ajfand SCHOLARLY, PEER REVIEWED
AFRICAN JOURNAL OF FOOD, AGRICULTURE, NUTRITION AND DEVELOPMENT
Volume 23 No. 6 June 2023
PUBLISHED BY AFRICAN SCHOLARLY SCIENCE COMMUNICATIONS TRUST
ISSN 1684 5374

Afr. J. Food Agric. Nutr. Dev. 2023; 23(6): 23737-23762 https://doi.org/10.18697/ajfand.121.23160

ASSESSMENT OF MAIZE PRODUCTION SYSTEM DURING THE COVID-19 PANDEMIC IN RWANDA: CASE STUDY OF KIGALI CITY REGION

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ABSTRACT

The SARS-CoV-2 virus caused a major transformation in the food system globally including in Rwanda. This research identified and assessed the status and structure of the maize production system in the Kigali city region before and during the COVID-19 pandemic. The methods adopted for this study include both quantitative and qualitative methods using primary data obtained from the participants' interview and focus group discussions, the secondary data were obtained from national institute of statistics of Rwanda (NISR). While production, processing, distribution and consumption are the four parts of the maize production system, the study only focused on the production system. The sample size for the study was 256 respondents who were maize production system actors from the Kigali city region. The study showed that before the COVID-19 pandemic, the prize of dried maize was significantly influenced by the cost of diammonium phosphate (DAP) (p=0.000), the source of the irrigating scheme (p=0.008), being a cooperative member (p=0.000) and marital status (p=0.002). During the pandemic, DAP (p=0.109) was absent at market due to lockdowns, and farmers did not access it. Maize farmers-built responses of resilience, persistence, adaptation, transformation, and persistence to encounter the consequences of the lockdowns. Innovative responses to shortage of maize- input stocks, and poor imports were presented, which represented 26.66% of resilient responses adopted by farmers. The innovative responses to labor shortage with farm workers` migration to their home provinces before and during the implementation of containment measures were 20%. Resilience built against the absence of extension services due to restricted movements was 13.33%. Reactions to restricted movement to and from fields, and adaptation to COVID-19 pandemic containing measures were 26.66 %, while reaction to the shortage of dried -maize at the market, which shortened the maize production cycle was 13.33%. Apart from maize production, more than half of the maize selling system were women 51.61%. Women in raw maize processing were 67.67% with a 100% level of university.

Key words: COVID-19, food systems, city region, resilience, aflatoxin, maize production system, Kigali

INTRODUCTION

The objective of this study was to assess the influence of the COVID-19 pandemic on maize production, sales, and consumer access, and the resilience of maize farmers and other supply chain actors to provide maize food for the Kigali city dwellers amidst tight COVID-19 policies.

The global impact of the COVID-19 pandemic is not limited to the direct threat that the virus imposed on life and human health, but extended to food security that disrupted local and national food systems and economies [1]. The first COVID-19 case in Rwanda was confirmed on 14th March 2020 [2]. The Government of Rwanda introduced measures to contain the spread of the virus in the country, which led to national lockdown policy measures introduced on March 21, 2020, and extended through May 4, 2020. The national lockdown policy paralyzed all sectors of life countrywide, resulting in food losses along the food supply chain [3]. There was restricted access to the border crossing, market closure, and other commercial activities, which limited farmers` accessibility to agricultural inputs. Middlemen could not work, and so were traders of agricultural inputs and produce who could not exercise their franchises. Financial institutions were also closed, and only online transactions were allowed [4]. Movements and in-person gathering restrictions inhibited consumers from accessing fresh and milled maize food. Maize food availability in the Kigali city region was impacted by the pandemic [5] and agricultural activities were limited to certain privileged conditions while enforcing measures to contain the pandemic. Regarding the maize production system in the Kigali city setting, food flow in the Kigali city region is usually from the Rulindo, Kamonyi, Bugesera, and Rwamagana districts, with the Kigali markets (Nyabugogo and Kimironko counting 80% of food sales) [6]. The Kigali city region has a population of 1,134,829 [7] that live on food purchases from markets. During the pandemic, the food system in the Kigali city region was disrupted, and challenges were observed along the way from fields to markets that affected the availability, and affordability of food for citizens influenced by a labor shortage. The fear of infection worsened the effect on food consumption through reduced visits to food markets [8].

MATERIALS AND METHODS

Description of the study area

This research was conducted in the Kigali city region (Kicukiro, Gasabo, and Nyarungege) of Rwanda (Fig. 1).

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Volume 23 No. 6
June 2023
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ISSN 1684 5374

The city of Kigali lies in a region of rolling hills with a series of valleys and ridges joined by steep slopes. The elevation of the lower part of the city is roughly 1400m above sea level and the highest point is Mount Kigali, which is 1850m high [8]. Geologically, Kigali is in a granitic and metasedimentary region, with lateritic soils on the hills and alluvial soils in the valleys, which is good for maize production. Kigali accounts for almost 60% of the urban population and experiences a very rapid population and economic growth.

Figure 1: Map of the Kigali city region indicating the three research districts

Sampling technique

A sample of 256 respondents was calculated according to Kothari [10], and participants were randomly selected across the three districts. Respondents included 162 maize farmers, 31 raw maize sellers, 12 maize processors, 31 maize flour milled sellers and 20 maize food consumers.

Data collection and analysis

Questionnaires were drafted and presented, and assessed for ethical aspects.
A team of five (5) enumerators was recruited, and trained on ethical considerations and approaches for data collection, enumerators used a pretested questionnaire to collect data in the field.

The collected data included specific socio-economic and demographic variables of the maize production system actors. Independent variables included cooperative membership, cost of manure, the price of maize seed, price of insecticide, price of maize packaging materials, and cost of urea. Data on irrigation schemes, price of DAP, land size, and land ownership were also captured. Dependent variable was the price of dried maize. Data on the adoption of innovative responses regarding the impact of the Covid-19 pandemic were captured.

