etc.) harder to get?" and question nine was "Did you directly access the seller/buyer without going to the market?" This was a proxy for increased difficulty for agricultural producers during the pandemic. Results from equation 5 will provide potential causes of experiencing a "high" impact on agricultural activities, using the variables increased/decreased demand, reduced labor availability, access to buyers and sellers, access to inputs, and available funds for investment.

$$Y = \beta_0 + \beta_1 x_1 + \beta_2 x_2 + \beta_3 x_3 + \beta_4 x_4 + \beta_5 x_5 + \beta_6 x_6 + u$$

with $P(Y = 1|x_1, x_2, x_3, x_4, x_5, x_6) = \phi(\beta_0 + \beta_1 x_1 + \beta_2 x_2 + \beta_3 x_3 + \beta_4 x_4 + \beta_5 x_5 + \beta_6 x_6$ (6)

Equation 6 attempts to answer objective four: to determine the root causes of food shortages among the respondents during the pandemic. Equation 6 uses Q12 from Table 1, where respondents indicated if they had experienced a food shortage within the last week. All of these responses suggest that the respondent experienced a food shortage factor into experiencing a food shortage, and this model can predict the likeliness of experiencing a food shortage based on answering yes to facing any food shortage-related issues and how they access sellers and buyers.

The independent variables from equation 6 are x_1, which is derived from Q11 from Table 1, which asked respondents if their household had experienced an increase in the price of food, if so, 1, if not 0. The variable x_2 corresponds with Q5 from Table 1, which asked respondents if the impact on agricultural activities was "high" or "low". If the respondent answered high, they are assigned binary variable 1,,if low or medium, 0. The variable x_3 relates to Q10 on Table 1, which asked ," Do you have less income (farm/off-farm) during the time when government measurements were taken due to COVID?", if they chose any response beginning with "Yes", they are assigned binary variable 1, if income was unchanged or increased, 0. Variables x_4 and x_5 are derived from answers to Q9 in Table 1, which asked if the respondent could contact sellers/buyers without going to the market. The variable x_4 represents those respondents who answered "Yes, word-of-mouth" and were given binary variable 1; if they did not access sellers or buyers via word-of-mouth, they were given binary variable 0. The variable x_5 combines those who answered "Yes, by telephone, messages" and "Yes, by Facebook, websites" to Q9 on Table 1 into a group that could access sellers or buyers via technology. If respondents accessed the

market via technology, they are binary variable 1, if not 0. The variable x_6 is derived from Q7 on Table 1, which asked respondents, "Have you faced difficulty in accessing the market?". The responses "Yes, curfew," "Yes, roadblock/restriction," and "Yes, less transport) were coded as binary variable 1 having difficulty accessing the market; if there was no difficulty reported, they were assigned 0.

Though the models will give us outputs of potential significance, our study will be focusing on the marginal effects of the mean for all variables to determine likeliness of a variable influencing a hypothetical situation. The marginal effects for equations 1-6 can be estimated as:

$$\frac{dy}{dx_k} = \beta_k \cdot \frac{\sum_{i=0}^{n} pdf(X'\hat{\beta})}{n} \quad (7)$$

Where the coefficient of a variable, represented by β_k, is multiplied by the probability density function, or pdf, of all variable coefficients predicted values. These predicted values are represented by $(X'\hat{\beta})$. The probability density function is then divided by the sample number, *n,* to get the mean. Multiplying it by the variable's coefficient, provides the marginal effect of the mean, which is a derivative of *y* with respect to the variable x_k. The marginal effects of the mean are interpreted as percentages, which predict the probability of a variable being true, or equaling 1 in the case of a probit model, for a hypothetical observation (Fernihough, 2011).

3. Results

3.1. Summary Statistics

Summary statistics from the survey are shown in Table 1. The original age answer choices were below 20, between 20 and 40, between 41 and 60, and above 60. Due to a lack of observations, we combined the responses into 40 or younger and 41 or older.

Table 3: Summary Statistics for Demographics

Demographics	Sample (N=1069)	%
Q1: Gender		
Male	808	76.30%
Female	251	23.70%
Q2: Age		
40 or younger	508	47.97%
41 or older	551	52.03%
Q3: Head of Household		
Yes	935	88.29%
No	124	11.71%
Q4: Location		
Urban	85	8.03%
Rural	772	72.90%
Peri-urban	202	19.07%

The summary statistics show that the respondents are mostly (>72%) male heads of households living in a rural area, unsurprising given that the dataset targeted agricultural workers.

Table 4: Summary statistics for survey question 5: "Is the impact on agricultural activities low or high?".

	M	F	40 & younger	41 & older	HOH	Not HOH	Urban	Rural	Peri-urban
Impact is low	16.13%	20.00%	18.18%	16.00%	15.57%	27.42%	15.29%	16.36%	20.40%
Impact is medium	51.36%	49.60%	33.40%	30.73%	32.01%	32.26%	58.82%	51.30%	46.27%
Impact is high	32.51%	30.40%	48.42%	53.27%	52.42%	40.32%	25.88%	32.34%	33.33%

* Summary statistics for Q5 in Table 1.

