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# FARMERS' PERSPECTIVE OF COVID-19 EFFECTS ON DEMAND AND SUPPLY OF AGRICULTURAL COMMODITIES IN NYAMASHEKE DISTRICT, RWANDA

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## ABSTRACT

COVID-19 is an infectious disease caused by a new strain of coronavirus. This disease disrupted the functionality of the global economy, and the agriculture sector was not spared. It is in this context that this paper aims at assessing farmers' perceptions about the perceived shocks of COVID-19 on the side of demand and supply of agricultural commodities. The study was guided by three objectives viz to investigate the perceptions of farmers on the effects of COVID-19 pandemic on the demand for agricultural commodities, to explore the perceptions of farmers on the effects of COVID-19 pandemic on the supply of agricultural commodities and to analyze the factors affecting farmers' perceptions of COVID-19 pandemic on demand and supply of agricultural commodities in Nyamasheke district. The target population size was 6237 composed of farmers of three irrigated lands in Nyamasheke District. Yamane's formula for the sample size determination was used to find the sample size of the respondents which was 376 and then stratified and systematic sampling procedures were employed to get 174 farmers in Kirimbi, 114 farmers in Mugonero and 88 farmers in Kamiranzovu irrigated lands, respectively. This study employed both descriptive and inferential statistical tools to analyze data. Descriptive statistics were used to analyze data on the perceptions of farmers towards COVID-19 pandemic effects on the demand and the supply for agricultural commodities while the inferential statistics were used to estimate the logit of farmers' perceptions on COVID-19 pandemic effects of demand and supply of agricultural commodities in the area under study. Results from the descriptive statistics revealed that 326 (86.7%) farmers agreed that COVID-19 pandemic has affected the demand of agricultural commodities while 244 (64.9%) farmers confirmed that COVID-19 pandemic has affected the supply of agricultural commodities in the area under study. The output of the model revealed that the independent variables that significantly contribute to the logit of the dependent variable were farming experience and labor. During the COVID-19 pandemic, farmers encountered several challenges that disrupted their livelihoods including changes in household consumption patterns, changes in market functionalities, discontinuity of the planned training and field visits, and low number of farmers in the farms. Researchers recommend that farmers' purchasing power should be reinforced by providing financial support to them through lowering interest rates on loans.

**Key words:** Demand, supply, COVID-19, pandemic, agricultural commodities, binary logistic regression, Rwanda

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## INTRODUCTION

The novel coronavirus (COVID-19) that was considered as an epidemic in December 2019 soon became a global pandemic that affected human life and the global economy [1]. According to the World Health Organization (WHO), by May 9, 2020, the virus had globally infected 4,024,009 people and caused 279, 311 deaths [1]. A total lockdown that affected normal human activity pushed the world including Rwanda into a deep crisis of recession that was worse than the global financial crisis from 2008-2009 [2]. The pandemic did not only affect the lives of people but its spread caused a negative supply and demand shock [3]. The negative supply shocks came mainly from a reduction in labor. Several issues related to the COVID-19 impacts on consumer demand for food were explored, and the demand-side factors accounted for most of the changes that can be seen in the retail food market [4].

An initial COVID-19 scenario provides some preliminary insights into the short-term impacts of the current pandemic on agricultural markets. The scenario illustrates the historically significant market shock created by the COVID-19 pandemic. Agricultural prices fell strongly in response to COVID-19, which induced a decline in disposable income, especially in low-income countries [5]. Due to this unprecedented loss in purchasing power, food consumption decreased despite the offsetting price declines. It also showed a reduction of demand for vegetables, oil and animal products, whereas the demand for staple foods was less affected. While the scenario provides an indication of potential short-term impacts of the disruptions caused by the pandemic, the economic, social and political fallout of the pandemic continues to evolve in an extremely complex pattern.

From the national perspective, an assessment of the impact of COVID-19 on the Rwandan economy by the Government of Rwanda (GoR) showed that the service sector was mainly impacted compared to agriculture and industry. The tourism industry had lost about USD 10 million in the months of March and April 2020 as most hotels across the country were closed [6]. The hospitality industry had lost about 3 billion Rwandan francs and it is expected that the Rwandan agriculture sector will slightly decline due to the global COVID-19 crisis [7]. In addition to beans, the price of maize grain reduced on average by 14.0 % in March 2020 [7]. However, the weekly reports of early April 2020 showed an increase of 7.0 % between March and April since the onset of COVID-19 [8].

The International Monetary Fund (IMF) anticipated a global recession in 2020 due to the COVID-19 pandemic and its impacts on domestic economies. The IMF also

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projected a 5.1% economic growth in 2020 for Rwanda instead of the initial forecast of 8.0% due to the pandemic [9]. This indicates that the agricultural sector and other sectors of the Rwandan economy will not be exempted from those impacts of the COVID-19 pandemic. In China, the impacts of COVID-19 on the agricultural economy were mainly observed in crop production, agricultural products supply, livestock production, farmers' income and employment, economic crop development, agricultural products sales model, leisure agriculture development and agricultural products trade [10].

On the regional perspective, COVID-19 had negatively affected the exports and imports of agricultural commodities among East African Countries (EAC), which declined due to reduction in regional business activities owing to border restriction measures to reduce cross border infections. The spillover effect of this disruption has been felt by other African businesses, both exporters and importers of goods and services in the global economy. Using a few typical examples, Kenya exported 5000 tons of perishable products per week by air against a capacity of 6000 tons [11]. In April, 2020, the capacity went down to 1500 tons per week against demand of 4000 tons [11]. Similarly, in the floriculture subsector, before COVID-19, Kenya was exporting 30,000MT of flowers per week. The industry currently exports 12,000MT per week [11].

On the continental perspective, Africa is known to have fertile agricultural land but is an importer of agricultural goods and food products with up 66.0% worth of USD 46 billion of total African food imports [12]. With the unexpected, prolonged presence of COVID-19, imports likely declined, which in turn caused serious issues in the African food system. Rice and wheat exporting countries-imposed restrictions, which increased food insecurity in Africa and led to increases in food prices.