Data were subjected to regression analysis using Excel, Stata SE 13 software package. Descriptive statistics, t-test, OLS regression analysis, editing of results, descriptive analysis of chi-square and proportion test were used to interpret the relationship between the dependent variable Ys (Price/Kg of dried maize before/during the pandemic at the farm gate) and the independent variable Xs. Cross-tabulation of data, and statistical tables showing frequencies and percentages of respondents were done. Analysis of variance (ANOVA) table was used to assess the level of resilience adoption by maize production system actors.

RESULTS AND DISCUSSION

Socio-economic characteristics of maize production system actors

The maize farmers surveyed were 48.15% females, with 33.95% married, and 14.2% widowed. The male population of the farmers surveyed was 51.85 %. Findings were coherent with those of Bojang and Ndeso-Atanga [13], who showed that women and girls were more affected by the pandemic than men as only 48.15% of the sample (females) compared to men with 51.85 %, were able to exercise their outdoor activities. The COVID-19 pandemic forced females to stay indoors, while in normal conditions women dominate agriculture and play a key role in agricultural production in Africa [14]. This observation calls for the bridging of maize farming gender gaps, and more enhancements and empowering strategies for female maize farmers. This approach would equip female maize farmers who are more vulnerable than men to be resilient to shocks that may occur to farmers, as observed with the COVID-19 pandemic.

The average age of maize farmers was 42.5 years. Almost half the population of respondents (44.44%) had an average age of 27.5 years. This shows that younger and old farmers equally participated in maize production. The COVID-19 pandemic situation contradicted the argument by Hatungimana and Srinivasan [15], that there is low participation of African youth in primary maize production.

The distribution of education level of maize farmers was as follows, among maize farmers 45.68% had more than six years of basic education and 54.32% had less than six years of education. These statistics support national institute of statistics

https://doi.org/10.18697/ajfand.121.23160

of Rwanda [16] reported in 2016 that 66.6% of agricultural operators had a primary level of education, and only 6.5% attended secondary.

Among raw maize sellers, 51.61% were female and 48.39% male and the women demonstrated the capacity and willingness to engage in income generating activities. Among maize sellers, 58.07% had an average age of 27.5 years, 19.36% had an average age of 42.5 years, and 22.59% were above 50 years of age. Within raw maize sellers, during the pandemic 77.42% the youth with more than six years of basic education. Among the raw maize processors, 67.67% were women with 75.00% of that population having an average age of 42.5 years, married and all of them (100%) with university education. Among maize flour sellers, 61.29% were men, and 38.71% were women. Among maize flour sellers, 45.16% had age average of 42.5 years, while 64.52% of those maize flour sellers had more than six years of basic education. For maize consumers, 60% of them were single, and 40% were married. Among those maize consumers, 75.00% of them had an average age of 42.5 years, and 80.00% of maize consumers had over six years of basic education.

Assessment of the maize production system in the Kigali city region before the pandemic

Costs of maize production inputs were pillars of the assessment of maize price at the farm gate. The influence cost of 1 kg of UREA (p=0.147 >0.1), price of packaging materials (p=0.105>0.01), and land size in ha (p=0.135>0.01) to the price of dried maize at the farm gate were not statistically significant.

Inorganic fertilizer (UREA) was subsidized by the government of Rwanda (GoR) through the crop intensification program (CIP); therefore, maize farmers did not invest heavily in fertilizers.

The DAP (p=0.00) fertilizer, was the most inorganic fertilizer applied by maize farmers compared to other inorganic fertilizers during the 2017-2018 cropping season [17]. The demand for DAP statistically influenced the price of dried maize at the farm gate. The analysis of data showed that the cost of 1kg of maize seeds before the pandemic (p=0.048) was statistically significant at 5%. The CIP had undertaken a multi-pronged approach that includes the facilitation of inputs such as improved seeds and fertilizers [18]. Maize seeds have been subsidized for smallholder and cooperative farmers. However, its high demand by farmers makes farmers incur additional costs on maize seed input to be able to access seeds for a desirable profit. Before the COVID-19 pandemic lockdowns in the Kigali city region, the average price of manure was 50Frw kg^{-1} (Table 4), and the cost of 1 kg of

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manure (p=0.016) was significant at 5% to influence the price of dried maize at the farm gate.

Irrigation schemes in Rwanda are categorized into large and small-scale schemes [19]. Irrigation schemes gained attention in maize cultivation in Rwanda due to limited rainfall, and changes in agricultural seasons experienced by the Kigali city region before the pandemic. The source of the irrigation scheme (p=0.008) significantly contributed to the price of maize at the farm gate, cooperative membership (p=0.000), education (p=0.028), and marital status (p=0.002) also significantly impacted irrigation use in Rwanda.

Farmers who mechanically irrigated maize fields were 60.49%, while 39.51% of maize farmers used traditional manual irrigation methods (by fetching water from streams and rivers with basins). Maize farmers who used mechanical irrigation schemes were charged fees [20]. This made the irrigation parameter to be one of the factors that statistically influenced the price of dried maize before the pandemic.