Table 4 shows that agricultural activities were the most impacted for heads of household and those 41 years old or older, with over 50% of both groups being highly impacted. No formal definition of "highly impacted" was given to survey participants, and it was up to each respondent to myopically define what highly impacted meant. Future research should more clearly delineate what the definition of "high, medium, and low" relates to. It can also be seen that compared to urban dwellers, COVID-19 more highly impacted rural inhabitants' agricultural activities, which again should be no surprise given the litany of difficulties living in rural areas in times of hardship.

Table 5: Summary statistics for survey question 6, "How has COVID and measurements taken by your government impacted your agricultural activities?".

	M	F	40 & younger	41 & older	HOH	Not HOH	Urban	Rural	Peri-urban
There is no reduction on my agricultural activities until now	7.19%	8.01%	8.41%	6.45%	6.64%	12.75%	4.83%	7.20%	9.39%
There is higher demand	1.22%	1.70%	1.52%	1.16%	1.13%	2.94%	1.38%	1.26%	1.62%
There is reduced availability of hired labor for farm activities	14.39%	13.83%	12.62%	15.75%	14.34%	13.73%	8.28%	15.36%	12.30%
Me and my family have less time available to invest in agricultural activities	1.87%	1.21%	1.05%	2.33%	1.82%	0.98%	3.45%	1.34%	2.59%
I have less money available to invest in agricultural activities	14.17%	17.72%	15.42%	14.59%	14.78%	16.67%	18.62%	14.39%	15.86%
I have reduced access to inputs (seed, fertilizer, pesticides, etc)	22.88%	19.66%	21.61%	22.62%	22.48%	19.61%	24.14%	22.26%	20.71%
It's harder to sell or get agricultural produce	38.27%	37.86%	39.37%	37.10%	38.82%	33.33%	39.31%	38.20%	37.54%

* Summary statistics for Q6 from Table 1.

Table 5, which relates to Q6, "How has COVID and measurements taken by your government impacted your agricultural activities?" indicates that the most predominate impact was that agricultural produce found it harder to sell or buy, a possible outcome of market restrictions imposed by the government during the pandemic. Across all sub-samples, there was a consensus that there was a reduction in agricultural activities and that demand for agricultural activities had decreased during the pandemic. Roughly one-third of each subs-sample suggested it was more challenging to sell or get agricultural produce during the pandemic, a likely proxy for market failures attributed to the pandemic.

Table 6: Summary statistics for survey question 7: "Have you faced difficulty accessing the market?".

	M	F	40 & younger	41 & older	HOH	Not HOH	Urban	Rural	Peri-urban
Yes, curfew	8.31%	8.80%	9.09%	7.82%	8.49%	8.06%	10.59%	7.66%	10.45%
Yes, roadblock/restriction	52.73%	50.00%	52.17%	52.00%	53.81%	39.52%	51.76%	53.77%	45.77%
Yes, less transport	13.15%	13.60%	12.06%	14.36%	12.67%	16.94%	10.59%	14.03%	11.44%
No	19.11%	20.40%	20.36%	18.55%	18.58%	25.81%	16.47%	19.22%	21.39%
NA**	6.70%	7.20%	6.32%	7.27%	6.44%	9.68%	10.59%	5.32%	10.95%

* Summary statistics for Q7 i Table 1.

** NA represents no response chosen.

Table 6 shows the responses by demographic groups to the question concerning the difficulty in accessing agricultural markets. Overwhelmingly, the results in Table 6 suggest difficulty accessing agricultural markets during the pandemic. It is shown that rural inhabitants faced difficulty accessing markets due to roadblocks and reduced public transportation. Roadblocks are the most significant obstacle to accessing agricultural markets for all groups.

Table 7: Summary statistics for survey question 8: "Are agricultural inputs (seed, fertilizer, pesticides, etc.) harder to obtain?".

	M	F	40 & younger	41 & older	HOH	Not HOH	Urban	Rural	Peri-urban
Yes, because of restricted access to market	23.20%	26.40%	23.52%	24.36%	24.70%	18.55%	21.18%	24.94%	21.39%
Yes, because of less availability of inputs	37.22%	32.40%	36.17%	36.00%	35.88%	37.90%	48.24%	36.62%	28.86%
No, there is no difficulty to access inputs	31.64%	32.40%	32.81%	30.91%	31.15%	36.29%	22.35%	31.95%	35.32%
NA**	7.94%	8.80%	7.51%	8.73%	8.27%	7.26%	8.24%	6.49%	14.43%

* Summary statistics for Q8 inTable 1.

** NA represents no response chosen.

Table 7 addresses Q8 in Table 1, which asks if agricultural inputs such as seeds, fertilizer, pesticides, etc., are harder to access. A majority (minimum >68%) of all subgroups faced difficulty accessing inputs due to availability or restricted market access. The reduction in input availability was a larger constraint than restricted market access during the pandemic.

Table 8: Summary statistics for survey question 9: "Did you directly access the seller/buyer without going to market?".

	M	F	40 & younger	41 & older	HOH	Not HOH	Urban	Rural	Peri-urban
No	25.06%	24.00%	25.89%	23.82%	24.06%	30.65%	30.59%	22.47%	31.34%
Yes, word-of-mouth	52.85%	55.20%	53.56%	53.27%	53.71%	50.81%	45.88%	56.49%	44.78%
Yes, by telephone, messages	19.85%	18.80%	17.59%	21.45%	19.87%	17.74%	17.65%	19.48%	20.90%
Yes, by Facebook, websites	2.23%	2.00%	2.96%	1.45%	2.36%	0.81%	5.88%	1.56%	2.99%

* Summary statistics for Q9 from Table 1.

