Short-term impact of the COVID-19 pandemic on the livelihood of smallholder rice farmers in developing countries

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Abstract

The COVID-19 pandemic is a major international health crisis which has resulted in simultaneous economic, social and food security crises. This study aimed to provide a snapshot of the short-term impact of the COVID-19 pandemic on smallholder rice farmers in Côte d'Ivoire. Using three survey types (village-level, farmer association level, and household level), a total of 585 rice farmers were interviewed nine months after the starting of the pandemic in Cote d'Ivoire. Multivariate probit and Poisson regression models were used to analyze the determinants of the impact of the pandemic on farmers and the intensity of the impact, respectively. Results showed that all rice farmers were aware of coronavirus disease, and television and radio were the main sources of knowledge of the pandemic. After one growing season, the pandemic had negative impact on access to inputs, access to hired labor, yield, income and food security. Around 43% of farmers experienced at least one negative impact of the pandemic. About 30% of farmers perceived that the rice yield and income decreased due to the pandemic. Access to inputs and hired labor became more difficult and expensive for about 28% of farmers. Surprisingly, farmers in more remote villages were also affected by the pandemic as well. The main factors that influenced significantly and positively the intensity of the pandemic impact were the household size, being married, being producer of foundation seed, access to credit in the past, facing drought or flood as constraints. The facilitation of credit access for smallholder farmers could be one strategy to avoid food shortages and deficits among value chain actors.

Keywords: Rice farmers, COVID-19 pandemic, short-term impact, wellbeing, Africa
JEL Code: Q13, Q18, C93

1- Introduction

Agriculture is a key sector of the economy in many developing countries and thus remains the basis of any development strategy. It provides employment for about two-thirds of the continent's working population and for each country contributes an average of 30 to 60% of gross domestic product and about 30% of the value of exports (World Bank, 2020). Agriculture can help reduce poverty, raise incomes and improve food security for 80% of the world's poor, who live in rural areas and work mainly in farming (World Bank, 2020). Agricultural development is one of the most powerful tools to end extreme poverty, boost shared prosperity and feed a projected 9.7 billion people by 2050. Analyses in 2016 found that 65% of poor working adults made a living through agriculture (World Bank, 2020). It can therefore contribute towards sustainable development goals and major continental priorities, such as eradicating poverty and hunger, boosting intra-Africa trade and investments, rapid industrialization and economic diversification, sustainable resource and environmental management, and creating jobs, human security and food security. In the agricultural sector, cereal production especially rice, wheat and maize have become essential to food security as they provide more than 60% of daily calory in developing countries.

Rice is an important staple crop that plays an important economic role and feeds approximately half the world's population (Fahad *et al.,* 2019). Rice represents the staple food for more than 750 million people in Sub-Saharan Africa (USDA, 2018). West Africa consumes more rice than any part of Africa as regional demand has continued to grow at almost 6% annually, driven by the growing population, urbanization and changing in consumer behavior in the region. However, local production has not kept pace with the increase in demand and the gap is being filled through importation of Asia rice whose characteristics are more preferred by consumers (Demont *et al.*, 2013). In West Africa, 310 million people derived about 20% of their daily calorie from rice. Also, in this region, the annual per capita consumption levels rose five-fold in the last six decades and are currently the highest on the continent. Production increased less during the same period (USDA, 2019) and the region increasingly relies on rice imports (Mendez del Villar and Lançon, 2015). This renders West Africa very vulnerable to international trade disruptions such as the ones currently inflicted by the corona virus disease (COVID-19) crisis (Arouna *et al*., 2020).

On December 31st, 2019, the World Health Organization (WHO) was informed of a cluster of cases of pneumonia of unknown cause detected in Wuhan City, Hubei Province, Republic of

China. This was subsequently confirmed as an outbreak of a new type of coronavirus, 2019 novel Coronavirus (2019-nCOV) by the China and the WHO. Since then, the world is facing unprecedented challenges caused by the coronavirus pandemic (COVID-19), one of the most serious public health emergencies since last century. According to the World Health Organization (WHO), as of March 1st, 2021, more than 114,795,908 and 3,872,085 cases of COVID-19 have been reported in the world and Africa, respectively, with about 2,550,334 and 102,286 deaths, respectively (WHO, March 01, 2021). Since the end of the second world-war, the COVID-19 pandemic is the first international health crisis which is likely to result simultaneously to economic, social and food crisis. Around the world, governments and populations continue to grapple with the effects of the coronavirus outbreak. Concerns are the potential impacts of the COVID-19 pandemic and related lockdown measures on agriculture and food security. Côte d'Ivoire with 32,791 confirmed cases is among the African countries with the highest toll of confirmed COVID-19 cases (WHO, March 01, 2021). To slow down the speed of contamination, movement restrictions, maintenance of strict hygiene practices, social distancing rules, wearing of face masks, travel restrictions, quarantines, curfews and complete lockdowns were imposed in many countries of Africa including Cote d'Ivoire. While these measures are important to contain the pandemic and arrest the spread of coronavirus, they are, however, adversely impacting livelihoods, jobs, food and nutrition security and economic activities.

To address these needs and help inform the responses of policymakers, we conducted a rapid perception survey to provide a snapshot of the impact on COVID-19 pandemic on rice farmers in Cote d'Ivoire. This study aims to assess the short-term impact of the COVID-19 pandemic on smallholder rice farmers in Cote d'Ivoire after nine months of facing the coronavirus disease crisis. Although literature exists on the potential impact of the pandemic in Africa (e.g. Arouna *et al*., 2020. Kalle *et al.,* 2021), this is among the scarce studies using primary data to estimate the impact of COVID-19 on smallholder farmers in rural areas of Africa.

2- Synoptic view of COVID-19 pandemic situation in Africa

As of March 1st, 2021, the number of confirmed COVID-19 cases in Africa amounted to 3,872,085 which represented around 3.37%of the infections around the world (114,795,908). In the African continent, South Africa was the most drastically affected country, with more than 1,514,815 infections following by Morocco, Tunisia, Egypt, Ethiopia and Nigeria (WHO, March 2021). In February 2020, the first case of COVID-19 in West Africa was recorded in Nigeria. Within one month, the virus had spread to all 17 countries. As of March 1st, 2021, more than 390,680 cases with 5,235 deaths have been recorded in West Africa. Nigeria, Ghana, Cote d'Ivoire and Senegal are the fourth most infected country in West Africa. As of March 01, 2021, at least seven different vaccines across three platforms have been rolled out in countries. Ghana and Cote d'Ivoire became on March 1st, 2021, the first countries in West Africa to vaccinate their citizens against COVID-19 thanks to “COVAX (COVID-19 Vaccines Global Access Facility)”. COVAX is working for global equitable access to COVID-19 vaccines. Some members of the government of Ghana and Côte d'Ivoire have already been vaccinated.