Assessment of the maize food production in the Kigali City region during the COVID-19 pandemic lockdowns

Analysis of the maize production system during the COVID-19 pandemic in the Kigali city region was based on the price of dried maize, the price implies the availability, affordability, and accessibility of dried maize as presented in Table 4. It shows that R^2 =0.97, which implies 97% of the variance in the dependent variable is explained by the independent variable in the regression model. The study showed that only the cost of 1 kg of DAP (p=0.109) did not significantly explain the change in the price of dried maize at the farm gate. This is explained by the scarcity of DAP where farmers were not able to afford it and produced without applying DAP. Jules Ngango and Seungjee Hong [17] show that during the 2017/2018 cropping season (season A), diammonium phosphate was highly used (DAP; 35%) compared to NPK 17-17-17 (27%) and urea (33%). The high usage of DAP made it run out of storage. When the COVID-19 pandemic lockdowns were imposed, even the limited quantity of DAP in stocks was quickly used and cross border movement restrictions induced logistical challenges and disruptions on critical transport routes [21]. In separate studies, evidence indicates that import volumes in Rwanda decreased by 32% between March and April 2020 [22]. This further explains why DAP was not utilized by maize farmers in the Kigali city region during lockdowns. Manure (p=0.007) usage during the COVID-19 lockdown increased instead of chemical fertilizers to provide minerals needed by plants that could have been from the application of DAP [23]. The result of this increase in

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manure application induced the price increase of manure, and therefore the increase in the price of dried maize at the farm gate.

Small-scale irrigation mechanisms (p=0.000) were significant at 1% to influence the price of the dried maize at the farm gate. Maize farmers used two different mechanisms of irrigation. Some used irrigating machines powered by fuel (gasoline) (39.51%), while others used basins and other materials (60.49%) manually worked by farmers. The statistics show how imperative it is to invest in maize-growing irrigation facilities as a strategy to boost maize production for profit. Cooperatives affiliation significantly (p=0.000, at 1%) helped farmers to efficiently use available resources to profit from their maize farming. This finding was supported by Giulia and Adrienne [24] that there is a positive correlation between the contributions of agriculture cooperatives to the socio-economic development of cooperative members, including education level with significance (p=0.000) at 1%. Respondents with less than six years of basic education (years of education<6) were 45.68% and respondents with more than six years of basic education (years of education>6) were 54.32%.

Marital status (p=0.000) contributed to the change in the price of dried maize at the farm gate and it was statistically significant at 1%. In households where the farming couple of the family (in Rwanda) worked together, there was the likelihood of a higher production than the production obtained by single-headed households, male or female. The result of this study showed that 82.1% of respondents were married, compared with 17.9% who were one head maize farmers. Alliance for green revolution in Africa (AGRA) [25] found that in maize production systems, a bigger percentage of farmers are married and men dominate the sector. Maize packaging materials (p=0.000) were available through great importers who imported packaged items and after selling their products sold empty sacks to farmers who used them to bag and sell their dried maize. Therefore, a shortage in imports resulted in a shortage of those sacs [26]. The cost of 1 kg of maize seed during covid-19 was significantly high (p=0.004) due to cross-border trade and import restrictions. Maize seed reserves intervened to provide farmers with seeds. However, maize seeds were scarce for a lack of seed import, and farmers responded to this shortage by sharing available seeds. A study demonstrated that during the lockdown, maize farmers were able to use innovative mechanisms to access the maize yields [27].

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Maize production resilience built by maize farmers in Kigali city region during COVID-19 lockdowns

Maize smallholder farmers were found to be more vulnerable to the disruptions and impacts of the pandemic because their agricultural production activities were labor intensive, with poor production technologies and a shortage in input availability [28]. Different aspects of challenges have been identified to impact surveyed maize smallholder farmers and maize cooperative farmers, including access to key maize agricultural inputs, especially inorganic fertilizers [29], seeds and insecticide, and labor force as the lockdown measures impacted activities of the cropping seasons.

Rwanda usually has significant migration of farm labor between provinces [30]. During the COVID-19 pandemic, many farmworkers migrated to their home provinces before the containment measures were implemented. Therefore, there were temporary labor shortages that contributed to increased farm labor costs from 42% to 67% [27].

Closed markets and prohibited public gatherings [31] were the other challenges identified during the survey, which impacted market output. Respondents expressed concerns about the absence of extension services, and regular visits to their maize plots by agricultural extension officers from the sector and district levels. To this, maize farmers in the Kigali city region built certain responsive activities against the consequences of COVID-19 lockdowns, for maize production. Responsive actions included sharing maize seeds, sharing manure and household available inorganic fertilizers and insecticides, which strengthened farmer-to-farmer and farmer-cooperative relations. Certain responses by farmers showed a strong level of resilience such as persistence, adaptation and transformation [32]. Strategies of persistence included the expansion of arable land, and maize farmers were champions in domesticating their innovations, which contributed to the resilience of the maize food system. Maize farmers in Kigali city region increased their use of manure as an alternative to the application of Diammonium Phosphate (DAP) in maize production due to its shortage with increased demand and high prices. In comparison with other mineral fertilizers for maize farming, DAP use increased from 42.1% to 44.6% during the 2020-2021 growing seasons compared to UREA that increased from 33.1% to 39.5%, and NPK that increased from 12.1% to 18.5 % countrywide [33].

Maize farmers in the Kigali city region jointly decided to increase solidarity in the purchase of maize farming inputs through the adoption and domestication of the national digitization program that the Government of Rwanda instituted in response to movement restrictions, to facilitate transactions [34]. The program included zero

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Volume 23 No. 6
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ISSN 1684 5374

charges on all transfers between bank accounts and mobile wallets, zero charges on all mobile money transfers, and zero merchant fees on payments for all contactless point-of-sale (via mobile) transactions, farmers also shared technical skills and know-how, farmer-to-farmer extension, and adopted online extension made available by the Ministry of Agriculture. On the side of harvesting, farmers entered in the Rwandan historical home-grown solution commonly known as "Ubudehe" (Ubudehe refers to the long-standing Rwandan cultural practice of collective action and mutual support to solve problems within the community. The focus of traditional Ubudehe was mostly on cultivation).

Outdoor activities in agriculture during lockdowns were privileged but with limited timing. As maize harvesting is a high time-labor demand, maize farmers chose to work collectively in one farmer`s field after the other, to speed harvesting in a shorter period, thereby saving time without leaving produce in the fields.