Table 8 reports the summary statistics to Q9 in Table 1, "Did you directly access the seller/buyer without going to the market?". Rural inhabitants used word-of-mouth to access buyers and sellers more than telephones or Facebook/websites. At least 23% of all subgroups could not directly access their buyer/seller without going to the market during the pandemic,

further illustrating the effects of the pandemic on the agricultural community. Those who could access their buyer/seller did so predominately by word of mouth, followed by phone/text messages.

Table 9: Summary statistics for survey question 10 asked, "Do you have less income (farm/off-farm) during the time when measurements are taken due to COVID?".

	M	F	40 & younger	41 & older	HOH	Not HOH	Urban	Rural	Peri-urban
Yes, I have lost my job	6.51%	11.03%	9.78%	5.56%	7.10%	11.43%	8.49%	6.04%	13.16%
Yes, I work less due to measurements	43.49%	40.34%	41.68%	43.72%	43.60%	35.71%	39.62%	44.65%	36.84%
I'm getting less remittances from off-farm sources	33.19%	30.69%	31.39%	33.70%	33.05%	29.29%	32.08%	32.69%	32.46%
No, my income has increased because higher demand	1.74%	2.07%	2.57%	1.11%	1.31%	5.71%	3.77%	1.94%	0.44%
My income did not change	15.08%	15.86%	14.58%	15.90%	14.94%	17.86%	16.04%	14.69%	17.11%

* Summary statistics for Q10 from Table 1.

Table 9 indicates that across all subgroups, at least 76% of agricultural producers had a reduction or no change in income due to the pandemic. Covid measurements were the leading reason for a reported reduced income in each sub-group, as it reduced the hours respondents could work. While scarcity often means that the "haves" can pray on the "have nots," that does not appear to be the case for agricultural producers in Kenya as increased income was only reported by 5.71% of respondents.

Table 10

Summary statistics for survey question 11: "During the last weeks of the COVID crisis, did the cost of food increase for you and your family?".

	M	F	40 & younger	41 & older	HOH	Not HOH	Urban	Rural	Peri-urban
Yes	78.78%	79.20%	79.64%	78.18%	79.38%	75.00%	77.65%	78.70%	80.10%
No	21.22%	20.80%	20.36%	21.82%	20.62%	25.00%	22.35%	21.30%	19.90%

* Summary statistics for Q11 from Table 1.

Table 10 correlated to Q11, asking, "During the last weeks of the COVID crisis, did the cost of food increase for you and your family?" At least 75% of each subgroup answered that food costs had increased.

Table 11: Summary statistics for survey question 12: "During the last week, did your household experience shortages of food?".

	M	F	40 & younger	41 & older	HOH	Not HOH	Urban	Rural	Peri-urban
No, there was no shortages in food during the last weeks	41.68%	34.45%	42.26%	37.81%	39.05%	46.21%	35.35%	41.39%	36.55%
Yes, worried that we would not have enough food available	9.23%	9.03%	10.10%	8.33%	9.31%	8.28%	11.11%	9.06%	8.84%
Yes, ate a limited variety of food due to a lack of resources	22.16%	26.76%	21.04%	25.31%	23.91%	18.62%	22.22%	21.92%	28.51%
Yes, ate fewer meals in a day due to lack of food	26.94%	29.77%	26.60%	28.55%	27.74%	26.90%	31.31%	27.63%	26.10%

* Summary statistics for Q12 from Table 1.

Table 11 also relates to food security, asking, "During the last week, did your household experience food shortages?". Again, a majority (minimum of 53.79% across subgroups) of each group answered that they had experienced a food shortage, with a reduction in daily meals being the most common reason. In terms of percentages, females appeared to be hit harder than males regarding food shortages.

Table 12: Summary statistics for survey question 13: "Since the COVID crisis started, has anyone in your household done any of these things?".

	M	F	40 & younger	41 & older	HOH	Not HOH	Urban	Rural	Peri-urban
Consumed less expensive food of the same type	17.10%	20.88%	18.20%	17.84%	17.97%	18.40%	19.01%	18.01%	17.54%
Stopped eating certain kinds of food	19.80%	18.53%	19.67%	19.32%	19.49%	19.02%	19.83%	19.77%	18.28%
Limited portion size or reduced meals	30.39%	32.06%	29.29%	32.16%	31.39%	26.38%	38.84%	29.31%	32.84%
Borrow food or bought it on credit	4.09%	5.88%	4.73%	4.32%	4.31%	6.13%	4.96%	4.58%	4.10%
NA**	28.62%	22.65%	28.11%	26.35%	26.84%	30.06%	17.36%	28.33%	27.24%

* Summary statistics for Q13 from Table 1.

** NA represents no response chosen.

Question 13 asks about the type of coping mechanisms implored for dealing with a food shortage. Like Table 11, Table 12 shows that limiting portion sizes or meals per day was the most common coping strategy to deal with a food shortage.