Cote d’Ivoire is among the African countries with the highest toll of confirmed COVID-19 cases (32,791 cases), particularly in the economic capital Abidjan and its suburbs (Figure 1). However, the death rate is below 2% and government restrictions have been partially lifted. The Ivorian government reacted quickly at the onset of the crisis. A state of emergency was declared on March 23, while the country had only 25 confirmed cases. With a dawn to dusk curfew, schools and airports closed, intra-regional travels in Côte d'Ivoire and gatherings banned, as well as restaurants and local "maquis" closed: Ivorians were being asked to confine themselves.

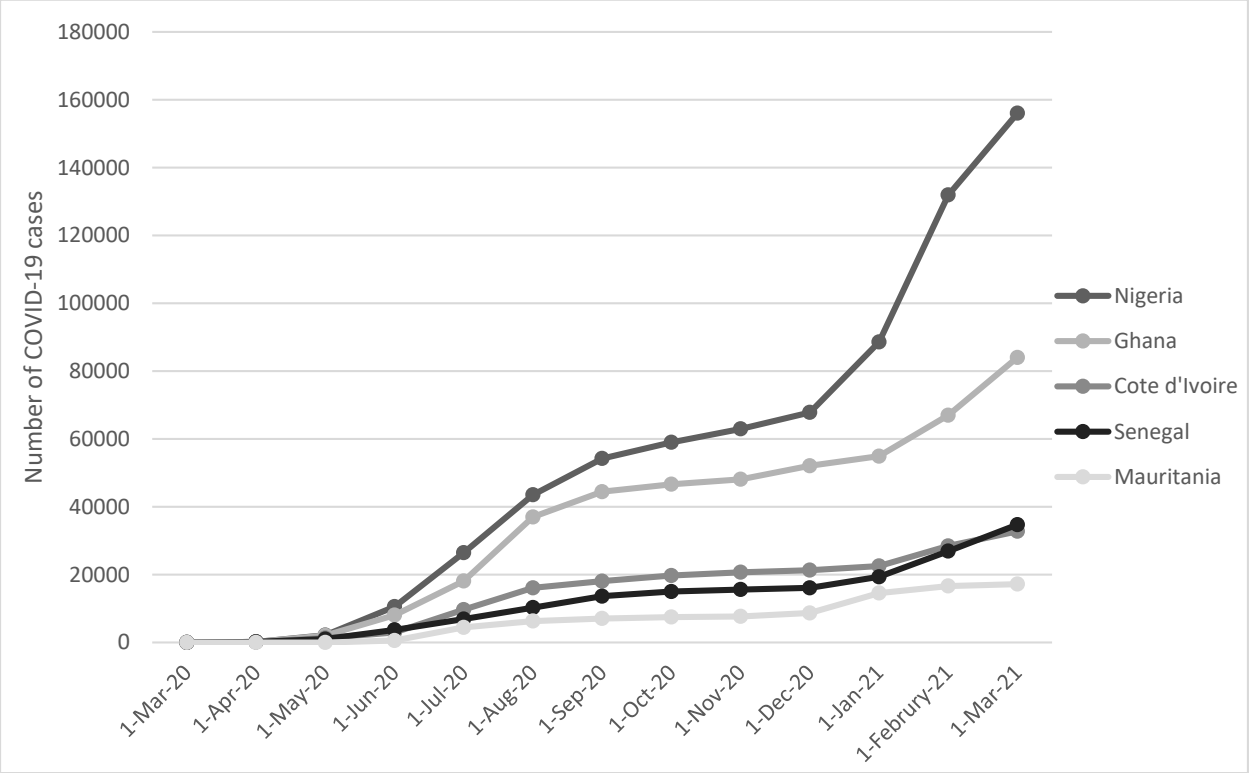

Figure 1. Trend of total COVID-19 confirmed cases in the five most affected countries of West Africa
Source: WHO, 01/03/2021

There are about 1.24 people affected by the coronavirus disease for every 1,000 population in Cote d'Ivoire (Table 1). Nigeria, Ghana, Cote d'Ivoire, Senegal and Mauritania are respectively, the five most affected countries of West Africa. Among these five African countries with higher cases, Mauritania is the country with high density (3.70) following by Ghana (2.70), Senegal (2.07), Cote d'Ivoire (1.24) and Nigeria (0.76).

Table 1. Number of people infected by COVID-19 in the five most affected countries of West Africa

Rank	Countries	Number of cases	Population in the country	Ratio	Density per 1,000 population
1	Nigeria	156017	206139587	0.00076	0.76
2	Ghana	84023	31072945	0.00270	2.70
3	Cote d'Ivoire	32791	26378275	0.00124	1.24
4	Senegal	34732	16743930	0.00207	2.07
5	Mauritania	17217	4649660	0.00370	3.70

Source: WHO, 01/03/2021

3. Methodology

3.1. Study area and sampling

We designed and implemented three types of questionnaire: a village level questionnaire (head of the village), a rice farmer association leader questionnaire, and a rice household questionnaire. Complete population survey approach was used. All rice farmers of 12 villages (six in Gbêkê region and six in Hambol region) of the *Vallee de la Bandama* were interviewed (Figure 2). These regions were selected as one of the major rice-growing areas or "hubs" within Cote d'Ivoire. Hubs are zones of high potential impact where rice research innovations are integrated across value chains to achieve development outcomes and impact. The two regions were part of the e-registration survey for technology dissemination in Cote d'Ivoire (Arouna and Aboudou, 2020). The villages selected were those on which pre-COVID-19 socio-economic data are available (Arouna and Aboudou, 2020). A total of 585 rice farmers were interviewed with 312 farmers (232 male farmers and 80 female farmers) in Gbêkê region and 273 farmers (252 male farmers and 21 female farmers) in Hambol (Table 2). The number of farmers per village and gender is presented in the table 2.