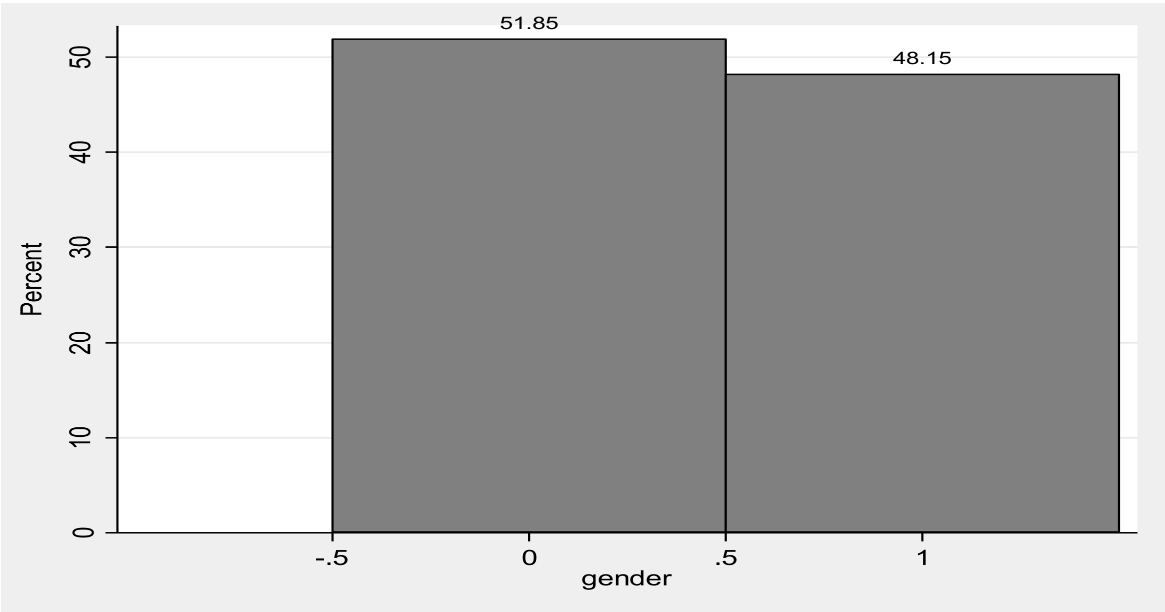
Smallholder farmers increased their willingness to work together, enhanced cooperation among themselves, and that helped maize farmers to share ideas and know-how to work collectively without Agricultural Extension Officers from the District and Sector agriculture offices. The other identified form of responsive action adopted by maize farmers in the City region of Kigali was the quick adaptation to the COVID-19 pandemic containment measures [35], including changing physical movements' modalities, and personal hygienic practices, which allowed farmers to move to and from maize fields and markets, which other non-essential economic activities agents were not allowed [35]. The results of this study revealed that some farmers anticipated the buying of inputs (maize seeds, chemicals such as insecticide, fertilizers) when news of the first COVID-19 case was announced in Rwanda to offset any abrupt increases in farm input prices. Changing the number of ploughing before sowing was identified by smallholder farmers as an innovation to shorten the maize value chain for consumers.

Practices and methods developed during the pandemic demonstrated the ability of farmers to adopt online services such as agricultural extension services, adoption of online buying and selling with outside catering and product delivering mechanisms, and online banking using phones to make withdrawals and payments, while domesticating online marketing and advertisement.

Other innovations included common transportation (vehicle pooling) for products by buyers and sellers, which reduced over-crowding in public places with limited contacts and also reduced the emission of gases (mostly carbon dioxides, but some nitrous oxide, and methane) from exhausts of vehicles as greenhouse gases.

Aflatoxin management

Aflatoxin is produced by Aspergillus flavus, a saprophytic and pathogenic fungus, which contaminates, poisons, and reduces food values. Temperature, humidity, environmental stress, injury caused by insects or birds on the host, and post-harvest practices, are some of the factors that cause the growth of aflatoxin [34]. The management of aflatoxin requires technological materials to measure humidity, temperature and kernel moisture. Abhishek Kumar and Hardik Pathak [35] demonstrated that the optimum temperature is 28^{o}C-37^{o}C, relative humidity is 85% and kernel moisture is 18% for Aspergillus flavus development. This study found that maize farmers in the Kigali city region did not have devices during the survey to measure temperature, and relative humidity at their dryers. During the pandemic 100% of maize farmers harvested their maize between 30 and 60 days after ripening and maturation of maize grains with moisture loss between 15% and 36%. The study revealed that all maize dryers in the Kigali city region belonged to cooperatives, a crucial element in monitoring the period for maize drying as no farmer should deviate from that common practice with other farmers. Though maize farmers did not have devices to control temperature, and relative humidity, through sufficient dry-down period of maize and common maize dryer, aflatoxin management has been assured.



Graph 1: Gender of respondents (1=female &0=male)