Using the data, shown in Tables 3-12, our objectives were to; 1) determine which groups of Kenyan agricultural producers are most likely affected by economic shocks, such as the high impact on agricultural activities and an increase in food prices, as a result of covid, 2) determine

which groups of producers are most likely to experience a food shortage and implore coping mechanisms to deal with this food shortage they experienced, 3) determine what the root causes of being classified as having a high impact on agricultural activities as a result of the pandemic, and 4) to determine the underlying causes of a food shortage during the covid pandemic in Kenya.

3.2. Regression Results & Marginal Effects of the Mean

Table 13: Regression Results for Models 1-4

Dependent Variables	**Model 1**[a] High Impact on Agricultural Activities	**Model 2**[b] Experienced an Increase in Food Prices	**Model 3**[c] Experienced a Food Shortage	**Model 4**[d] Implored Coping Strategies for a Food Shortage
Intercept	-0.27 **	0.72 ***	0.07	0.45 ***
Male	-0.02	-0.05	-0.26 ***	0.12
41 years old or older	0.10	0.02	0.12	-0.23 **
Head of household	0.30 **	0.15	0.28 **	0.13
Rural Inhabitant	0.01	-0.03	-0.11	-0.13
AIC	1465.20	1097.30	1441.50	1382.40

***, **, and * denote statistical significance at the 1, 5, and 10 percent levels, respectively.
[a] Model 1 derived from Equation 1.
[b]Model 2 derived from Equation 2.
[c]Model 3 derived from Equation 3.
[d] Model 4 derived from Equation 4.

Table 14: Marginal Effects for Models 1-4

Dependent Variables	**Model 1**[a] High Impact on Agricultural Activities	**Model 2**[b] Experienced an Increase in Food Prices	**Model 3**[c] Experienced a Food Shortage	**Model 4**[d] Implored Coping Strategies for a Food Shortage
Male	-0.0088 (0.038)[e]	-0.0137 (0.031)	-0.1028 *** (0.039)	-0.085 ** (0.037)
41 years old or older	0.0378 (0.032)	0.0060 (0.026)	0.0463 (0.031)	0.046 (0.03)
Head of household	0.1170 ** (0.051)	0.0446 (0.041)	0.1119 ** (0.051)	0.049 (0.049)
Rural Inhabitant	0.0047 (0.035)	-0.0087 (0.029)	-0.0451 (0.035)	-0.049 (0.034)

***, **, and * denote statistical significance at the 1, 5, and 10 percent levels, respectively.
[a] Model 1 derived from Equation 1.
[b]Model 2 derived from Equation 2.
[c]Model 3 derived from Equation 3.
[d]Model 4 derived from Equation 4.
[e]Values in parentheses denote standard errors.

Model 1 marginal effects results on Table 14 indicates that if a respondent is the head of household, they are 11.70% ($P<0.05$) more likely to experience a high impact on agricultural activities than someone who is not the head of household. This could be associated with the fact that non-head-of-household memebers were employed outside of the agricultural industry or simply that head of households "felt" the econoimic burden from COVID-19 more than non-head of households. Model 1 (Table 14) indicates that were no statistical differnces ($P>0.1$) between sex (male and female), age (<41 and > 41), and rural vs urban participants. The insginficance between sexes seems to suggest that, at least in the agricultural community, the impact of COVID-19 affected everyone equally. However, given that the dependent variable was subjective (highly or non-highly impacted), further reaserach may be warranted.

The marginal effects from Model 2 (Table 14) indicates that there are no statistical differences ($P>0.1$) across all subgroups regarding the probablity of experiencing higher food prices. This finding is not surprising given that food prices in Kenya were trending upward at the time, likely affecting all citizens regardless of sex, age, or region (GAIN, 2021; Kunyaga et al., 2023).

The marginal effects from Model 3 (Table 14) estimate the likeliness of different demographic groups to experience a food shortage. Unlike model 2, where everyone had an equal probability of experiencing increases in food prices, model 3 seeks to understand how impactful food price increases were on household food availability. Males were 10.28% ($P<0.01$) less likely to experience a food shortage than females. This finding aligns with the findings of previous literature that women are more likely than men to be food insecure (Ingutia & Sumelius, 2022). Future analysis should focus on the current relationship status of survey participants. It could be that single/widowed females are more vulnerable than married women in

times of crisis. Further, Model 3 indicates that heads of household are 11.19% (P<0.05) more likely to experience a food shortage. One hypothesis for this could be that because they are the family's financial decision maker, they have better optics relating to the amount of food purchased before and after the pandemic. Further, heads of households may feel obliged to feed others before themselves, leaving them more vulnerable to food insecurity.

Model 4 (Table 14) indicates that men are 8.5% (P<0.05) less likely to use coping strategies to combat food shortages brought on by COVID-19. These results are similar to the results from Model 3, as men are less likely to experience a food shortage therefore, they would also be less likely to implore coping strategies for said food shortage. Interestingly, heads of household were not more likely to use a coping strategy than those who are not heads of households, even though they were estimated to experience a food shortage more than their counterparts.