**Theorizing Demand and Supply in agriculture: In the presence of the pandemic**

The Food and Agriculture Organization of the United Nations (FAO) has produced a systematized analysis of the main channels of transmission of the impacts of the pandemic on food and agriculture, using a model that identifies the effects on food demand, supply and international trade (see diagram 1). The key factors in each case are:

**- Demand:** the share of income that households spend on food and the price and income elasticities of food that affect household purchasing power and the distribution of spending among types of food.

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**- Supply:** the relative capital or labor intensity of production and the importance of fixed capital and intermediate inputs.
**- International trade:** the effects depend on each country's position as a net importer or net exporter.

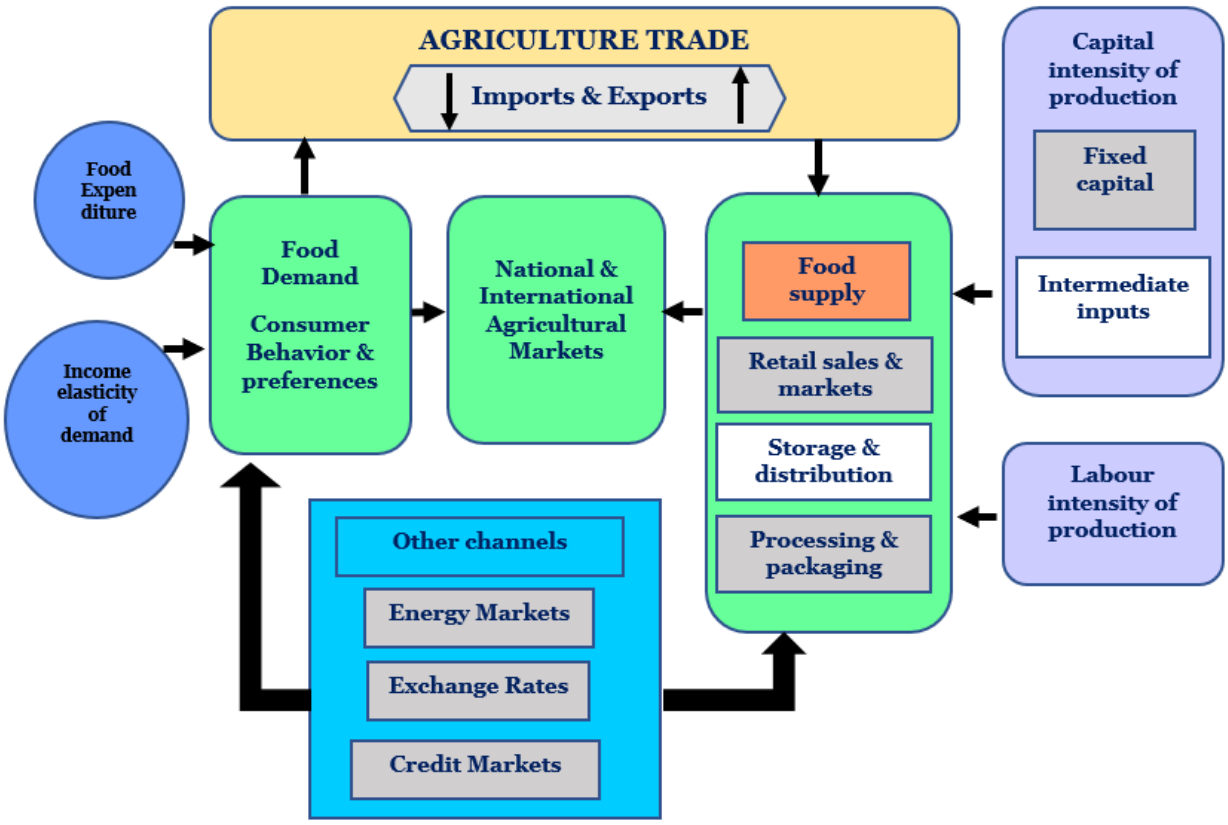


**Figure 1: Channels of transmission of the impacts of COVID -19 pandemic on food and agriculture**

Based on the preceding discussions and perspectives, the overall objective of this study was to determine whether the COVID-19 pandemic affected demand and supply of various agricultural commodities. The specific objectives of this study were to (i) investigate the perceptions of farmers on the effects of COVID-19 pandemic on the demand for agricultural commodities (ii) explore the perceptions of farmers on the effects of COVID-19 pandemic on the supply of agricultural commodities and (iii) analyze the factors affecting farmers' perceptions of COVID-19 pandemic on demand and supply of agricultural commodities in Nyamasheke district. From the third objective, the research tested the following hypotheses: $H_N$: There is no significant effect of COVID-19 pandemic on the demand and supply of various agricultural commodities. $H_A$: There is a significant effect of COVID-19 pandemic on the demand and supply of various agricultural commodities.

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## LITERATURE REVIEW

Various research studies on the COVID-19 effects on supply and demand for agricultural commodities were conducted. Luke *et al.* [13] explored how food producers in Wales collaborated to protect livelihoods while also providing accessible food to the nation during COVID-19. Based on the findings, the study reported two innovative strategies to protect livelihood and accessible food, which users range from those choosing to buy local produce contact free, through an online click and collect service, to that most vulnerable, food box delivery scheme developed through cross sector collaboration. Viliamu *et al.* [14] conducted a study on the impacts of COVID-19 on agriculture and food systems in Pacific Island countries. They stated that to reduce the negative impacts of COVID-19 mitigation measures, governments have put in place a number of interventions to sustain food and income security. However, both mitigations and interventions have had impacts on agricultural production, food systems and dietary status at the national and household levels. Due to lockdowns of urban areas, people with no employment were forced to return to their village and engage in agricultural activities which increased the availability of workers in agriculture. Another impact was a decreased access to markets and disrupted transportation of produce between rural and urban areas or between islands. In regards to governments' interventions, Pacific Island governments mobilized resources to address the impacts whereby they increased the supply of seedlings, home garden tools and information to increase cultivation of early maturing root crops, vegetables, fruits and ornamentals. Amy *et al.* [15] explored how regional food supply chains can improve the resilience of the U.S. food supply system in the face of large-scale disruptions like the COVID-19 crisis [15]. Their findings revealed that the successes experienced by farmers and distributors at the height of the COVID-19 pandemic were a result of their willingness to adopt new distribution and logistics strategies where collaboration among Regionalized Food Supply Chains (RFSC) actors was an effective strategy as well as the adoption of scale-appropriate information and communication technologies which helped to facilitate collaboration. Blazy *et al.* [16] assessed the immediate impacts of the COVID-19 crisis on the agricultural and food systems of the Caribbean. They found that the COVID-19 crisis had strong impacts on Caribbean farmers and weakened agricultural systems. The main identified impacts were a drop in income, production losses due to difficulties in marketing through conventional channels, difficulties in managing the farming systems due to reduced access to inputs and labor. Results showed that the crisis had an impact on consumer behavior and their perception of the importance of the agricultural sector: reduction of food