Author: primary data, 2022

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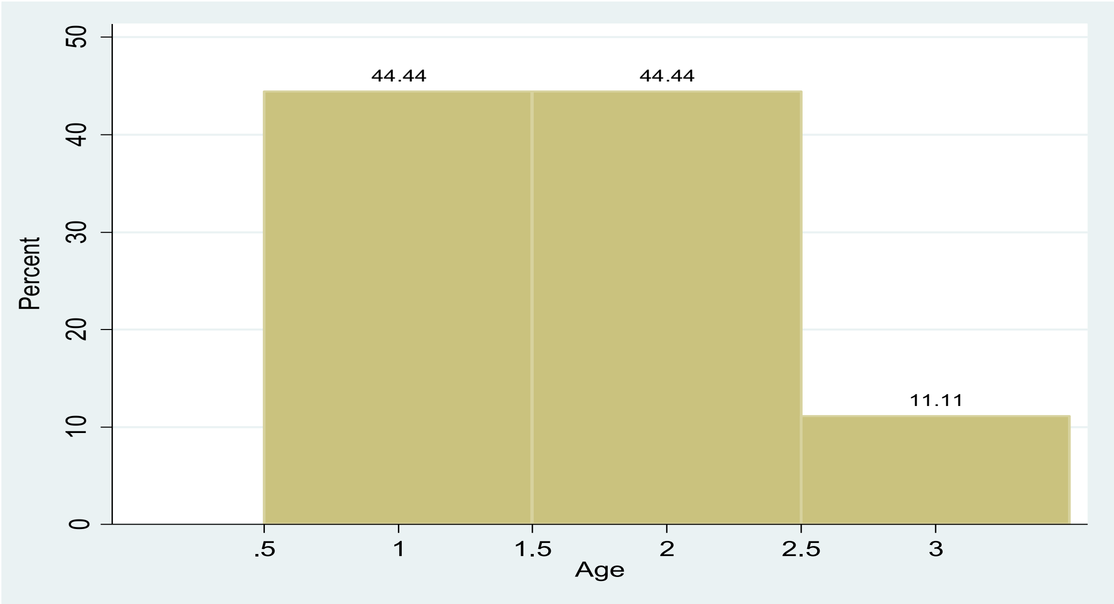
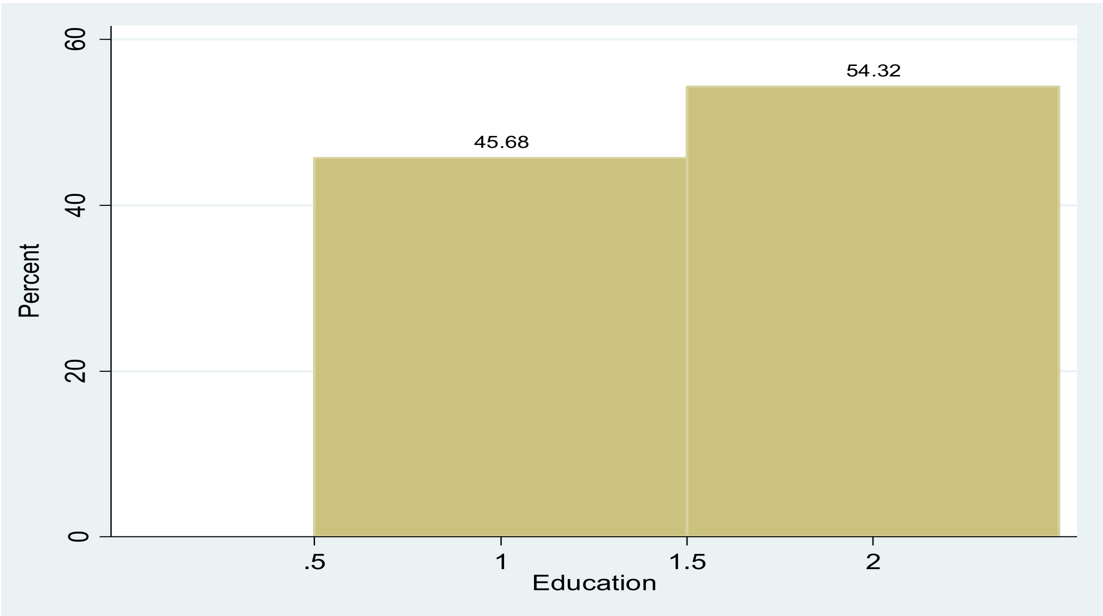
ISSN 1684 5374



Graph 2: Age of respondents (1= average of 42.5 years, 2= average of 27.5 years 3= age average< 50 years old)
Author: primary data, 2022



Graph 3: Education of respondents (1=6 years≥ & 2=6 years≤)
Author: primary data, 2022

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AFRICAN JOURNAL OF FOOD, AGRICULTURE, NUTRITION AND DEVELOPMENT
Volume 23 No. 6
June 2023
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ISSN 1684 5374

CONCLUSION, AND RECOMMENDATIONS FOR DEVELOPMENT

In Rwanda when the first COVID-19 case was confirmed on 14 March 2020, the Government introduced measures to contain the spread of the virus in the country, which led to the national lockdown policy measures introduced on the 21st of March and extended through 4th May 2020. The lockdown policy, which included directives related to personal hygiene, and social distancing practices to health care system preparedness, which effectively limited food systems of maize in the city regions, was extended to provinces, districts, sectors and some cells to restrict population movement.

This research identified the ways COVID-19 pandemic affected the maize production system in the Kigali city region. The research analyzed any aspect of resilience including persistence, adaptation, and transformation in the city region of Kigali, and suggested scientific interventions against any future shocks in the maize food system. Maize was chosen for this study as the test crop due to its importance in Rwanda. The COVID-19 pandemic situation changed the normal understanding of the engagement of the youth in agriculture in Rwanda. Based on the investigated maize farmers in the Kigali city region, women and girls were more affected by the pandemic than men, and the young generation actively contributed to maize farming during the pandemic. Women must be empowered to firmly stand for future shocks. Maize seeds were subsidized for maize smallholder and cooperative farmers, yet due to its high demand, farmers incurred additional costs to be able to afford and have access to those seeds. This additional cost of maize seeds was factored into the production cost, which impacted the increase of the farm gate price of dried maize. The increased manure utilization rate induced the capacity of maize farmers' resilience. Training stallholder farmers on composting and encourage them to raise the use of manure must be one of priorities of agriculture sector.

In the maize production system of the Kigali city region, during the COVID-19 pandemic, maize farmers jointly decided to increase solidarity among themselves in the purchase of maize farm inputs through the adoption and domestication of the national digitization program instituted by the government of Rwanda. Farmers also shared technical skills and knowledge of extension services by adopting online extension made available by the ministry of agriculture. To make more maize farming resilient for future shocks, maize farmers are called to raise the domestication of modern digital technology and increase adhesion into cooperatives.