Table 15: Regression Results for Model 5

Dependent Variables	**Model 5**[a] High Impact on Agricultural Activities
Intercept	-0.64 ***
No reduction on agricultural activities until now	-1.16 ***
Higher demand for agricultural products	0.64 **
Reduced availability of labor for hire	1.68 *
Family has less time for farm activities	0.66 **
Less money to invest in agriculture	0.55 ***
Reduced access to inputs	0.17 *
Harder to sell or get agricultural produce	0.52 ***
Market access is difficult	-0.14
Harder to acquire agricultural inputs	0.29 ***
No access to seller or buyer outside the market	-0.02
AIC	1276.80

***, **, and * denote statistical significance at the 1, 5, and 10 percent levels, respectively.
[a] Model 5 derived from Equation 5.

Table 16: Marginal Effects for Model 5 - The Likelihood of Having a High Impact on Agricultural Activities

Dependent Variables	Model 5[a] High Impact on Agricultural Activities
No reduction on agricultural activities until now	-0.3929 *** (0.068)[b]
Higher demand for agricultural products	0.2163 * (0.116)
Reduced availability of labor for hire	0.0557 * (0.034)
Family has less time for farm activities	0.2224 ** (0.035)
Less money to invest in agriculture	0.185 *** (0.035)
Reduced access to inputs	0.0583 * (0.033)
Harder to sell or get agricultural produce	0.1758 *** (0.036)
Market access is difficult	-0.0462 (0.035)
Harder to acquire agricultural inputs	0.0980 *** (0.033)
No access to seller or buyer outside the market	-0.0077 (0.034)

***, **, and * denote statistical significance at the 1, 5, and 10 percent levels, respectively.
[a] Model 5 derived from Equation 5.
[b] Values in parentheses denote standard error.

The marginal effects for model 5 (Table 16) estimate the likelihood of experiencing a "high" impact on agricultural activities during the pandemic. Respondents were 39.29% ($P<0.01$) less likely to be highly impacted if they had just begun to experience an impact the two weeks before the survey was given. This could potentially be the result of a loyal customer base, being less involved in the global supply chain, or having savings to keep paying employees. Interestingly, if respondents reported experiencing higher demand for their agricultural products, they were 21.63% ($P<0.1$) more likely to experience a high impact. This could be because they could not keep up with the higher demand and felt they were leaving a surplus on the table. Typically, higher demand would be advantageous for a business, but in this case, agricultural producers could not capture all of the increased demand.

A respondent who found it more challenging to hire labor during the pandemic was 5.57% ($P<0.10$) more likely to experience a "high" impact than those who had no trouble finding labor. Given movement restrictions during covid and the heavy reliance on labor in agriculture, a lack of labor can lead to reduced output and a feeling of being "highly" impacted. While hired labor can help supplement workloads, family labor is heavily relied upon for agricultural activities in Kenya. Families that found they had less time for agricultural activities were 22.24% ($P<0.01$) more likely to experience a "high" impact. Health and safety measures to prevent the spreading and infection of COVID-19 could be taking time away from agricultural activities for families. It appears that household labor constraints played a larger role in feeling "highly" impacted than the inability to hire outside labor during covid.

Another necessity for agricultural activities is inputs, such as fertilizer and pesticides. Those with reduced access to inputs during covid were 5.83% ($P<0.10$) more likely to have experienced a "high" impact. Outside of accessing inputs, there is the ability to acquire them. In this case, accessing is the ability to find the inputs and acquiring them is the ability to purchase them. If respondents had difficulty acquiring inputs, they were 9.8% ($P<0.01$) more likely to experience a high impact on agricultural activities.

With many agricultural markets closing in Kenya coupled with movement restrictions, some producers found it harder to buy and sell agricultural outputs. If the respondent indicated they had difficulty buying or selling produce, they were 17.58% ($P<0.01$) more likely to experience a high impact on agricultural activities. This is likely driven by reduced revenue for sellers and a reduced supply for consumers. Interestingly, restricted access to markets and no access to sellers and buyers outside of markets were not statistically significant ($P>0.1$). As being

"highly" impacted is not narrowly defined in this study, further research into the effects on agricultural activities is recommended.

Table 17: Regression Results for Model 6

Dependent Variables	**Model 6**[a] Experienced a Food Shortage
Intercept	-1.23 ***
Food price increased	1.34 ***
High impact on agricultural activities	0.29 ***
Reduced income (farm/off-farm)	0.1
Accessed seller or buyer via word-of-mouth	-0.17
Accessed seller or buyer via technology	-0.37 ***
Market access is difficult	0.22 **
AIC	1172.68

***, **, and * denote statistical significance at the 1, 5, and 10 percent levels, respectively.
[a] Model 6 derived from Equation 6.

Table 18: Marginal Effects for Model 6 - The Likelihood of Having Experienced a Food Shortage

Dependent Variables	**Model 6**[a] Experienced a Food Shortage
Food price increased	0.4533 *** (0.042)
High impact on agricultural activities	0.0979 *** (0.03)
Reduced income (farm/off-farm)	0.0347 (0.038)
Accessed seller or buyer via word-of-mouth	-0.0581 (0.037)
Accessed seller or buyer via technology	-0.1260 *** (0.045)
Market access is difficult	0.0734 * (0.038)

***, **, and * denote statistical significance at the 1, 5, and 10 percent levels, respectively.
[a]Model 6 derived from equation 6.