waste, return to fresh and local products, adaptation of the diet, consumption of new products and cultivation of food gardens. Finally, the results of the study revealed that the crisis strengthens the links between farmers and the rest of the population. Siche [17] assessed the impacts of COVID-19 pandemic on agriculture. Starting with its impacts on food supply, he reported that food supply at farm level was not affected; it will, however, be affected depending on the imported or exported goods due to the closure of borders, causing international trade interruption. On the side of food demand, he argued that it was heavily affected due to mobility restrictions, reduced purchasing power and with a greater impact on the most vulnerable people. These impacts affect the household food security levels. He concluded that the pandemic has a great impact on the food demand side and thus food security.

TechnoServe found that 34.0% smallholders had challenges in American Latina with trouble accessing supplies, labor, inputs transportation, markets and technical assistance for their farms due to COVID-19 [18]. Similarly, to the price variable, it was revealed that since the beginning of the pandemic, some farmers were not able to sell their produce while others reported low prices once they managed to sell. In the study conducted by Lina *et al.* 65.0% of farmers confirmed that COVID-19 affected crop sales in Latin America and Caribbean [19] but did not affect crop production, which was the observation in this study. They concluded that reduction in sales was caused by issues related to transport of agricultural production, a decrease in the demand for food caused by reduction in income and price [20]. The demand for food decreased due to uncertainty and reduction of people's spending capacity. They added that the situation could worsen if the pandemic continues for long. The impact of COVID-19 on agricultural markets for nonperishable (wheat) and perishable (tomato and onion) commodities in India was assessed [21]. It was found that prices of non-perishable goods were relatively low in some months while for perishable goods were stable due to the provision on the minimum support prices. COVID-19 restrictions blocked the outflow channels of agricultural products, hindered production inputs, destroyed production levels and undermined production capacity in China [22]. COVID-19 has an impact on the whole process of food supply chain from the field to the consumer due to challenges in the food supply chain mainly in food production, processing, distribution and demand that were observed [23]. The COVID-19 pandemic affected almost all the vegetable supply chain with a great effect on the sales, which made farmers' income decline tremendously [24]. It was concluded that agricultural insurance played an important role in stabilizing the supply of vegetables. In Michigan, it was found that the pandemic decreased the overall economic output attributable to agriculture by 18.6% with dairy and vegetable

production being the hardest hit, with 25.2% and 27.2% reduction in economic output, respectively [25]. Michigan's economy experienced a decline of $2,186,268,000 of primary and secondary sales due to pandemic effects on agricultural producers. During the first quarter of 2020, 3.11% or 17.03 million tons of agricultural production was reduced in aggregate volume in Southeast Asia due to decline in agricultural farm labor affecting 100.77 million individuals due to the pandemic [26]. It was reported by Mediterranean Agricultural Market Information Network that the supply side impacted mainly on agricultural production, imports, logistic disruptions and agri-food industries [27] while the production side showed that the pandemic crisis did not induce significant changes on the grain harvest in the Mediterranean countries as it did not correspond with the harvest (to start in June-July in most of the countries). On the logistic disruptions in agri-food industries, they found that shortages of labor and demand shock disrupted the processing of food in the Mediterranean countries. Results showed logistical disruptions for horticulture crops. On the demand side, the closure of the hotels, restaurants and cafes, and closing of touristic sites in all the Mediterranean countries heavily impacted the demand patterns (consumer behavior). COVID-19 affected all the processes, which link farm production to final consumer and the supply chain was hit hard by the pandemic, which in turn caused food insecurity to worsen especially among the vulnerable people [28]. Most of the migrant, informal and seasonal workers lost their jobs, which affected the demand for food. The negative impact of COVID-19 on supply and demand for food led food security at risk [29]. Pacific Island Farm Organization Network (PIFON) produced a report on the impact survey of COVID-19 and agriculture and found that in all the countries there was reduction in local sales of produce due to the lockdowns imposed by the government which did not permit farmers to cross internal borders [30]. Most of the farmers reported reduced visits from extension services such as training providers, because of the lockdowns and safety instructions to practice social distancing. COVID-19 had strong impacts on Caribbean farmers and weakened the agricultural systems [31]. The main impacts were a decline in income, production losses due to difficulties in marketing and reduced access to inputs and labor due to difficulties in managing farms. Studies have also shown the impact of the pandemic on consumer behavior due to the reduction of food quantity [32]. As a result, the prices of vegetables rose significantly from 15 to 50% during the first phase of lockdown due to disruptions in the supply chains.