Table 2. Statistics of farmers surveyed per village and region

Regions	Villages	Number of farmers		
		Male	Female	Total
Gbêkê	Dieribanouan	29	16	45
	Djekro	39	8	47
	N'gatakoffikro	31	21	52
	Samoikro	22	5	27
	Tikakro	45	14	59
	Yomien-Kouadiokro	66	16	82
Sub Total 1		232	80	312
Hambol	Fendene	75	12	87
	Kaniéne	29	3	32
	Nadiokaha	33	0	33
	Nassoulo	85	6	91
	Ouanan	13	0	13
	Tenenakaha	17	0	17
Sub Total 2		252	21	273
Total		484	101	585

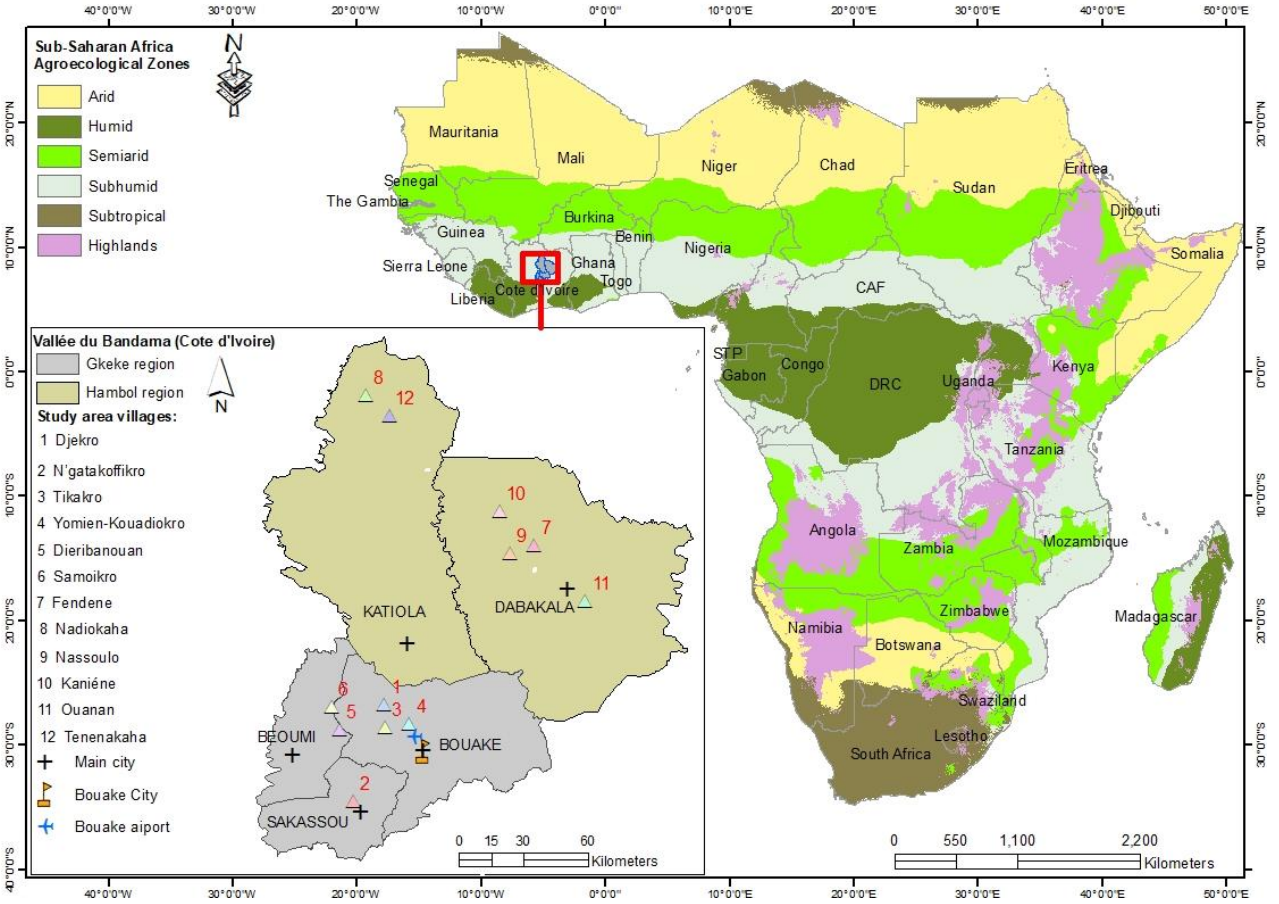

Figure 2. Map of sub-Saharan Africa highlighting the study area

3.2. Data collection and analysis

3.2.1. Data collection

Data collection was conducted between October 3-23, 2020. Data were collected by enumerators trained using the web-based application ONA and Android terminals using the ODK collect installed on tablets. Computerized data collection has avoided many of the biases associated with paper questionnaires, such as errors in recording responses, changing variable values, and recoding test responses for numeric variables. Data collection was implemented outside in a socially distanced fashion.

Socio-economic characteristics, demographics, perception of farmers on COVID-19 and geographic data were collected. With regard to the attitudes toward COVID-19 virus, the questionnaire included perception of rice farmers toward COVID-19 on their activities, the sources of knowledge of the COVID-19 pandemic, measures taken and applied to prevent the spread of

the coronavirus. In particular, farmers were asked to assess the effect of coronavirus disease on agriculture production during the 2020 first production season (March to July 2020). The response options were "Positive", "Negative" or "null". Moreover, farmers were asked to access the effect of coronavirus disease on agricultural inputs (fertilizers, seeds, herbicides and insecticides) for rice production during the 2020 production season. The response options were "Has not changed", "More expensive" or "More difficult". Furthermore, farmers were asked to assess the effect of coronavirus disease on access to market and paid labor for rice production during the 2020 first production season. The response options were "Has not changed", "More expensive" or "More difficult". In addition, respondents were asked about rice yield and income during the 2020 first production season. The response options were "Has not changed", "Increased" or "Decreased". Finally, the respondents were also asked about self-assessment of the household food security during the COVID-19 pandemic. The response options were "Food security has not change" and "Food insecurity."

3.2.2. Data analysis

Data were processed with STATA 16 software and focused mainly on socioeconomic and demographic characteristics, knowledge and source of information on COVID-19 and measure taken. Data analysis was conducted using descriptive statistics (mean, standard deviation, percentile, etc.), correlation coefficients and regression models. Two regression models were used: multivariate probit and Poisson regression.

- **Multivariate probit model**

To overcome the problem of Multinomial Logit Model (MNL) model, Multivariate Probit (MVP) Model was used assess the determinants of COVID-19 impact on farmers. The dependent variables in the empirical estimation for this study were the five potential impacted factors (Access to hired labor, access to input, ability to sell rice, yield and food security) of the COVID-19 pandemic. The covariates include demographic, socio-economic, farming, farm specific, institutional, market and environment characteristics. Following Cappellari and Stephen (2003), the multivariate probit econometric approach for this study is characterized by a set of *m* binary dependent variables Y_{im} such that: the estimation is based on the observed binary discrete variables Y_{im} that indicate whether or not farmers has experienced negative impact of COVID-19 (denoted by 1 for negative impact and zero for no impact). The regression model is expressed as:

$$Y_{im}^{*} = \beta_{m}^{*\prime} X_{im} + \varepsilon_{im}\,, m = 1, \ldots .5 \qquad (1)$$

Where m represents the five potential impacted factors (Access to hired labor, access to input, ability to sell rice, yield and food security) by the COVID-19 pandemic.

$$Y_{im} = 1 \; if \; Y_{im}^{*} > 0 \quad \text{and 0 otherwise} \qquad (2)$$

Where $\varepsilon_{im}\,, m = 1, \ldots .5$ are error terms distributed as multivariate normal, each with a mean of zero, and unitary variance. The status of the impact is assumed to be influenced by various observed characteristics (X_{im}). The unobserved characteristics are captured by the error term denoted by while is a parameter to be estimated.