The marginal effects from Model 6 (Table 18) estimates the likelihood of experiencing food shortage. Not surprisingly, if a respondent experienced an increase in food price, they were

45.33% (P<0.01) more likely to experience a food shortage than those who did not experience a food price increase. Intuitively, this makes sense because as food prices rise, purchasing power for food would decrease, making respondents less likely to afford the food they did pre-pandemic. Having a "high" impact on agricultural activities also increased the likelihood of a food shortage by 9.79% (P<0.01). Interestingly, experiencing a reduced income did not (P>0.1) increase the likelihood of food shortage, potentially because many agricultural producers in Kenya are subsistence farmers and can produce at least a portion, of their food.

Accessing markets became difficult across Kenya during COVID-19, and those who found market access more difficult were 7.34% (P<0.10) more likely to experience a food shortage. A hypothesis for this would be that they had reduced access to purchasing food and therefore had less to eat. Outside of markets, some citizens could contact buyers and sellers via technology (mobile phone, Facebook, etc.) or by word-of-mouth in their region. While accessing sellers and buyers via word-of-mouth did not affect the likelihood of experiencing a food shortage, accessing sellers or buyers via technology did have a significant effect. If respondents could access sellers/buyers using technology, they were 12.60% (P<0.01) less likely to experience a food shortage. This could result from a seller finding new ways to earn income to feed their household by reaching a wider audience via technology or a buyer finding new ways to purchase food for their household.

4. Conclusion

This study analyzed data collected from 1,069 smallholder agricultural producers across Kenya during the COVID-19 pandemic to estimate the pandemic's economic impact and coping mechanisms used to mitigate its effects. CIAT Nairobi collected survey data in an attempt to quantify the impacts of the pandemic on the agricultural community across Kenya. The impetus

of the study was to address four main questions: 1) determine which agricultural producers were most affected by the economic shocks of COVID-19, 2) determine which agricultural producers were most likely to experience a food shortage and implore coping mechanisms, 3) determine the causes that resulted in some Kenyan producer experiencing a “high impact” on agricultural their activities, and 4) to determine the underlying causes of the food shortages that arose during the COVID-19 pandemic in Kenya. A better understanding of the underlying causes for the four objectives of this study may allow the Kenyan government to better prepare the agricultural community for the next large-scale economic shock.

Heads of households were the most likely to experience a “high” impact on their agricultural activities due to covid. The heads of households in Kenya likely are primarily responsible for agricultural decision making, therefore more likely to experience a larger impact of any economic shock than those who are not the head of household or decisions maker. This result could also be the result of the head of households in an agricultural setting feeling more accountable for their families' economic well-being and thus feeling like the impact weighed heavier on them. There were no statistical differences across gender, indicating that both sexes had an equal probability of being highly impacted by the pandemic.

Men were less likely to experience a food shortage and less likely to implore coping mechanisms, such as a reduction in meals, a reduction in food amounts, and a change in the type of food consumed. Heads of households were also more likely to experience a food shortage, potentially because they feel a responsibility to feed their families before themselves. The findings suggest that women and heads of household were more likely to experience a food shortage, and women were more likely to implore coping mechanisms against food shortages brought about by COVID-19.

Difficulty in accessing and acquiring inputs were large factors driving those who classified themselves as being highly impacted by covid. If producers could not access or acquire agricultural inputs, that would result in reduced production and income. These inputs would usually be acquired at markets, many of which had shut down due to the effort to reduce COVID-19 spreading. Reduced income available to invest in agriculture was also a cause of highly impacted agricultural activities, likely because the inputs previously given to agricultural activities could no longer be afforded.

The increased cost of food was found to be the leading cause of food shortages during COVID-19. Having a high impact on agricultural activities and reduced access to markets also increased the likelihood of experiencing a food shortage. The inflation of food prices affected everyone in Kenya, and the results of this study show that it made experiencing a food shortage more likely.

Some themes can be seen across the study, the first being that women were more likely than men to experience food shortages and implore coping mechanisms such as reducing meals and changing food type/quantity eaten, which result in a higher likelihood of food insecurity. These results are similar to the 2022 findings of Ingutia and Sumelius, who found that female producers in rural Kenya were more likely to be affected by food insecurity than men. The second overarching theme is that heads of household feel that they take on a larger burden of the economic effects of COVID-19, as they are more likely to classify themselves as being highly impacted and experience a food shortage. Lastly, it is shown that market access was an economic bottleneck for Kenyan smallholder farmers because it has made it more difficult to access and acquire agricultural inputs and purchase food, increasing the likelihood of experiencing a food shortage.

Though every pandemic is myopic, ideally, this study's results can inspire policies to prevent economic collapse in a future pandemic. Functioning markets are essential to smallholder farmers, both for selling and buying. With closed markets, producers could not access agricultural inputs, purchase food, or sell their produce. Keeping these small markets, or "vibandas", open could reduce the high impact on agricultural activities and food shortages via functioning supply chains. Though markets were closed to prevent the spreading of COVID-19, it was economically devastating to producers and resulted in increased economic hardship (decreased revenue) and social discontent (food shortages). For the next large-scale economic shock such as Covid, it would be ideal to keep the markets open with rules and limited contact, perhaps by alternating days of who can sell at the market and limiting the capacity of buyers allowed to enter.