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Volume 23 No. 6
June 2023
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ISSN 1684 5374

CONFLICT OF INTEREST

The authors declare no conflict of interest.

ACKNOWLEDGEMENTS

The authors wish to acknowledge the University of Rwanda for facilitating the execution of this study. We also acknowledge all stakeholders in the maize value chain in the Kigali city region who participated in the study.

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Volume 23 No. 6
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ISSN 1684 5374

Table 1: Socio-economic characteristics of maize farmers surveyed

Variable		Frequency (Percentage)			
		Married	**Widow**	**Combined**	**n=162**
Sex	(1=female)	55(33.95)	23(14.2)	78(48.15)	
	(0=male)	78(48.15)	6(3.7)	84(51.85)	
Age	(1=[20-35])	72(44.44)	0(0.00)	72(44.44)	
	(2=[35-50])	51(31.48)	21(12.96)	72(44.44)	
	(3=[50<])	10(6.17)	8(4.94)	18(11.11)	
Education	(1=6 years≥)	53(32.72)	21(12.96)	74(45.68)	
	(2=6 years≤)	80(49.38)	8(4.94)	88(54.32)	

Source: primary data, 2022

https://doi.org/10.18697/ajfand.121.23160

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ISSN 1684 5374

Table 2: Socio-economic characteristics of other maize production actors surveyed

Variable		Frequency (Percentage) of raw maize sellers			
		Married	**Widow**	**Combined**	**n=31**
Sex	(1=female)	12(38.71)	4(12.90)	16(51.61)	
	(0=male)	12(38.71)	3(9.68)	15(48.39)	
Age	(1=[20-35])	12(38.71)	6(19.36)	16(58.07)	
	(2=[35-50])	6(19.36)	0(0.00)	6(19.36)	
	(3=[50<])	6(19.36)	1(3.23)	7(22.59)	
Education	(1=6 years≥)	5(16.13)	2(6.45)	7(22.58)	
	(2=6 years≤)	18(58.06)	6(19.35)	24(77.42)	
		Frequency (Percentage) of raw maize processors			
		Married	**Widow**	**Combined**	**n=12**
Sex	(1=female)	8(67.67)	0(0.00)	8(67.67)	
	(0=male)	4(33.33)	0(0.00)	4(33.33)	
Age	(1=[20-35])	3(25.00)	0(0.00)	3(25.00)	
	(2=[35-50])	9(75.00)	0(0.00)	9(75.00)	
	(3=[50<])	0(0.00)	0(0.00)	0(0.00)	
Education	(1=6 years≥)	0(0.00)	0(0.00)	0(0.00)	
	(2=6 years≤)	12(100.00)	0(0.00)	12(100.00)	
		Frequency (Percentage) of maize flour milled sellers			
		Married	**Widow**	**Combined**	**n=31**
Sex	(1=female)	8(25.81)	4(12.90)	12(38.71)	
	(0=male)	13(41.94)	6(19.35)	19(61.29)	
Age	(1=[20-35])	7(22.58)	4(12.90)	11(35.48)	
	(2=[35-50])	10(32.26)	4(12.90)	14(45.16)	
	(3=[50<])	2(6.45)	4(12.90)	6(19.35)	
Education	(1=6 years≥)	5(16.13)	6(19.35)	11(35.48)	
	(2=6 years≤)	14(45.16)	6(19.35)	20(64.52)	

		Frequency (Percentage) of maize flour milled consumers			
		Married	**Single**	**Combined**	**n=20**
Sex	(1=female)	2(10.00)	4(20.00)	6(30.00)	
	(0=male)	6(30.00)	8(40.00)	14(70.00)	
Age	(1=[20-35])	1(5.00)	11(55.00)	5(25.00)	
	(2=[35-50])	4(20.00)	4(20.00)	15(75.00)	
	(3=[50<])	0(0.00)	0(0.00)	0(0.00)	
Education	(1=6 years≥)	2(10.00)	2(10)	4(20.00)	
	(2=6 years≤)	6(30.00)	10(50.00)	16(80.00)	

Source: primary data, 2022

ajfand SCHOLARLY, PEER REVIEWED
AFRICAN JOURNAL OF FOOD, AGRICULTURE, NUTRITION AND DEVELOPMENT
Volume 23 No. 6
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PUBLISHED BY AFRICAN SCHOLARLY SCIENCE COMMUNICATIONS TRUST
ISSN 1684 5374

Table 3: OLS regression of the assessment of maize production system in Kigali city region before the pandemic

Price of Kg of maize before pandemic	Coef.	Std.Err.	t	P>t	[95% Conf.Interval]	
Cost of 1 kg of manure before pandemic	-0.003	0.001	2.440	0.016	-0.006	-0.001
Cost of 1 kg of UREA before pandemic	-0.076	0.052	1.460	0.147	-0.180	0.027
Cost of 1 kg of DAP before pandemic	-0.116	0.026	4.550	0.000	-0.167	-0.066
Cost 1kg of maize seeds before pandemic	-0.097	0.048	2.000	0.048	-0.192	-0.001
Price of maize pack. materials before pandemic	2.736	1.679	1.630	0.105	-0.583	6.054
Water Source	0.089	0.033	2.680	0.008	0.023	0.155
Land size in Ha	-0.056	0.038	1.500	0.135	-0.131	0.018
Household own land	-0.099	0.034	2.920	0.004	-0.165	-0.032
Being a cooperative member	-0.248	0.047	5.290	0.000	-0.340	-0.155
Education	-0.029	0.013	2.220	0.028	-0.056	-0.003
Martial_status	0.116	0.037	3.110	0.002	0.042	0.190
_cons	0.620	0.131	4.720	0.000	0.360	0.880
R-squared	0.982					
F	676.38***					
N	162					

Source: primary data, 2022

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Table 4: Descriptive statistics of parameters of price of maize before the pandemic