- **Poisson regression model**

To identify the factors that influenced the intensity of the impact of COVID-19 pandemic on farmers, we estimated Poisson regression. The Poisson distribution models the probability of k events (counts). It assumes that the dependent variable (Y) has a Poisson distribution, and the logarithm of its expected value can be modeled by a linear combination of known and unknown parameters (Cameron and Trivedi, 2005). This regression is similar to logistic regression, which also has a discrete response variable. However, the Poisson response is not limited to two specific values, as in a logistic regression. The dependent variable in the Poisson model is the count number of negative impacts of COVID-19 pandemic observed by the producer.

We calculated the intensity of the impact by summarizing the number of the negative impact of COVID-19 on access to hired labor, access to input, ability to sell rice, yield and food security. This variable (with six modalities: 0 to 5) shows the appropriateness of the use of the Poisson regression model. The following empirical model was used to estimate intensity of the impact of COVID-19 pandemic observed by the producer: By definition, Y follows a Poisson distribution with parameter λ if and only if

$$\mathrm{P}(Y = \mathrm{k}) = \frac{\exp(-\lambda)\lambda^{k}}{k!}, \varepsilon_{\mathrm{i}} \qquad (3)$$

For k=0, 1, 2, 3, 4 and 5, we recall that for Poisson variable:

$$\mathrm{E}[Y] = \lambda \text{ and } \mathrm{Var}[Y] = \lambda \qquad (4)$$

4. Results

This session presented the main results obtained of the study. In the first part, socio-economic characteristics of respondents are presented. Secondly, we present the main sources of knowledge of the COVID19 pandemic and the measures applied to prevent its spread. This is followed by the determinants and perception on impact of different outcomes.

4.1. Socio-economics characteristics of respondents

Table 3 described the characteristics of rice farmers in Cote d'Ivoire. A difference in household characteristics for the two groups was observed. The average age of respondent is 42 years with 12 persons per the household. Results showed that agriculture activity is mainly carried out by men (82.73%). Farmers with negative impact of COVID-19 are younger and are mainly men. Farmers with cell phone, educated people and member to farmer association such as cooperatives experienced more the negative impact of the COVID-19 pandemic.

Furthermore, farmers in more remote villages were also affected by the pandemic as well. Remote village from the main city of Bouake such as Djekro, Yomien-Kouadiokro, Nassoulo, Ouanan and Tenenakaha experienced more the negative impact of the coronavirus disease. Rice farmers using improved varieties (50%) and farmers having access to credit (14%) experienced more the negative impact of the coronavirus disease (Table 3).

About 98% of farmers facing negative impact of climate change such as flood and drought constraints also face a negative impact from the COVID-19 pandemic (Table 3). This finding highlights the twin challenges of the COVID-19 pandemic and climate change for agriculture and food security in Africa. Climate change is affecting the fundamental basis of agriculture over the years through changes in temperature, rainfall and weather, and by intensifying the occurrences of floods, droughts and heat stress. Like climate change, a pandemic is a global risk. The COVID-19 has further disrupted many activities in agriculture and supply chains in Africa, further compounding the challenges of food and nutrition security and sustaining livelihoods.

Table 3. Socio-economic characteristics of farmers observing negative impact of COVID-19 and farmers with no impact of COVID-19 on their activities

Variables	Overall (n=585)	Farmers with no impact of COVID-19 (n= 249)	Farmers with at least one negative impact of COVID-19 (n= 336)
Household characteristics			
Age (years)	42.52 (11.47)	42.95 (12.46)	41.95 (9.97)
Household size (Number)	12.54 (6.10)	11.84 (5.95)	13.49*** (6.18)
=1 if male (%)	0.83 (0.38)	0.80 (0.40)	0.87** (0.33)
=1 farmer married (%)	0.84 (0.37)	0.84 (0.36)	0.84 (0.36)
=1 if farmer has a formal education (%)	0.29 (0.45)	0.24 (0.43)	0.35*** (0.47)
=1 head of household is farmer (%)	0.68 (0.46)	0.62 (0.48)	0.76*** (0.42)
=1 if produce of foundation seed (%)	0.14 (0.35)	0.13 (0.33)	0.17 (0.37)
=1 if produce certified seed (%)	0.02 (0.13)	0.01 (0.09)	0.03* (0.16)
=1 if trade rice (%)	0.71 (0.45)	0.69 (0.46)	0.75* (0.43)
=1 if have a phone (%)	0.81 (0.39)	0.77 (0.42)	0.87*** (0.33)
=1 if Gbeke (%)	0.53 (0.50)	0.55 (0.49)	0.51 (0.50)
=1 if Hambol (%)	0.47 (0.49)	0.45 (0.49)	0.49 (0.50)
=1 if Dieribanouan (%)	0.08 (0.26)	0.13*** (0.33)	0.00 (0.06)
=1 if Djekro (%)	0.08 (0.28)	0.04 (0.20)	0.13*** (0.33)
=1 if Ngatakoffikro (%)	0.09 (50.21)	0.09 (0.28)	0.09 (0.28)
=1 if Samoikro (%)	0.05 (0.21)	0.04 (0.19)	0.06 (0.23)
=1 if Tikakro (%)	0.10 (0.30)	0.13** (0.33)	0.06 (0.24)
=1 if Yomien-Kouadiokro (%)	0.14 (0.35)	0.12 (0.32)	0.17* (0.37)
=1 if Fendene (%)	0.15 (0.36)	0.26*** (0.43)	0.00 (0.06)
=1 if Kaniene (%)	0.05 (0.23)	0.08*** (0.26)	0.02 (0.15)
=1 if Nadiokaha (%)	0.06 (0.23)	0.10*** (0.29)	0.00 (0)
=1 if Nassoulo (%)	0.16 (0.36)	0.02 (0.13)	0.34*** (0.47)
=1 if Ouanan (%)	0.02 (0.15)	0.00 (0)	0.05*** (0.22)
=1 if Tenenakaha (%)	0.03 (0.17)	0.00 (0.05)	0.06*** (0.24)
Institutional characteristics			
=1 if belong to farmer association (%)	0.15 (0.35)	0.12 (0.32)	0.19** (0.39)
=1 if contact with extension agents (%)	0.31 (0.46)	0.34* (0.47)	0.27 (0.44)
=1 if access to credit (%)	0.08 (0.27)	0.04 (0.19)	0.14*** (0.34)
Land and Farm characteristics			
Total Area cultivated (ha)	5.78 (6.22)	6.02 (6.43)	5.46 (5.90)
= 1 if rice farmer use fertilizer (%)	0.24 (0.43)	0.22 (0.41)	0.28* (0.44)
= 1 if use improved varieties (%)	0.45 (0.50)	0.41 (0.49)	0.50** (0.50)
= 1 if use smart-valley (%)	0.45 (0.50)	0.39 (0.48)	0.54*** (0.49)
= 1 if face RYMV constraints (%)	0.93 (50.26)	0.89 (0.31)	0.98*** (0.12)
= 1 if facing flood as a constraint (%)	0.90 (0.29)	0.85 (0.35)	0.97*** (0.16)
= 1 if facing drought as a constraint (%)	0.94 (0.24)	0.90 (0.30)	0.99*** (0.08)
Environmental characteristics			
=1 if upland (%)	0.17 (0.38)	0.25*** (0.43)	0.07 (0.25)
=1 if irrigated upland (%)	0.11 (0.31)	0.15*** (0.35)	0.06 (0.23)
=1 if lowland (%)	0.41 (0.49)	0.24 (0.42)	0.64*** (0.48)
=1 if irrigated lowland (%)	0.28 (0.45)	0.36*** (0.48)	0.18 (0.38)