A second policy implication that can be made is to subsidize agricultural production during pandemics. While some cash transfer programs were ongoing for those in extreme poverty, there was no macrolevel assistance for the inflated food prices affecting everyone. If food production were to be subsidized through the producers, that would increase producer revenue and lessen the burden of food inflation by increasing supply. Targeted cash transfers to producers could allow them to obtain agricultural inputs to increase production at a reduced cost.

A policy recommendation to possibly cushion the next major macroeconomic shock to the Kenyan agricultural sector would be to invest in the empowerment of women producers. In 2021, only 75.35% of women 15 years or older had a bank account or access to a mobile-money-service provider, compared to 83.24% of men (World Bank, 2021). Increasing female producers' access to financial institutions would allow them to be better prepared for any exogenous shocks,

and expand their farming operations, potentially resulting in excess food products for themselves and increased income from sales (White, 2021).

Several limitations need to be addressed regarding the data used in this survey. Ideally, a more quantitative definition of what it means to be classified as being "high," "medium," and "low" impact on agricultural activities are, so that producers are better able to identify their impact level. Further, asking specific questions about income would have been ideal rather than simply classifying if income increased or decreased during the pandemic. Having producers identify their pre-pandemic earnings, and then their current earnings would allow for a better analysis of the average percentage decrease in wages among Kenyan smallholder producers. Lastly, these results are concluded from a singular observation per household. Giving this survey over time to the same people, asking the same questions would allow a panel data analysis of the impacts of covid. Observing changes and coping mechanisms over time would allow us to find results that would better prepare us for a future pandemic.

5. References

Fernihough, A. (2011). Simple logit and probit marginal effects in R. *UCD Centre for Economic Research Working Paper Series*, WP11/22. http://hdl.handle.net/10419/72194.

Food and Agriculture Organization of the United Nations (2023). Crops and livestock – Kenya. *FAOSTAT.* https://www.fao.org/faostat/en/#data/TCL.

GAIN (2021). Impact of COVID-19 on Kenya's Food Systems: A Situation Report. *GAIN*, 2. https://www.gainhealth.org/sites/default/files/publications/documents/impact-of-COVID-19-on-kenya-food-systems-situation-report-edition-ii.pdf.

Global Hunger Index Organization (2022). Global Hunger Index 2022: Kenya. https://www.globalhungerindex.org/pdf/en/2022/Kenya.pdf.

Ingutia, R. & Sumelius, J. (2022). Determinants of food security status with reference to women farmers in rural Kenya. *Scientific African*, 15, e01114. https://doi.org/10.1016/j.sciaf.2022.e01114.

International Trade Administration (2022). Kenya – Country Commercial Guide. https://www.trade.gov/country-commercial-guides/kenya-agribusiness.

Janssens, W., Pradhan, M., de Groot, R., Sidze, E., Donfouet, H. P. P. & Abajobir, A. (2021). The short-term economic effects of COVID-19 on low-income households in rural Kenya: An analysis using weekly financial household data. *World Development*, 138, 105280. https://doi.org/10.1016/j.worlddev.2020.105280

Kansiime, M. K., Tambo, J. A., Mugambi, I., Bundi, M., Kara, A., & Owuor, C. (2021). COVID-19 implications on household income and food security in Kenya and Uganda: Findings from a rapid assessment. *World Development*, 137, 105199. https://doi.org/10.1016/j.worlddev.2020.105199.

Karim, S. S. A., Churchyard, G. J., Karim, Q. A., & Lawn, S. D. (2009). HIV infection and tuberculosis in South Africa: an urgent need to escalate the public health response. *The Lancet*, 374, 921-933. https://doi.org/10.1016/S0140-6736(09)60916-8.

Kimani-Murage, E. W., Schofield, L., Wekesah, F. *et al.* (2014) Vulnerability to Food Insecurity in Urban Slums: Experiences from Nairobi, Kenya. *Journal of Urban Health*, 91, 1098-1113. https://doi.org/10.1007/s11524-014-9894-3.

Kunyanga, C. N., Byskov, M. F., Hyams, Keith, H., Samuel, M., Werikhe, G. & Bett, Rawlynce (2023). Influence of COVID-19 Pandemic on Food Market Prices and Food Supply in Urban Markets in Nairobi, Kenya. *Sustainability*, 15, 1304. https://doi.org/10.3390/su15021304.

Mayhew, S. H., Kyamusugulwa, P. M., Bindu, K. K., Richards, P., Kiyungu, C., & Balabanova, D. (2021). Responding to the 2018-2020 Ebola Virus Outbreak in the Democratic Republic of the Congo: Rethinking Humanitarian Approaches. *Risk Management, and Healthcare Policy*, 14, 1731-1747. https://doi.org/10.2147/RMHP.S219295

McDade K.K., Ogira D., Onyango J., Ojal J., Kokwaro G., Mao W., & Yamey G. (2020). Kenya's policy response to COVID-19. *The Center for Policy Impact in Global Health*. Policy Report: August 2020. http://centerforpolicyimpact.org/our-work/the-4ds/kenya-policy-re- sponse-to-COVID-19/.