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## MATERIALS AND METHODS

### Description of the study area

Three main irrigated lands from the Nyamasheke district including Kirimbi, Mugonero and Kamiranzovu were the study areas. The Nyamasheke district is in Western province of Rwanda and shares its borders in the East with the Nyamagabe District, Lake Kivu to the West, the Rusizi District to the South and the Karongi District to the North. Due to its agro-ecological conditions, the soil is more fertile and productive. Farmers cultivated rice in irrigated lands of 237 hectares. The Kirimbi marshland consists of 127ha, Kamiranzovu 80ha and Mugonero 30ha. These irrigated lands are of great importance as they contribute to the improvement of the socio-economic life and therefore poverty reduction for rice farmers in general and the development of the district of Nyamasheke in general. The target population for this study was 6, 237, composed of 2879 rice farmers from the irrigated land of Kirimbi, 1469 from the Kamiranzovu and 1889 from the irrigated land of Mugonero. The sample size that represented this target population from these three irrigated lands was estimated using Yamane's [33] formula, which is as follows:

$$n = \frac{6237}{1 + 6237(0.05)^2} \approx 376$$

After determining the sample size, researchers intended to know the sample size that should represent each irrigated land from the three considered irrigated lands. In this regard the stratified sampling method was used to select the number of farmers that could be included in the total sample size from each stratum (irrigated land) and the individuals who participated in the study from the three irrigated lands were estimated as follows:

$n_i = \frac{N_{i\times n}}{N}$ where in this estimation, $n_i$ stands for the sample size to be extracted from i[th] irrigated land, $N_i$ stands for the number of all farmers in the i[th] irrigated land, $n$ stands from the total sample size and $N$ stands for the total target population of all the three irrigated lands and $i = 1, 2, 3$ stands for the three irrigated lands under study. Substituting

$n=376, N_1 = 2879, N_2 = 1469, N_3 = 1889, N = 6237$ in the formula of stratified sampling $n_i = \frac{N_{i\times n}}{N}$, the number of farmers representing each irrigated land was computed and yielded the following samples:

$n_1 = \frac{2879\times376}{6237} \approx 174$ Farmers from Kirimbi irrigated land

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$n_2 = \frac{1469 \times 376}{6237} \approx 88$ Farmers from Kamiranzovu irrigated land

$n_3 = \frac{1889 \times 376}{6237} \approx 114$ Farmers from Mugonero irrigated land

To select 174, 88 and 114 farmers from Kirimbi, Kamiranzovu and Mugonero irrigated lands, respectively, a systematic sampling procedure was used with the aid of the sampling frames from these irrigated lands, and from each sampling frame of each irrigated land the sampling interval was computed as follows: $K_i = \frac{N_i}{n_i}$ where in this estimation, $n_i$ stands for the sample size extracted from i$^{th}$ irrigated land, $N_i$ stands for the number of all farmers in the i$^{th}$ irrigated land, $K_i$ stands for the sampling interval to be used in i$^{th}$ irrigated land and $i = 1, 2, 3$ stands for the three irrigated lands under study. Substituting $N_1 = 2879, N_2 = 1469, N_3 = 1889,\ n_1 = 174,\ n_2 = 88,\ n_3 = 114$ respectively in the formula of sampling interval $K_i = \frac{N_i}{n_i}$, the sampling interval to be employed on each sampling frame of the three irrigated lands was computed and this yielded the sampling intervals:

$K_1 = \frac{2879}{174} \approx 16$ sampling interval used on the sampling frame of Kirimbi irrigated land

$K_2 = \frac{1469}{88} \approx 17$ sampling interval used on the sampling frame of Kamiranzovu irrigated land

$K_3 = \frac{1889}{114} \approx 16$ sampling interval used on the sampling frame of Mugonero irrigated land

Systematic sampling method was adopted by selecting randomly the first item on the sampling frame and then applying the sampling interval to get the other farmers to be interviewed from each irrigated land.

**Techniques of data collection**

Since the country was in total lockdown to prevent the spread of the coronavirus, the authors used a telephone interview to collect the data. After talking to the presidents of the selected irrigated land areas, details on the target population and other related sampling procedures were revealed to authors to make rational

decisions that ensure sample representativeness and data reliability. The process through which this technique was performed is explained in three steps below.

**Designing and validating the questionnaire tool**

The questionnaire was designed in accordance with the set objectives. It consists of series of questions having three parts. The first part emphasizes on the questions about the perceptions of farmers towards COVID-19 pandemic effects on the demand for agricultural commodities. The second part focuses on the perceptions of farmers towards COVID-19 pandemic effects on the supply of agricultural commodities. The third part refers to questions related to the influencing factors of the perceptions of farmers towards COVID-19 pandemic effects on supply and demand for agricultural commodities. The last part highlights questions in regards to challenges faced by farmers during COVID-19 pandemic. After designing a tool, researchers performed a pilot study to validate it and then ensure data reliability and consistency. Data reliability and consistency are ensured through computing a coefficient named as Cronbach Alpha (α) which was found to be 0.823 indicating a good level of internal consistency for the scale under measurement.

**Requesting farmers' phone numbers**

Researchers requested phone numbers of the president (in-charge) of each irrigated land to enable them to obtain those of farmers who are in this case considered as respondents. After having the presidents' numbers, researchers asked them to provide detailed lists with farmers' names and phone numbers from each irrigated land.

**Make phone calls**

Phone calls were made by researchers to respondents to provide answers on the questionnaires. The answers were then recorded immediately on the pre-designed excel sheet. This activity of collecting data using phone calls started from July 21, 2020, and ended on August 15, 2020.

**Description of dependent and independent variables**

***Independent variables***

The independent variables to influence the dependent variable under study were farm size, agricultural extension, labor, educational level, farming experience, household size, market price, social distancing effects, psychological effects of COVID-19 pandemic, gender, marital status, agricultural inputs, transport and training on the farming activities.

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***Dependent variable***

The question asked to the respondents on whether COVID-19 pandemic affected the demand and supply of agricultural commodities enabled researchers to collect data on the dependent variable having four levels. Those levels were "0" for strongly disagree, "1" for disagree, "2" for agree and "3" for strongly agree. From this context, it can be confirmed that based on the structure of the categories, the dependent variable under study is that the model is of ordered logistic regression type.

After merging the levels of the outcome variable, the coefficient of skewness was found to be small compared with the same statistical metric of the dataset prior to merging the levels. For this reason, researchers decided to merge the levels "strongly disagree" and "disagree" as one level and was coded as "0" to stand for disagree and the levels "strongly agree" and "agree" were also merged into one level coded as "1" to stand for "agree". Thus, the new codes of the dependent variable were "0," for "disagree" and "1" for agree. Based on this process, researchers concluded to apply an econometric model type of binary logistic regression.