***, ** and * are significantly higher than the other group mean at 1%, 5% and 10% level. *( ) standard deviation; n=Number of farmers.*

4.2. Sources of knowledge of the COVID-19 pandemic

Results showed that in terms of awareness, all rice farmers were aware of coronavirus. The main sources of knowledge of the coronavirus disease by rice farmers was television (61%). This means that, for 2 out of 3 rice farmers, television was the main source of information on COVID-19 followed by radio (23%). Only 2% of farmers got information on coronavirus disease through social media such as WhatsApp and Facebook, 7% from a parent, and 5% from a friend of the village (Figure 3). In total, 81% of farmer had a smartphone but most were afraid of “fake news” and relied on the national channel (radio and television). The preference was a direct and visible contact with a governmental source of information.

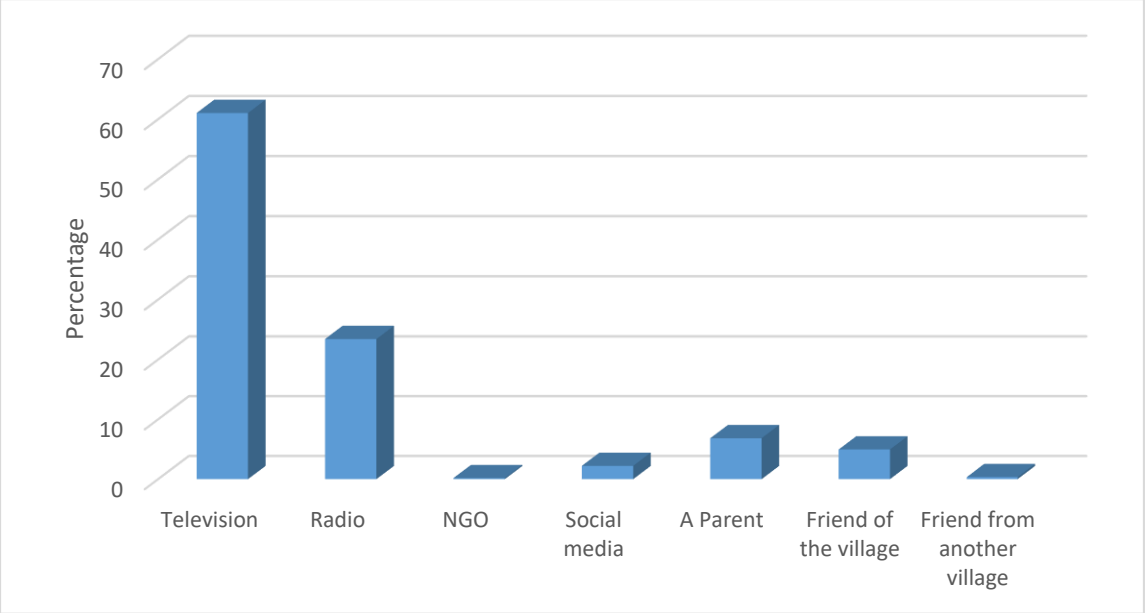

Figure 3. Main sources of information on the COVID-19 pandemic

4.3. Measures taken and applied to prevent the spread of the coronavirus by rice producer

Most the respondents were knowledgeable of the various ways by which COVID-19 is transmitted. All farmers knew that the coronavirus disease is transmitted through "physical contact". Lot of sanitary measures were taken and applied to prevent the spread of coronavirus disease in rural area. All respondents were aware of different sanitary and prevention measures such as: wearing a mask, regular hand washing, closure of schools, cough or sneeze into the elbow of the hand, prohibition of intra-regional movement, lockdown, and quarantine. The most used sanitary

measures took and applied to prevent the spread of coronavirus disease in rural areas were: wearing a mask (92%), regular hand washing (89%), cough or sneeze into the elbow of the hand (47%), prohibition of intra-regional movement (17%), confinement/lockdown (16%) and quarantine (3%) (Figure 4).