Muyanga, M. Jayne, T. S., Argwings-Kodhek, G., Ariga, J. (2005). Staple Food Consumpiton Patterns in Urban Kenya, Trends and Policy Implications. *Michigan State University Working Papers*, 16. http://dx.doi.org/10.22004/ag.econ.55163.

Nchanji, E. B. & Lutomia, C. K. (2021). Regional impact of COVID-19 on the production and food security of common bean smallholder farmers in Sub-Saharan Africa: Implications for SDG's. *Global Food Security*, 29, 100524. https://doi.org/10.1016/j.gfs.2021.100524.

Nyariki, Dickson M. & Wiggins, S. (1997). Household food insecurity in sub-Saharan Africa: lessons from Kenya. *British Food Journal*, 99-7, 249-262. https://doi.org/10.1108/00070709710179363.

Odula, T. (2020). Kenyans fear they're on their own as COVID-19 surges again. *AP News*. https://apnews.com/article/health-coronavirus-pandemic-africa-kenya-nairobi-ba02c148539fdf14d3e2a264df9be625.

Peralta, E. (2021). Kenya Escaped the Worst Health Effects of COVID-19 – But Got Hit Hard in Other Ways. *NPR*. https://www.npr.org/2021/06/28/1011043643/kenya-escaped-the-worst-health-effects-of-COVID-19-but-got-hit-hard-in-other-way.

Sibiko, K. W. & Qaim, M. (2020). Weather index insurance, agricultural input use, and crop productivitiy in Kenya. *Food Security*, 12, 151-167. https://doi.org/10.1007/s12571-019-00987-y.

Siche, R. (2020). What is the impact of COVID-19 disease on agriculture? Scientia Agropecuraria, 11. http://dx.doi.org/10.17268/sci.agropecu.2020.01.00.

Sinha, N., Vintar, M., Haynes, A. & Deluis, A. (2022). For many Kenyans, dealing with soaring prices and uncertain rainfall in 2022 meant lowered consumption or reduced incomes. *World Bank Blogs: African Can End Poverty*. https://blogs.worldbank.org/africacan/many-kenyans-dealing-soaring-prices-and-uncertain-rainfall-2022-meant-lowered-consumption.

Statista (2021). Main exports from Kenya between 2015 and 2021. https://www.statista.com/statistics/1135439/main-exports-from-kenya/.

The World Bank (2021). Account ownership at a financial institution or with a mobile-money-service provider, female (% of population ages 15+) – Kenya. *Global Findex Database, World Bank.* https://data.worldbank.org/indicator/FX.OWN.TOTL.FE.ZS?end=2021&locations=KE&start=2011&view=chart.

The World Bank (2021). Account ownership at a financial institution or with a mobile-money-service provider, male (% of population ages 15+) – Kenya. *Global Findex Database, World Bank.* https://data.worldbank.org/indicator/FX.OWN.TOTL.MA.ZS?end=2021&locations=KE&start=2011&view=chart.

The World Bank (2020). Population living in slums (% of urban population) – Kenya. *United Nations Human Settlements Programme.* https://data.worldbank.org/indicator/EN.POP.SLUM.UR.ZS?locations=KE.

The World Bank Group (2017). Sustainable cities and communities. *SDG Atlas 2017*. https://datatopics.worldbank.org/sdgatlas/archive/2017/SDG-11-sustainable-cities-and-communities.html#:~:text=According%20to%20the%20United%20Nations,water%20or%20adequate%20sanitation%20facilities.

Trading Economics (2021). Kenya Imports of Fertilizers. https://tradingeconomics.com/kenya/imports/fertilizers.

United Nations (2020). Policy Brief: The Impact of COVID-19 on Food Security and Nutrition. *United Nations Sustainable Development Goals*, 1-23. https://unsdg.un.org/sites/default/files/2020-06/SG-Policy-Brief-on-COVID-Impact-on-Food-Security.pdf.

Vila-Real, C. P. de Melo, Sofia-Pimenta-Martins, A., Kunyanga, C. N., Mbugua, S. K., Katina, K., Maina, N. H., Gomes, A. M. P., Pinto, E. C. B. (2022). Nutritional intake and food sources in an adult urban Kenyan population. *Nutrition Bulletin*, 47, 423-437. https://doi.org/10.1111/nbu.12582.

Warah, R. (2022). COVID-19 only heightened Kenya's existing economic problem. *ONE Africa*. https://www.one.org/africa/blog/covid19-kenya-economy-inflation/.

White, T. (2021). Figure of the week: Closing the gender gap to reduce food insecurity in Africa. *Brookings.* https://www.brookings.edu/blog/africa-in-focus/2021/05/26/figure-of-the-week-closing-the-gender-gap-to-reduce-food-insecurity-in-africa/.

World Health Organization (2023). COVID-19 Kenya Situation. https://covid19.who.int/region/afro/country/ke.

Zhang, T. (2020). IMF Executive Board Approves a US$739 Million Disbursement to Kenya to Address the Impact of the COVID-19 Pandemic. *International Monetary Fund Press*

Release. https://www.imf.org/en/News/Articles/2020/05/06/pr20208-kenya-imf-executive-board-approves-us-million-disbursement-address-impact-COVID-19-pandemic.