Variable	Frequency	Mean	Percentage
Price of dried maize≥300frw	94	315.5	58.02
Price of dried maize<300frw	68		41.98
Price of insecticide≥4500frw	68	4334.5	41.98
Price of insecticide<4500frw	94		58.02
Price of manure≥50	113	49.9≈50	30.25
Price of manure<50	49		69.75
Cost of Urea≥450	96	450.3≈450	59.26
Cost of Urea<450	66		40.74
Cost of seeds≥500	137	516.18≈516	84.57
cost of seeds<500	25		15.43
Cost of DAP≥470	128	470.76≈471	79.01
Cost of DAP<470	34		20.99

Table 5: Type of small-scale schemes irrigation

	Frequency	Percentage
Mechanical	98	60.49
Machine	64	39.51
Total	162	100

Source: primary data, 2022

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ISSN 1684 5374

Table 6: OLS regression of the assessment of maize production system in Kigali city region during the pandemic

Price of 1kg of dried maize during covid	Coef.	Std. Err.	t	P>|t|	[95% Conf. Interval]	
Cost of 1kg of organic manure during covid	-19.312	7.094	-2.72	0.007	-33.328	-5.296
Cost of 1 kg of UREA during covid	4.570	0.436	10.49	0.000	3.709	5.432
Cost of 1 kg of DAP during covid	0.041	0.025	1.61	0.109	-0.009	0.091
Cost of 1 kg of maize seed during covid	-0.317	0.108	-2.93	0.004	-0.531	-0.103
Price of maize packing materials	927.63	157.7	5.88	0.000	615.94	1239.33
Source of irrigating water	73.303	8.152	8.99	0.000	57.196	89.411
Land size in Ha	-22.097	3.833	-5.77	0.000	-29.670	-14.524
Household own land	-76.400	8.089	-9.44	0.000	-92.383	-60.416
Being a cooperative member	-112.31	6.096	-18.4	0.000	-124.36	-100.27
Education	-10.290	2.123	-4.85	0.000	-14.485	-6.095
Martial status	61.234	8.298	7.38	0.000	44.838	77.631
_cons	-1996.5	231.9	-8.61	0.000	-2454.65	-1538.3
R-squared	0.9718					
F	469.72***					
N	162					

Source: primary data, 2022

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Table 7: Maize production resilience responses built by maize farmers in Kigali city region during Covid-19 lockdowns

S/N	Challenge imposed by lockdowns	Reaction to lockdown	Innovative activity adopted	Percentage	Cumulative
1	Shortage of maize inputs	Run out of stocks and poor imports	-Maize inputs sharing -Strengthening farmer-farmer relations -Strengthening farmer-cooperative relationship -Adoption of traditional culture of ubudehe	26.66	26.66
2	Labour shortages	Farm workers migration to their home provinces before and during the containment measures were implemented	-Strengthening farmer-farmer relationship -Adoption of land consolidation -Cultivate land of one farmer as a team and when finished do the same for all farmers	20	46.66
3	Absence of extension services	Restricted movements	-Adopt online extension services on phones, radios and TVs -Sharing Farming Knowledge and skills among farmers	13.33	59.99
4	Movement to and from fields	Quick adaptation to covid-19 pandemic containing measures	-Accepting voluntary vaccination -Mask wearing -frequent hand washing -Social distancing	26.66	86.65
5	shortage of dried maize at market	Shortening to maize production cycle	-Payments for all contactless point-of-sale (via mobile) transactions -Reducing the number of Ploughing before sowing	13.33	99.98
	Total			99.98≈100	100

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Table 8: Summary of the maize production system resilience methods adopted

	Production	Transport	Milling	Product	Retailing manufacturing
Activities	Maize planting: Sharing seeds, increase quantity of manure. Maize harvesting: collective work (Ubudehe) Shortening maize production cycle Strengthening farmer-farmers relationship	Loading & transport: Hiring /use common car for many sellers Storage: usage of Cooperative storage and infrastructures Drying: use of common dryers Collective work (Ubudehe)	Milling, Sorting, Grading and transport: reduced workers and work in shifts Produce as you sell in order to reduce storage cost	Processing, Packaging: reduced workers and work in shifts Marketing: Advertisements using Facebook, instagram, twitter and online markets	Transport Re-packaging Value adding: online markets with outside catering to reach consumers
	Environment common transportation for products by many buyers and sellers that reduced cars`gas emissions Reduction in the use of chemicals				
	Community Quick adaptation to Covid-19 containing measures				

<table>
<tr><td rowspan="2"></td><td>Frequent hand washing and hygiene</td><td></td><td></td><td></td><td></td></tr>
<tr><td>Economics

Increase market linkages

Develop selling points and packaging techniques</td><td></td><td></td><td></td><td></td></tr>
<tr><td rowspan="3">Direct actors</td><td>Agriculture & economic advisors</td><td colspan="4">Maize food transport companies</td></tr>
<tr><td>Input suppliers

Online transactions and product delivery to clients` localities</td><td colspan="2">Owners of storage facilities
Adaptation to national grain reserve and adoption of maize collection centers</td><td rowspan="2">Manufacturers

Product designers

Marketers &Packagers

Adoption of online technologies of marketing and trading</td><td rowspan="2">Post-processors

Customers

Domestication of reduction in food loss at household level</td></tr>
<tr><td colspan="2">Farmers & producers
Innovative responses in increase of manure application, shortening of production cycle</td><td>Millers

Produce-sell system and reduction of storage costs</td></tr>
<tr><td>Indirect actors</td><td colspan="5">Financial institutions, inventors, buyers, Traders, Export agents, Advertisers

Adoption and domestication of online financial services, inventing new online markets, and online marketing and advertisement.</td></tr>
</table>

Author: primary data, 2022

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REFERENCES

1. **Béné C, Bakker D and MJ Chavarro** Impacts of COVID-19 on People ' s Food Security, Foundations for a more Resilient Food System, February 2021.