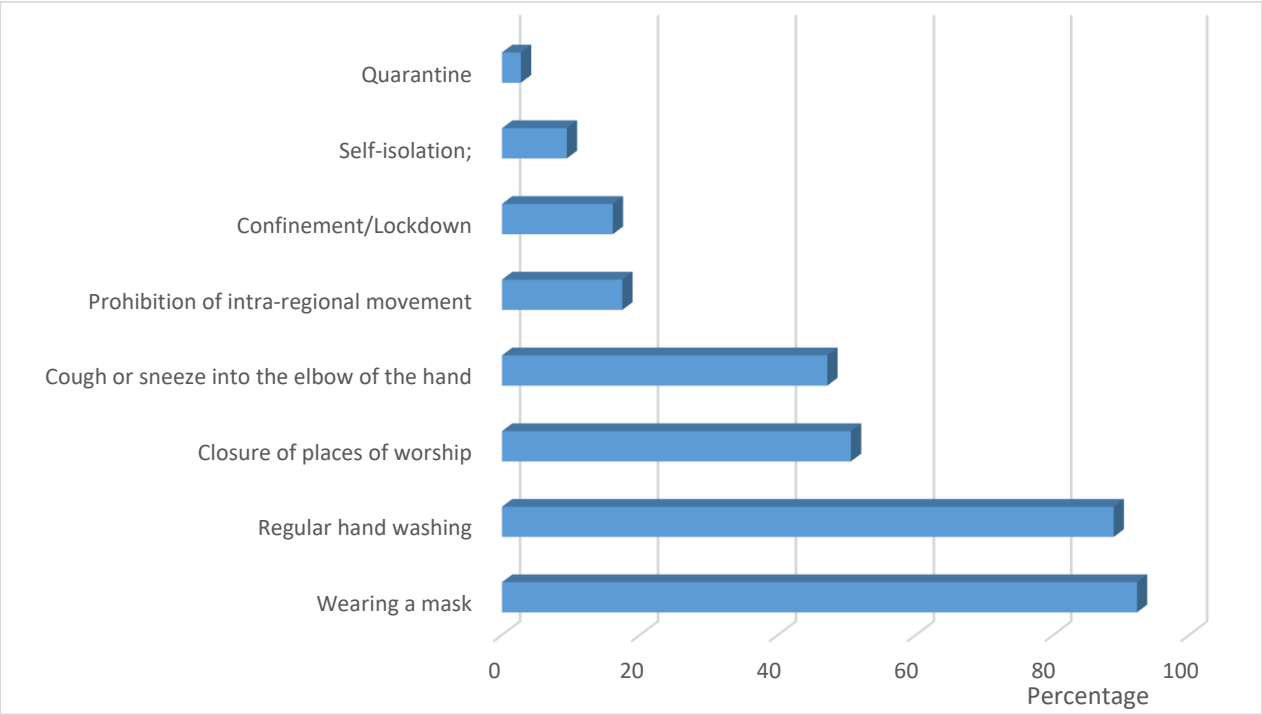

Figure 4. Measures applied to prevent the spread of the coronavirus in the communities

4.4. Producer perception on the impact of coronavirus disease on rice production

The village-level and household level questionnaires revealed that the COVID-19 pandemic had an uneven impact on rice farmers, with some being affected negatively and other farmers' conditions remaining the same. The village-level interview showed that 50% of the villages in our sample experienced negative impacts of the COVID-19 pandemic, with the more remote villages tending to experience the negative effects from the pandemic as well. However, individual farmer survey showed that about 43 % of farmers experienced at least one negative impact of the COVID-19 pandemic (Table 4). Male farmers seemed to experience more the negative impact of the coronavirus disease. Female farmers were less affected by the pandemic.

- **Effect of coronavirus disease on access to hired labor and agricultural inputs**

Individual farmer-level questionnaires revealed that the COVID-19 pandemic had no large effect on access to hired labor for production activities. Results showed that access to hired labor for production activities has not changed for about 71% of farmers (Table 4). However, about 28% of farmers found that access to hired labor for production activities became more difficult. COVID-19 pandemic also had some negative impact on access to agricultural inputs (fertilizers, seeds, herbicides, insecticides, etc.) for agricultural production. Access to input became more expensive for about 28% of farmers and more difficult for about 12% of the farmers (Table 4). However, access to agricultural inputs for production had not changed for about 60% of farmers. During the COVID-19 pandemic, farmers experienced difficulties in selling of the paddy rice produced. For about 27% of farmers, the ability to sell the paddy rice produced decreased (Table 3). We found that for about 71% of farmers, the situation was not changed by the pandemic.

- **Effect of coronavirus disease on yield, income and food security**

The impact of COVID-19 pandemic was assessed on rice yield, income and food security. The results showed that the coronavirus disease has decreased yield and income of some farmers and also put them in a food insecure situation. Rice yield and income of the paddy rice produced decreased for about 30% of rice farmers (Table 4). The impact of COVID-19 on yield and income was higher for male farmers than female farmers. About 31% of male farmers and 22% of female farmers declared a negative impact from the coronavirus pandemic on yield. Furthermore, about 32% of male farmers and 18% of female farmers experienced negative impact from the coronavirus pandemic on rice income (Table 3).

After nine months facing the COVID-19 pandemic, the rice farming households reported that the COVID-19 pandemic did not have a large impact on food security of the household. Female farmers tended to be affected less than male farmers by the impact of COVID-19 pandemic on food security. However, 19% of the farmers had experienced food insecurity due to COVID-19 pandemic. About 80% of the rice farmers said that their household situation did not change (Table 4). Gkeke region experienced more food insecurity than Hambol region. This can be explained by the fact that Gkeke region is closer to the main city of Bouake, which was more exposed to coronavirus disease prevention measures. The villages in Hambol region are far from Bouake. Agriculture production is more concentrated in remote villages and agricultural products come from villages to towns. This is likely to increase food availability in the remote village households

from local production. Farmers may not need to buy or sell more food in big town and may be able to reduce food expenditure, leading to an increase in food security in the households.

Table 4. Impact of COVID-19 on rice production activities

Variables	Gbeke			Hambol			Total (n=585)
	Male (n=232)	Female (n=80)	Overall (n=312)	Male (n=252)	Female (n=21)	Overall (n=273)	
Farmers with at least one negative impact of COVID-19 (%)	42	36	41	46	14	44	42
Access hired labor (%)	26	34	28	32	0	30	28
Access to input (%)	38	35	37	46	14	43	40
Access to market (%)	28	21	26	33	0	30	28
Rice yield (%)	23	29	25	39	0	36	30
Rice income (%)	28	24	27	37	0	34	30
Household food security (%)	28	26	28	11	10	11	20

4.5. Determinants of the impact of coronavirus disease on rice farmers

This section analyzes the determinants of the impact of coronavirus disease on farmers using Multivariate probit (MVP) model. MVP model provides good estimates of the regression coefficients, but also the correlation matrix. The use of a MVP model fits well than univariate probit model.[1]

The results show that socioeconomic, institutional and plot characteristics were significant in determining the impact of the coronavirus. Nine explanatory variables had significant effect on yield. The size of the household, being a producer of foundation seed, rice trader status, the distance between the village and Bouake, access to credit, facing floods as a constraint, facing drought as a constraint and growing in lowland ecology have increased the likelihood of rice yield decreasing; whereas use improved varieties has a significant negative influence on decrease of yield (Table 5). This means that improved varieties are adapted to chocks such as the COVID-19 pandemic.

[1] The MVP model had a likelihood ratio test Wald chi-square (115) = 393.22 (P< 0.000) (Table 5) implying that model is globally significant. The rho21, rho31, rho41, rho51, rho32, rho42, rho52, rho43, rho53 and rho54 were positively and significantly correlated at 1% level of significance (Table 5). This allows to reject the null hypothesis of no correlation or the independence between the different dependent variables (access to hired labor, access to input, access to market, yield and food security).

Household size increases the likelihood of difficulties in having access to hired labor (10% level of significance), access to input (1% level of significance), access to market and yield (10% level of significance) and food insecurity, implying that the likelihood of negative effect of the pandemic on access to hired labor, input, ability to sell rice, yield and food security increased with the size of the family members. These are due to the fact that agriculture requires more labor force to undertake various specific production activities. Large household size had more mouths to feed. Movement restrictions, maintenance of strict hygiene practices, social distancing rules, quarantine, and complete lockdowns imposed in Cote d'Ivoire to slow down the speed of contamination had impact on farming work which is mainly collective. This implies that farmers with more household members and involve more in agriculture activities were not able to farm easily leading to, reduction of yield, income and food insecurity.