**Model specification**

***Baseline category of the dependent variable***

Any category of the dependent variable was the baseline category and the model fits the data equally well by obtaining the same logit of the outcome variable producing the same estimated values, only the values and interpretation of the parameters will vary. In this study, the reference category with the smallest frequency was considered, and so the category of "disagree" and "strongly disagree" were merged. With this choice of the reference category, comparison was made against the respondents in the sample who reported that the COVID-19 pandemic has affected the supply of and demand for agricultural commodities. After having insights on the dependent and independent variables under consideration, a binary logistic regression model to be estimated is specified as: For a response variable $Y$ with two measurement levels (dichotomous) and explanatory variable $X$, let: $\delta(x) = p(X = x) = 1 - p(X = x)$, the binary logistic regression model has linear form for logit of this probability:

$$Logit[\delta(x)] = log\ log\left(\frac{\pi(x)}{1-\pi(x)}\right) = \alpha_0 + \alpha_1 x,$$

where the $odds = \frac{\delta(x)}{1-\delta(x)}$.

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The $odds = e^{(\alpha_0+\alpha_1 x)}$, and the logarithm of the odds is called logit, so:

$$Logit[\delta(x)] = log\ log\left(\frac{\delta(x)}{1-\delta(x)}\right) = log\ log\ [exp\ (\alpha_0 + \alpha_1 x)]$$
$$= \alpha_0 + \alpha_1 x\ .$$

The logit has a linear approximation relationship, and logit = logarithm of the odds. The logistic regression can extend to models with multiple explanatory variables. Let consider the case of $k$ predictors for a binary response Y by $x_1, x_2, \ldots\ldots x_k$, the model for log odds is:

$$Logit[p(Y=1)] = \alpha_0 + \alpha_1 x_1 + \alpha_2 x_2 + \alpha_3 x_3 + \cdots + \alpha_k x_k.$$

And the alternative formula, directly specifying $\pi(x)$, is

$$\delta(x) = \frac{exp\ (\alpha_0 + \alpha_1 x_1 + \alpha_2 x_2 + \alpha_3 x_3 + \cdots + \alpha_k x_k)}{1 + exp\ (\alpha_0 + \alpha_1 x_1 + \alpha_2 x_2 + \alpha_3 x_3 + \cdots + \alpha_k x_k)}$$

The parameter $\beta_i$refers to the effect of $x_i$on the log odds that Y =1, controlling other$x_j$, for instance, $exp(\alpha_i)$ is the multiplicative effect on the odds of a one unit increase in $x_i$, at fixed levels of $x_j$.

If there are $m$ independent observations with $q$-explanatory variables, and the qualitative response variable has $k$ categories, to construct the logits in the multinomial case, one of the categories must be considered the base level and all the logits are constructed relative to it. Any category can be taken as the base level, so authors consider category $k$ as the base level. Since there is no ordering, it is apparent that any category may be labeled $k$. In this case, authors assume $\delta_j$ denote the multinomial probability of an observation falling in the $j^{th}$ category, to find the relationship between this probability and the $m$ explanatory variables, $X_1, X_2, \ldots\ldots X_q$, the multiple logistic regression model is then:

$$log\ log\left(\frac{\delta(x_i)}{\delta_k(x_i)}\right) = \alpha_{0i} + \alpha_{1j} x_{1i} + \alpha_{2j} x_{2i} + \cdots + \alpha_{qj} x_{qi},$$

where $j = 1, 2, \ldots, (k-1), i = 1, 2, \ldots, m.$

Since the sum of all the $\delta's$ add to unity, this reduces to:


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$$log\ log\left[\delta_j(x_i)\right] = \frac{exp\ (\alpha_{0i} + \alpha_{1j}x_{1i} + \alpha_{2j}x_{2i} + \cdots + \alpha_{qj}x_{qi})}{1 + \sum_{j=1}^{k-1} \quad exp\ (\alpha_{0i} + \alpha_{1j}x_{1i} + \alpha_{2j}x_{2i} + \cdots + \alpha_{qj}x_{qi})},$$

for $j = 1, 2, \ldots, (k-1)$, the model parameters are estimated by the method of Maximum Likelihood estimation.

**Tools of data analysis**

The main data analysis tools used in this research were descriptive and inferential statistics. In regards to descriptive, frequencies were computed to investigate the farmers' perceptions of COVID-19 pandemic effects on demand and supply of agricultural commodities in the area under study. For the inferential statistics, the binary logistic regression model was employed to model the logit of farmers' perceptions of COVID-19 pandemic effects on demand and supply of agricultural commodities in the area under study.

## RESULTS AND DISCUSSION

### Preliminary result of the model

The table of the model fitting information reveals important information in the model fitting. This table reveals the parameters of the model for which the model fit will be estimated. The model fitting information table "Intercept Only" describes a model that does not control for any predictor variables while the word "Final" describes a model that includes the specified independent variables. By including the independent variables and maximizing the log likelihood of the dependent variable, the "Final" model should improve upon the "Intercept Only" model. This can be seen in the differences in the -2(Log Likelihood) values associated with the models. To test whether there is a significant difference between the null model (model with intercept only) and the model fit that includes all the independent variables, the model fitting information from the output reveals that there is a significant difference between the null model and model including the independent variables. This decision is made by comparing the p-value (sig.) corresponding to the Chi-square metrics of the final model with the marginal error (cutoff) in the analysis, with $\chi^2$ (17) = 210.343, p value=.000$< .05$, implying the null model does not fit the data instead there is an alternative model which includes all the independent variables.

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The output of the binary (ordered) logistic regression model revealed that the independent variables that increase the logit (the probability that shows the farmers' perceptions towards the impacts of COVID-19 on the demand and supply of agricultural commodities) were farming experience and labor. This decision was made in comparing the p-values corresponding to the chi-square metrics of these two independent variables and the cutoff (5%); that is $\chi^2$ (1) =0.07, p value=.033< .05 and is $\chi^2$ (1) =2.667, p value=.004< .05, respectively.

**Farmers' perspective of COVID-19 effects on demand for agricultural commodities**

Table 1 depicts the perceptions of farmers toward the COVID-19 effects on demand for agricultural commodities. Results show that the majority, 86.7% of farmers reported that the demand side of the agricultural commodities was affected by the COVID-19 pandemic while 13.3% reported no effects. This finding indicates that farmers' capacity of purchasing foods from the markets was disrupted due the COVID-19 pandemic. Furthermore, farmers' purchasing power was reduced due to the reduction in the quantity of agricultural produce supplied to the market. This finding is corroborative to the findings of Lina *et al.* [19] who found that the demand for foods was affected by the COVID-19 pandemic in Latin America and Caribbean. They specifically concluded that a decrease in the demand for food was caused by a reduction in income and price levels.