2. **Rwanda Public Health Bulletin**. Covid-19 Rwanda response updates March 14-April 25, 2020.

3. **Jenkins W, Tucker ME and J Grim** Routledge handbook of religion and ecology. In Routledge Handbook of Religion and Ecology, 2016.

4. **AGRA.** Regional food trade and resilience program, A rapid analysis of impacts of the COVID-19 pandemic on selected food value chains in Africa-A synthesis report, July 2020.

5. **Minagri and NISR.** Annual report 2020-2021. 2021.

6. **Dusengemungu L** Mapping Food Flows in Kigali: Regional Linkages as Catalyst for Sustainable Food Systems in Kigali and Rulindo, 2021.

7. **Rwanda**. Demographic and health survey. 2019.

8. **Bizoza AR and S Sibomana** Indicative Socio-Economic Impacts of the Novel Coronavirus (COVID-19) Outbreak in Eastern Africa: Case of Rwanda. 2020.

9. **Nduwayezu G** Modeling urban growth in Kigali city Rwanda, in Rwanda journal. March 2017.

10. **Kothari CR** Research methodology, methods and techniques. 2004.

11. **United Nations.** Policy Brief: The impact of Covid-19 on women. April 2020.

12. **Brenton P, Gamberoni E and C Sear** Women and Trade in Africa: Realizing the Potential. 2013.

13. **Bojang F and A Ndeso-Atanga** Africa youth in agriculture, natural resources and rural development. 2013.

14. **Ingabire C, Mshenga PM, Amacker M, Langat JK, Bigler C and EA Birach** Agricultural transformation in Rwanda: Can gendered market participation explain the persistence of subsistence farming?. 2018.

15. **Hatungimana J, Srinivasan R and R Vetukuri** Assessment of the effects of liquid and granular fertilizers on maize yield in Rwanda. ***African J Food, Agric, Nutr Dev***. 2021; **21(3):** 17787-17800.

16. **NISR.** Seasonal agricultural survey.2016.

17. **Ngango J and S Hong** Adoption of small-scale irrigation technologies and its impact on land productivity: Evidence from Rwanda. Journal of integrative agriculture. 2021.

18. **Jones M, Kondylis F, Magruder J and J Loeser** Factor Market Failures and the Adoption of Irrigation in Rwanda. 2022.

19. **Djiofack C, Dudu H and A Zeufack** Assessing COVID-19`s economic impact in sub-Saharian Africa: Insights from a CGE Model.2020.

20. **COMESA**. Study on the Economic Impacts of Covid-19 Pandemic in COMESA Released. Dec.2020.

21. **Aragie E, Diao X, Robinson S, Rosenbach G, Spielman DJ and J Thurlow** Assessing the economywide impacts of COVID-19 on Rwanda's economy, agri-food system, and poverty. A social accounting matrix (SAM) multiplier approach. May. 2021.

22. **Guillaume M, Safari E and AN Nyabyenda** Role of Agriculture-based Cooperatives on Socioeconomic development in Rwanda: A case of Abajeneza Cooperative in Kayonza District. *International journal of Scientific and Research Publications*. 2021; **11(5):** 673-681.

23. **Nzeyimana E** The impact of Maize Post-Harvest Management Practices on Smallholder farmers`Income in Bugesera District, Rwanda. International *Journal of Research and Innovation in Social Science.* May 2020.

24. **Giulia M and A Lees** The Economical Impact of the Pandemic in Rwanda: An Analysis of Firm-Level VAT Data, *Journal of African Economies*. 2022.

25. **AGRA.** REGIONAL FOOD TRADE AND RESILIENCE PROGRAMME. A Rapid Analysis of the Impact of the COVID-19 Pandemic on Selected Food Value Chains in Africa, Synthesis Report. October 2020.

26. **Raúl S** What is the impact of COVID-19 diseases on agriculture? Scientia Agropecuaria vol.11 no.1 Trujillo ene. March 2022.

ajfand SCHOLARLY, PEER REVIEWED AFRICAN JOURNAL OF FOOD, AGRICULTURE, NUTRITION AND DEVELOPMENT Volume 23 No. 6 June 2023 PUBLISHED BY AFRICAN SCHOLARLY SCIENCE COMMUNICATIONS TRUST ISSN 1684 5374

27. **Akaliza N, Urujeni R, Musayidizi P, Turatsinze F, Mukarusagara G and N Brozovic** Water for Food daugherty global institute, Covid-19 Impacts on Agricultural Entrepreneurship in Rwanda. 2020.

28. **NISR**.Thematic Report. Migration and spatial mobilty. Fourth Population and Housing Census, Rwanda.2012.

29. **WIEGO**. The Impact of COVID-19 Laws on Street Vendors AND Market Traders: Trends and Insights from Latin America. 2021.

30. **Jones S, Krzywoszynska A and D Maye** Resilience and transformation:Lessons from the UK local food sector in the COVID-19 pandemic. *The Geographical Journal*. 2022.

31. **NISR**. Seasonal agricultural survey.2021.

32. **Ntambara E** Mobile Money, Covid-19 and Digital Payments. University of Rwanda: Evidence from Rwanda. 2021.

33. **WHO**. Regional Office for Africa and African Health Observatory. Containment strategies: Lessons from early COVID-19 Responses in five African countries. December 2021.

34. **Gachara G, Suleiman R, Kadili SE, Barka EA, Kilima B and R Lahlali** Drivers of Post-Harvest Aflatoxin Contamination: Evidence Gathered from Knowledge Disparities and Field Surveys of Maize Farmers in the Rift Valley Region of Kenya. 2022.

35. **Kumar A, Pathak H, Bhadauria S and S Jebi** Aflatoxin contamination in food crops: Causes, detection and management: a review. July 2021.