In addition, results showed that six explanatory variables had significant effect on access to labor and access to input. Being married, having a cellphone, contact with extension agents, facing drought as a constraint and growing in lowland ecology had increased the likelihood of difficulties in access to hired labor. Also, distance between village and Bouake, access to credit, facing flood as a constraint, facing drought as a constraint and growing in lowland ecology had increased the likelihood of difficulties in access to input.

Results showed that seven explanatory variables had a significant effect on the ability to sell rice. Trading rice status, access to credit, facing flood as a constraint, facing drought as a constraint and growing in lowland ecology with increased the likelihood of difficulties in access to market, whereas contact with extension agents reduced the difficulties in access to market.

Results showed that three explanatory variables have a significant effect on food security. The size of household and growing in lowland ecology increased the likelihood of food insecurity of the framer's household, whereas having contact with extension agents reduced the food insecurity.

Distance between villages and Bouake increased the likelihood of the negative impact on yield and access to input. This can be explained by the fact that farmers living in villages far from Bouake have difficulties to come to Bouake (capital of the region) to buy inputs due to COVID-19 pandemic. This situation leads to difficulties of access to agricultural inputs such as fertilizers, seeds and herbicide which lead also to decrease of the yield.

Table 5. Multivariate probit (MVP) model estimation results

Variables	Yield	Access hired labor	Access to Input	Access to market	Food security
Age	-0.00 (0.01)	-0.00 (0.01)	0.00 (0.01)	-0.01 (0.01)	0.01 (0.01)
Household size (Number)	0.02** (0.01)	0.02* (0.01)	0.02*** (0.01)	0.02** (0.01)	0.04*** (0.01)
=1 if male	0.01 (0.19)	0.02 (0.18)	0.20 (0.18)	0.14 (0.19)	0.04 (0.19)
=1 farmer married (%)	0.13 (0.17)	0.35** (0.16)	0.01 (0.15)	0.05 (0.15)	0.06 (0.17)
=1 if farmer had a formal education (%)	0.12 (0.13)	0.12 (0.13)	0.06 (0.12)	0.05 (0.12)	0.14 (0.13)
=1 if producer of foundation seed (%)	0.32* (0.18)	0.20 (0.17)	0.04 (0.17)	-0.05 (18)	-0.17 (19)
=1 if trade Rice (%)	0.32** (0.14)	0.16 (0.14)	0.04 (0.13)	0.50*** (0.13)	0.00 (0.15)
Distance between village and Bouake (in minute)	0.01** (0.00)	-0.00 (0.00)	0.01*** (0.00)	0.00 (0.00)	-0.00 (0.00)
=1 if have phone (%)	0.13 (0.17)	0.28* (0.17)	0.13 (0.16)	0.18 (0.16)	0.20 (0.19)
=1 if contact with extension agents (%)	-0.01 (0.14)	0.43*** (0.14)	-0.16 (0.13)	-0.26** (0.13)	-0.45*** (0.16)
=1 if access to credit (%)	0.85*** (0.21)	-0.24 (0.19)	0.62*** (0.22)	0.64*** (0.19)	-0.26 (0.21)
= 1 if use improved varieties (%)	-0.23* (0.13)	-0.06 (0.12)	-0.07 (0.12)	-0.12 (0.12)	-0.21 (0.13)
= 1 if face flood as constraints (%)	0.51** (0.25)	0.28 (0.24)	0.77*** (0.22)	0.93*** (0.24)	3.94 (92.25)
= 1 if face drought as constraints (%)	0.88** (0.44)	0.89** (0.38)	0.63** (0.31)	0.92** (0.37)	3.62 (104.53)
=1 if lowland (%)	0.95*** (0.14)	1.02*** (0.13)	1.12*** (0.14)	0.28** (0.12)	0.53*** (0.14)
Constant	-3.62***(0.64)	-3.00***(0.57)	-3.30*** (0.53)	-3.42*** (0.57)	-9.19 (139.42)
Number of observations			585		
Log of likelihood			-915.40		
Wald Chi-square			296.33***		
rho21			0.84***		
rho31			0.90***		
rho41			0.91***		
rho51			0.76***		
rho32			0.86***		
rho42			0.79***		
rho52			0.75***		
rho43			0.93***		
rho53			0.83***		
rho54			0.81***		

** Significant at 10%; ** significant at 5% and *** significant at 1%. ( ) standard error*

4.6. Determinants of the intensity of the COVID-19 impact

This section examines the determinants of the intensity of the impact of coronavirus disease on farmers using the Poisson regression model. Results showed that the size of household, being married, producer of foundation seed, access to credit, facing drought as a constraint, facing flood as a constraint and growing in lowland ecology increased the likelihood of the intensity of the impact of the COVID-19 pandemic. In contrast, having contact with extension agents had decreased the likelihood of the intensity of the coronavirus disease impact (Table 6).

The size of household increased the likelihood of the intensity of the impact of the COVID-19 pandemic on farmers, perhaps because farmers with more household members had many mouths to feed and were involved more in agriculture activities for subsistence but were not able to farm as easily due to the COVID-19 pandemic, leading to reduction of yield, income and food insecurity.

Having contact with extension agents decreased the likelihood of the intensity of the coronavirus disease impact. This result implied that access to institutional support services such as extension agents helped farmers to have more access to information on farming technologies or approach and helped also to learn how to deal with some challenges such as coronavirus diseases. Being a farmer who trades rice increased the likelihood of the intensity of the impact of COVID-19 pandemic on rice producer. This implied that measures to slow down the pandemic in Cote d'Ivoire had reduced movement of people leading to decrease in access to market.

Having access to credit in the past increased the likelihood of the intensity of the impact of COVID-19 pandemic on rice producer. This can be explained by the fact that agriculture activities required money to purchase inputs and pay labor for production and post-harvest activities. Most farmers involved in agriculture obtained credit from microfinance institution which reduced their activities due to the pandemic.

Being a producer of foundation seed increased the likelihood of the intensity of the impact of COVID-19 pandemic on rice producer. This can be explained by the fact that seed production required more care and labors. The situation due to the pandemic reduced breeding activities.

Facing flood and drought as constraints increased the likelihood of the intensity of the impact of COVID-19 pandemic on rice farmers. This highlighted the twin challenges of COVID-19 pandemic and climate change for agriculture and food security.

Table 5 presents also the disaggregation of the Poisson regression model by gender. Results showed that for male farmers, being married had increased the likelihood of the intensity of the impact of the COVID-19 pandemic on male farmers; while being married decreased the likelihood of the intensity of the impact of the COVID-19 pandemic on female farmers. This implied that male farmers have more charge and have to feed the family while female famers are in charge of the husband. Due to the COVID-19 pandemic, male farmers are more worry this lead to a perception of negative impact of the COVID-19 pandemic.