**Farmers' perspective of COVID-19 effects on supply of agricultural commodities**

Findings from Table 1 showed that the supply side of agricultural commodities was affected. Table 1 depicts the perceptions of farmers toward the COVID-19 effects on supply of agricultural commodities. Results show that 64.9% of the sampled farmers reported that the supply side of the agricultural commodities was affected by the COVID-19 pandemic, while 35.1% reported that the supply side of agricultural commodities was not affected. This is explained by the fact that farmers preferred to keep foods for consumption purposes instead of supplying them to the markets for ensuring food safety. This finding is in line with that of Lina *et al.* (2020) who reported that 65.0% of farmers confirmed that COVID-19 affected crop sales in Latin America and Caribbean but did not affect crop production. They concluded that reduction in sales was caused by issues related to transport of agricultural production. It is also in agreement with GU and WANG (2020) findings which confirmed that COVID-19 pandemic affected almost all the vegetable supply chain with a great effect on the sales, which made farmers' income to decline tremendously.

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**Whether farmers encountered changes in the use of agricultural inputs due to COVID-19 pandemic**

Results from table 1 reveal that farmers reported change at 24% while the remaining 76% expressed no change. This finding is explained by the fact that farmers were regularly receiving farm inputs as agricultural related activities were not stopped during the pandemic.

**Binary logistic regression estimates**

The parameter estimates in Table 2 reveal the information related to the coefficient $\alpha$ for each predictor variable for each alternative category of the outcome variable.

From the output of the model, the independent variables that are statistically significant are the farming experience and labor. Farming experience and labor are considered the only two independent variables due to the fact that their Chi-square metrics have the corresponding p-value which are all less than the level of significance (cutoff), that is, the p-value corresponding to the chi-square metrics of farming is less than 5% (the cutoff) and the p-value corresponding to chi-square metrics of labor is less than 5%. For the interpretation of the parameter estimate from the model, for a one unit increase in farming experience it expects a 0.077 increase in the ordered log odds of being in agreement of stating that farming experience has positively affected demand and supply of agricultural commodities during COVID-19 pandemic in the area under study, all of the other variables in the model held constant. The economic implication of this finding is explained by the fact that farmers with a high level of farming experience tried to cope with the challenges faced during COVID-19 pandemic, therefore positively contributing to the supply and demand of agricultural commodities. Similarly, for a one unit increase in labor, it expects a 2.667 increase in the ordered log odds of being in agreement of stating that COVID-19 pandemic has positively affected the demand and supply of agricultural commodities in the area under study, all other variables in the model held constant. This indicates that an increase of labor in farms leads to an increase of production which in turn would lead to an increase in the level of supply. Furthermore, on the side of the demand, an increase in labor tends towards the increase of demand of agricultural commodities because additional labor implies additional consumer which means that the quantity of agricultural commodities to be demanded increases.

**Challenges encountered by farmers during COVID-19 pandemic**

Table 3 indicates main challenges revealed by the farmers during the survey including the changes in household consumption patterns, change in market functionalities, discontinuity of the planned training and field visits and low number

of farmers in the farms. After identifying these challenges, farmers were requested to rank them according to their level of influence through which mean ranks for each challenge was computed. The analysis of the mean rank showed that changes in household consumption habits of consumers ranked first, changes in market structures ranked second, discontinuity of the planned training and field visits ranked third and low number of farmers in the farms ranked fourth. Among the four main identified challenges, changes in household consumption were the first ranked, implying that though farmers kept their produce for the consumption purposes, they were inconsistently compared to the previous consumption levels as farmers reduced the quantity of food to be consumed due to precaution motive. The second challenge was the market functionalities which seemed to be varied in comparison to those in normal working conditions whereby a limited number of sellers were planned to enter the market. The third challenge was the discontinuity of the planned training and fields due to COVID-19 and the fourth challenge was the limited number of farmers in the farms due to social distancing measures which was even recommended to the farmers to avoid spreading Corona virus among farmers and people in the local community.

In the study of TechnoServe, it was found that 34.0% smallholders had challenges in American Latina countries with trouble accessing supplies, labor, inputs transportation, markets and technical assistance due to COVID-19 for their farms. Similarly, concerning prices, it was revealed that since the beginning of the pandemic, some farmers were not able to sell their produce while others reported low prices once they managed to sell.

## CONCLUSION

This study assessed the perceptions of the farmers on the various shocks associated with the COVID-19 outbreak, with a focus on demand and supply of agricultural commodities. For instance, a well-known theory of demand and supply was at the center of this study. Results from descriptive statistics showed that 86.7% of farmers reported that the demand side of the agricultural commodities was affected by the COVID-19 outbreak while 64.9% reported that the supply side of agricultural commodities was affected. Briefly, both sides were affected but the demand side was heavily affected by the COVID-19 pandemic as observed through the findings.

Analysis from the binary logistic regression model revealed that the independent variables that predict the logit of the outcome variable are farming experience, and labor indicating that they increase the probability of perceptions of farmers on the

effects of COVID-19 pandemic on demand and supply of agricultural commodities. The main challenges that farmers faced in the area under study due to the COVID-19 pandemic were found to be changes in household consumption patterns, change in market functionalities, discontinuity of the planned training and field visits and limited number of farmers in the farms due to social distance measure.

In the perspective of mitigating the effects of COVID-19 pandemic on the supply and demand for agricultural commodities in Nyamasheke district specifically and in Rwanda in general, recommendations were proposed based on the findings of the study as follows:

- There is an urgent need to ensure farmers' power of purchasing is maintained through providing financial support to farmers in terms of low interest rate on loans, loans with a long period for loan reimbursement to cushion farmers from the economic shocks faced during the pandemic.
- Markets (selling price and number of sellers) functionality to be normalized to make sure the supply side of the agricultural commodities is sustained as it was before the pandemic.
- Supply of agricultural commodities was affected by the pandemic therefore there is a need to assist farmers with necessary requirements to boost agricultural productivity of rice through the whole value chain.
- Improvement in the household consumption levels is needed as it was disrupted by the pandemic.
- Data on supply and demand for the agricultural products should be available on e-soko platform of MINAGRI as it is done for the prices of the products.
- Suspended training and farmers field school meetings due to the COVID-19 pandemic should be rolled back to ensure that farmers are facilitated enough to cope with shocks.
- Agricultural mechanization should be enhanced to minimize the number of farmers in farms as it may reduce spreading the coronavirus.

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**Table 1: Whether COVID-19 affected the supply, demand sides for agricultural commodities and use of agricultural inputs**

| | Frequency | Percent | Cumulative |
|---|---|---|---|

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| | | | |
|---|---|---|---|
| Demand side | | | |
| No | 50 | 13.3 | 13.3 |
| Yes | 326 | 86.7 | 100 |
| Supply side | | | |
| No | 132 | 35.1 | 35.1 |
| Yes | 244 | 64.9 | 100 |
| Whether farmers encountered changes in the use of agricultural inputs due to the COVID-19 | | | |
| No | 286 | 76 | 76 |
| Yes | 90 | 24 | 100 |

**Table 2: Ranking of the challenges encountered by farmers during COVID-19 period**

| Challenges | Mean Rank |
|---|---|
| Changes in household consumption patterns | 1.00 |
| Changes in market functionalities | 2.33 |
| Discontinuity of the planned trainings and field visits | 2.67 |
| Low number of farmers in the farms | 4.00 |

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**Table 3: Parameters' estimates**

| | Characteristic | Estimate | Std. Error | Wald | df | Sig. |
|---|---|---|---|---|---|---|
| Threshold | [Perception = 0] | -18.322 | 1542.154 | 0 | 1 | 0.991 |
| Loction | HHS | -0.44 | 0.441 | 0.995 | 1 | 0.318 |
| | Age | -0.002 | 0.032 | 0.003 | 1 | 0.955 |
| | F.E | 0.077 | 0.036 | 4.547 | 1 | 0.033 |
| | F.S | 2.10E-05 | 1.74E-05 | 1.456 | 1 | 0.228 |
| | [ED=1] | -20.495 | 1542.153 | 0 | 1 | 0.989 |
| | [ED=2] | 0[a] | . | . | 0 | . |
| | [Training=0] | -0.354 | 0.816 | 0.189 | 1 | 0.664 |
| | [Training=1] | 0[a] | . | . | 0 | . |
| | [Transport=0] | 0.195 | 0.789 | 0.061 | 1 | 0.805 |
| | [Transport=1] | 0[a] | . | . | 0 | . |
| | [M.Status=1] | 19.888 | 1886.323 | 0 | 1 | 0.992 |
| | [M.Status=2] | -0.184 | 2346.416 | 0 | 1 | 1 |
| | [M.Status=3] | 0[a] | . | . | 0 | . |
| | [Gender=0] | 0.385 | 0.69 | 0.312 | 1 | 0.576 |
| | [Gender=1] | 0[a] | . | . | 0 | . |
| | [A.Is=0] | -0.284 | 2043.992 | 0 | 1 | 1 |
| | [A.Is=1] | 0[a] | . | . | 0 | . |
| | [Labor=0] | 2.667 | 0.935 | 8.127 | 1 | 0.004 |
| | [Labor=1] | 0[a] | . | . | 0 | . |
| | [A.Ex=0] | 14.65 | 0 | . | 1 | . |
| | [A.Ex=1] | 0[a] | . | . | 0 | . |
| | [M.Price=0] | -31.773 | 2589.421 | 0 | 1 | 0.99 |
| | [M.Price=1] | -17.955 | 1024.923 | 0 | 1 | 0.986 |
| | [M.Price=2] | 0[a] | . | . | 0 | . |
| | [S.D.Ef=0] | -0.158 | 2466.863 | 0 | 1 | 1 |
| | [S.D.Ef=1] | 0[a] | . | . | 0 | . |
| | [Psy.Ef=0] | -6.693 | 1.214 | 30.392 | 1 | 0 |
| | [Psy.Ef=1] | 0[a] | . | . | 0 | . |


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## REFERENCES


1. **WHO.** COVID-19 in Rwanda: A country's response, 2020. https://www.afro.who.int/news/covid-19-rwanda-countrys-response *Accessed on 21/08/2020.*

2. **John B and C Wenjie** IMF Blog, 2020. https://blogs.imf.org/2020/05/18/making-economies-more-resilient-to-downturns/ *Accessed on 18/05/2020.*

3. **CEPR.** Mitigating the COVID Economic Crisis: Act Fast and Do Whatever it takes, 2020. Baldwin, R. and di Mauro, BW. (Editors). 2020, CEPR Press Center for Economic Policy Research 33 Great Sutton Street London, EC1V 0DX UK.

4. **Cranfield JA** Framing consumer food demand responses in a viral pandemic, 2020.

5. **OECD-FAO.** Agricultural outlook 2020–2029.

6. **MINICOM.** Trade and industry: government moves to protect businesses from COVID-19 impact, 2020.

7. **Julius B** Experts weigh in on mitigation COVID-19 impact on the economy. African economies in free fall as the coronavirus pandemic worsens (2020).