For female farmers, being producer of foundation seeds, contact with extension agents, and using improved varieties decreased the likelihood of the intensity of the impact of the COVID-19 pandemic on farmers, while facing drought as a constraint increased the likelihood of the intensity of the impact of the COVID-19 pandemic on farmers (Table 5).

Table 5. Poisson regression model estimated results

Variables	Overall (N=585)	Male (N=484)	Female (N=101)
Age	0.00 (0.00)	-0.00 (0.00)	0.01 (0.01)
Household size (Number)	0.02*** (0.00)	0.02*** (0.00)	0.03 (0.02)
=1 farmer married (%)	0.18** (0.08)	0.40*** (0.10)	-0.76*** (0.20)
=1 if farmer has a formal education (%)	0.10 (0.06)	0.13* (0.07)	-0.13 (0.25)
=1 if producer of foundation seed (%)	0.22*** (0.08)	0.33*** (0.09)	-0.52*** (0.20)
=1 if trade rice (%)	0.30*** (0.07)	0.43*** (0.08)	-0.21 (0.17)
Distance between village and Bouake (in minute)	-0.00 (0.00)	-0.00 (0.00)	-0.00 (0.00)
=1 if have phone (%)	0.06 (0.08)	0.21** (0.10)	0.03 (0.18)
=1 if contact with extension agents (%)	-0.16** (0.07)	-0.15* (0.08)	-0.81*** (0.26)
=1 if access to credit (%)	0.35*** (0.09)	0.32*** (0.09)	0.43 (0.38)
= 1 if use improved varieties (%)	0.01 (0.06)	0.14** (0.07)	-0.74*** (0.19)
= 1 if facing flood as a constraint (%)	0.64*** (0.15)	0.63*** (0.16)	0.67 (0.45)
= 1 if facing drought as a constraint (%)	0.58*** (0.18)	0.65*** (0.21)	0.60 (0.37)
=1 if lowland (%)	0.46*** (0.07)	0.43*** (0.07)	0.68*** (0.21)
Constant	-1.34*** (0.29)	-1.73*** (0.33)	-0.38 (0.73)
Number of observations	585	484	101
McFadden Pseudo R^2	0.09	0.11	0.24
Log of likelihood	-1135.75	-925.90	-157.47
Wald Chi-square	505.58***	469.49***	129.96***

** Significant at 10%; ** significant at 5% and *** significant at 1%. ( ) standard error; n=Number of produce*

5. Discussion

The objective of this study was to understand farmer perceptions of the potential short-term impacts of COVID-19 on smallholder rice farmers in Cote d'Ivoire after one season of production under the pandemic conditions. Results provide evidence that all rice farmers were aware of coronavirus disease. Television and radio were the primary sources of knowledge. The pandemic had a negative impact in rural areas, especially on the acquisition of inputs, access to hired labor, yield and income. Remote villages tended to be affected by the pandemic as well. Furthermore, the main factors that positively and significantly influenced the intensity of the impact of COVID-19 pandemic on farmers are the household size, being married, being producer of foundation seed, access to credit, facing drought as a constraint, facing flood as a constraint and growing in lowland ecology. These results are in line with the literature. Arouna *et al*. (2020) expected that both traditional and upgraded rice value chains will be seriously affected by the COVID-19 pandemic. The report based on survey data collected in April by the World Bank in Cote d'Ivoire finds that the COVID-19 pandemic had several direct repercussions on businesses: reduced working hours, lower sales and revenue (World Bank, 2020). The pandemic's shocks to agriculture in West Africa have been intense because the timing of its outbreak coincided with the cropping season of many crops including paddy rice. Movement restrictions, curfews and complete lockdowns in urban area in order to reduce the speed of contamination, were expected to have negative impacts in large towns and urban settlements (Nguyen *et al.,* 2020). However, we find evidence that the pandemic had also negative impacts in rural areas as well. This was not expected because the negative impact was expected in urban area (Nguyen *et al*., 2020). Possible disruptions to food value chains are more detrimental to urban households because they typically do not grow their own food (Kalle *et al.,* 2021). The negative impact of coronavirus in rural areas is due to the fact that agricultural inputs come from urban areas, which made obtaining them difficult and expensive due to the restriction measures put in place (Arouna *et al.,* 2020). However, our results are in line with finding of other studies that COVID-19 pandemic had affected farmers and agricultural workers in various ways (Rawal and Verma, 2020; Narayanan and Saha, 2020; Narayanan, 2020; Kim *et al*., 2020). Female farmers tended to be less affected by the negative impact of the COVID-19 pandemic than male farmers.

Results showed that facing flood and drought as constraints increased the likelihood of the intensity of the impact of coronavirus disease on rice farmers. This paper contributed to a better

understanding of the impact of COVID-19 in rural area and the linkages between the two global crises of climate change and COVID-19 and highlighted the need for integrated action for addressing the interconnected challenges. Our results are in line with finding of other studies (Golam *et al.*, 2021). Importantly, innovative strategies and approaches are needed to address both the coronavirus and climate crises (Barbier, 2020; Dobson *et al*., 2020). Regional and global cooperation is also necessary to address the effects of COVID-19 and climate change. Policy choices should focus both on resolving urgent needs of food and health and on ensuring long-term resilience and sustainability in agriculture while taking into account the impact of climate change (Engström *et al*., 2020). This study highlights that special attention should be devoted to the smallholder farmers in rural areas, particularly for access to agricultural inputs. Different policy options proposed to help West African governments mitigate the impacts of the COVID-19 crisis on smallholder farmers should be considered (e.g. Arouna *et al*., 2020). The facilitation of access to credit in Cote d'Ivoire could be one strategy to avoid food shortages and deficits among value chain actors.

6. Conclusion

This study aimed to estimate the short-term impacts of COVID-19 on rice production and food security. Results showed that nine months after the start of the COVID-19 pandemic and one rice growing season, all rice farmers were aware of coronavirus. Most respondents stated that television and radio were their main sources of information on COVID-19 and the majority was aware of the different ways by which the coronavirus is transmitted. Village-level and farmer level questionnaires revealed that the COVID-19 pandemic has an uneven impact on rice farmers, with some being affected negatively and other farmers' conditions remaining the same. Remote villages experienced the negative effects from the pandemic as well. However, 38% of farmers experienced at least one negative impact of the coronavirus disease. Rice yield, income and ability to sell harvested paddy rice decreased for about 30% of farmers. Access to inputs and hired labor became more difficult and expensive for about 28% of farmers. The impact of COVID-19 was higher for male farmers than female farmers. The main factors that positively and significantly influenced the intensity of the impact of COVID-19 pandemic on farmers were household size, being married, being producer of foundation seed, access to credit in the past, facing drought and flood as constraints. Results also contribute to better understanding the impact of COVID-19 in rural area and the linkages between the two global crises of climate change and COVID-19 and highlights the need for integrated action for addressing the interconnected challenges.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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