8. **UNDP.** The socio-economic impact of COVID-19 in Rwanda. June, 2020: https://www.google.com/

9. **Google scholar.** Rwanda slashes growth forecast to 5.1 percent over COVID, 2020. http://www.xinhuanet.com/english/2020-04/04/c_138946284.htm *Accessed on 11/11/2020.*

10. **Dan P, Yang J, Guzhen Z and K Fanbin** The influence of COVID-19 on agricultural economy and emergency mitigation measures in China: A text mining analysis, 2020. https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0241167 *Accessed on 11/11/2020.*

11. **EABC.** Impact of COVID-19 on East African Community Trade, 2020. https://www.tralac.org/documents/resources/covid-19/regional/3462-impact-of-covid-19-on-eac-trade-eabc-brief-24-april-2020/file.html *Accessed on 13/06/2020.*

12. **UN Nations.** Policy brief: Impact of COVID-19 in Africa, 2020. https://unsdg.un.org/sites/default/files/2020-05/Policy-brief-Impact-of-COVID-19-in-Africa.pdf *Accessed on 12/06/2020.*

13. **Luke P, Eifiona TL and J Rebecca** Collaboration for innovative routes to market: COVID-19 and the food system, 2021. *Agricultural systems,* 2021; **188:** 103038. https://www.sciencedirect.com/science/article/pii/S0308521X20308994 *Accessed on 20/08/2021.*

14. **Viliamu L, Morgan W, Gordon MH, David U, Diana HS, John W, Tammy T, Milton K, Chris T, Otto N, Jioje F, Robson T, Deeksha K, Hirdesh S, Nigel U, Cornelia G, Emily H, Filipe V, Linda V, Zina B, Michael H, Nasoni R, Soane P, Annika RD, Sashi K, Pitakia T, Jowalesi T, Siosiua H, Judith F and CW Alastair** Impacts of COVID-19 on agriculture and food systems in Pacific Island countries (PICs): Evidence from communities in Fiji and Solomon Islands, 2021. *Agricultural systems*, 2021;**190:** 103099. https://www.sciencedirect.com/science/article/pii/S0308521X21000524 *Accessed on 10/09/2021.*

15. **Amy M, Narjes S, Caroline CK, Anuj M, Sue B, Jaime C, Mike M, and G Jason** Resilient regional food supply and rethinking the way forward: Key takeaways from the COVID-19 pandemic, 2021. Agricultural systems, 2021; 190: 103101. https://www.sciencedirect.com/science/article/pii/S0308521X21000548 *Accessed on 15/09/2021.*

16. **Blazy JM, Causeret F and S Guyader** Immediate impacts of COVID-19 crisis on agricultural and food systems in the Caribbean, 2021. *Agricultural systems*, 2021; **190:** 103106. https://www.sciencedirect.com/science/article/pii/S0308521X21000597 *Accessed on July, 2021.*

17. **Siche R** What is the impact of COVID-19 disease on agriculture? Scientia agropecuaria, 2020; **11 (1):** 3-6. http://www.scielo.org.pe/scielo.php?script=sci_arttext&pid=S2077-99172020000100003 *Accessed on 11/10/2020.*

18. **TechnoServe**. Five ways COVID-19 is affecting smallholder farmers around the World, Africa Asia, Latin America and the Caribbean, (2020). https://www.technoserve.org/blog/5-ways-covid-19-is-affecting-smallholder-farmers/ *Accessed on 10/11/2020.*

19. **Lina S, Maja S, Ana Claudia P and P Nicolás** Challenges for family farming in the context of covid-19: Evidence from Farmers in Latin America and the Caribbean (LAC), 2020. https://publications.iadb.org/publications/english/document/Challenges-for-Family-Farming-in-The-Context-of-COVID-19-Evidence-from-Farmers-in-Latin-America-and-the-Caribbean-LAC.pdf *Accessed on 28/10/2020.*

20. **Lina S, Maja S, Ana CP and P Nicolas** Challenges for family farming in the context of COVID-19, 2020. https://publications.iadb.org/publications/english/document/Challenges-for-Family-Farming-in-The-Context-of-COVID-19-Evidence-from-Farmers-in-Latin-America-and-the-Caribbean-LAC.pdf *Accessed on 29/03/2021.*

21. **Deepak V, Devesh R and JV Meenakshi** Impact of COVID-19 on agricultural markets: assessing the roles of commodity characteristics, disease caseload and market reforms, and 2020. *India Economic Review,* 2020; **55(1):** 83-103.

22. **Mingzhe P and Y Zhong** Rising concerns over agricultural production as COVID-19 spreads: Lessons from China. Global food security, 2020; **26:** 2-8.

23. **Serpil A and SA Mehmet** Impact of COVID-19 on the supply chain. *Food Quality and Safety*, 2020; **4:** 167-180.

24. **Gu HY and CW Wang** Impacts of the COVID-19 pandemic on vegetable production and countermeasures from an agricultural insurance perspective. *Journal of Integrative Agriculture*, 2020; **19(12):** 2866-2876.

25. **Steve M, Trey M and S Aleks** Conceptual model for the impact of COVID-19 on Michigan agricultural production centers, 2020. https://www.canr.msu.edu/news/economic-impact-of-covid-19-on-michigan-agricultural-production-sectors *Accessed on 10/12/2020.*

26. **Glenn BG and CA Rico** Assessing the impact of the COVID-19 pandemic on agricultural production in Southeast Asia: Toward transformative change in agricultural food systems. *Asian Journal of Agriculture and Development,* 2020; **17 (1):** 1-13.

27. **MED-Amin.** Impact of the COVID-19 pandemic on agricultural markets and the grains sector in the Mediterranean, 2020. https://www.ciheam.org/wp-content/uploads/2020/07/Report_MED-Amin_COVID_-EN-2.pdf *Accessed on 15/09/2020.*

28. **Padam BP, Mukti RP, Aasish G, Samiksha P, Chiran KT, Nisha B and B Shila** COVID-19 and its global impact on food and agriculture. *Journal of Biology and Today's World*, 2020; **9(5):** 1-4.

29. **Siche R** What is the impact of COVID-19 disease on agriculture? *SciAgropecu*, 2020; **11:** 3-6.

30. **PIFON**. Impact Survey of COVID-19 and agriculture, 2020. https://pacificfarmers.com/wp-content/uploads/2020/05/PACIFIC-FARMERS-HAVE-THEIR-SAY-SURVEY-REPORT.pdf *Accessed on 10/07/2020.*

31. **Blazy JM, Causeret F and S Guyader** Immediate impacts of COVID-19 crisis on agricultural and food system in the Caribbean. *Agricultural systems*, 2021; **190:** 103-106.

32. **NIAP**. COVID-19 Lockdown and Indian agriculture: Options to reduce the impact, New Delhi-19, 2020, Published by Dr Suresh Pal, Director, NIAP.

33. **Yamane T** Statistics, An introductory Analysis, 1967. 2nd edition, and New York: Harper and Row.