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Research Article

Challenges and Opportunities for the Agricultural Producers in Sinana District in Reflection of COVID-19 Pandemic

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Introduction. Analyzing the effect of COVID-19 is an important issue in agricultural sectors. However, such analysis requires a complex hierarchical statistical model. Rapid spread of the COVID-19 pandemic has disrupted the world's production and productivity in many sectors. Among those sectors, the agricultural sector is highly affected. The Bale zone in the larger extent and Sinana district, in particular, is one of the potential agricultural areas in the Oromia regional state, Ethiopia where agriculture is the major sector in supporting the livelihood of thousands of subsistence farmers in the area as well as the country at large. *Research Methodology*. This study involved primary data collected from the farmers in the Sinana district during the period 2020–2021. A total of 991 farmers were selected from the entire 22 kebeles in the district. The data were analyzed using multilevel binary logistic random intercept regression models with maximum-likelihood parameter estimation. *Results*. Of the 991 farmers, 549 (55.4%) responded that COVID-19 has brought only challenges in their agricultural production and 311 (31.4%) responded both challenges and opportunities. About 632 (63.8%) of the farmers said that there was wastage of products such as milk, dairy, fruits, and vegetables. Three hundred twenty-eight (33.1%) of the participants obtained modernization in their agricultural production system like use of tractors and irrigation systems. According to the model results, farmer's sex, age, educational level, family size, farmland size, types of effect, aggravation in food insecurity, input delay, lack of workers, slowdown of service, falling in income, modernization in the system of production, wastage of product, and types of wasted products were identified as significant factors. About 8% of the total variability in the effect of COVID-19 is due to differences across kebeles (ICC = 0.08, P value ≤ 0.05), and the remaining is due to individual differences. *Conclusion*. This study further demonstrated the potential of a hierarchical model for the study of COVID-19 effect variation within and between the kebeles. The majority, about 92% variation in the effect, is due to the disparity of individuals (farmers). The farmers with large family sizes and high capacity to produce and who were females were negatively related to the effect of COVID-19 in agricultural production.

1. Background

The rapid spread of COVID-19 pandemic has disrupted the world's production and productivity in many sectors and, as a consequence, slowed down the world's economic growth to a larger extent. The agricultural sector is among the highly affected especially in the Third-World countries. Even during prepandemic times, agricultural production was subjected to high risk, as compared to other sectors, because of its dependence on environmental conditions, which are largely unpredictable nowadays. The pandemic halted the rate of economic growth in many countries during 2019 and is expected to result in severe recession in the upcoming years, especially in the Third-World countries where agriculture is a key sector [1]. bib3

Ethiopia is among the highly affected countries and faced a dramatic decrease in agricultural production and productivity, hence a minimum economic growth (GDP) as compared to the last ten years. The pandemic and related partial social restrictions have posed a negative impact on the smallholder farmers such as market loss and cause significant income losses in specific sectors such as livestock and horticulture [2].

A number of farmers had left some vegetables on the field to rot due to the lack of buyers. Prices of important inputs crucial to vegetable production such as fungicides, insecticides, herbicides, fertilizers, and improved seeds are increasing due to shortages. These seem to be linked to land border closings, which have blocked imports from neighboring countries, and to reduced imports from China [3]. Labor shortages, due to the stay-at-home policies, are expected to impact production and processing of food, especially for vegetables, meat, and dairy-processing plants that usually require a large number of daily laborers. For pastoralists, there will be a loss of income from selling livestock and products (milk, butter, ghee, and eggs), resulting in an increased reliance on the environment (charcoal burning) and overall reduction in the purchasing power of households [4].

Following the pandemic and social restrictions, the highest increment in the food price has been recorded for nutritious foods such as fruits, vegetables, meat, eggs, and dairy products. Similarly, the pandemic coincided with the start of the long rainy seasons in Eastern Africa, particularly in Ethiopia, where labor-intensive staple food and vegetable production across the region is performed. The pandemic directly affected food systems by impacting both food supply and capacity to produce and distribute food and hence decreased consumers' purchasing power. Pandemic restrictions have also imposed access to agricultural input such as improved seeds, fertilizers, and insecticides that in one way or the other reduced production and productivity. On top of that, transportation facilities from rural areas to the processing centers and/or markets were highly impaired [5].

The pandemic has a negative effect on pre-existing gender and other intersecting inequalities (age, ethnicity, race, disability) in all dimensions of food security and nutrition, through reduced food production and distribution capacities, decreased purchasing power, and diminished access to nutritious food [6].

Bale zone in the larger extent and Sinana district in particular is one of the potential agricultural areas in the Oromia regional state, Ethiopia, where agriculture is the major sector in supporting the livelihood of thousands of subsistence farmers in the area as well as the country at large. However, this year, 25 to 45 percent of the population in the area faced food insecurity, which is the largest figure as compared to the past years. The main drivers for such severe food insecurity include COVID-19 pandemic and increased food prices [7]. To minimize the problems and eventually to support food security in the area, the Federal Democratic Republic of Ethiopia together with the regional and district agricultural offices is working towards the modernization of agriculture and providing agricultural inputs and loans for mechanized framings.

Even though analyzing the effect of COVID-19 is an important issue in agricultural sectors, such analysis requires a complex hierarchical statistical model. Thus, this study was initiated to assess the challenges and opportunities of agricultural productions in reflection to the COVID-19 pandemic using a multilevel approach, because most of the studies on COVID-19 are based on a qualitative study. For example, according to Jiang et al. [8], COVID-19 has pointed out that it is adversely affecting the development of China's grain cultivation, livestock, seed industry, recreational agriculture, agricultural product processing, vegetable industry, fruit industry, flower industry, and so on. Zhang et al. [9] showed that COVID-19 has a potential impact on almost every aspect of agribusiness, including mass unsellable agricultural products, underdeveloped livestock sector, disruption of agricultural supply, obstruction of trade in products and agricultural products, reduction of farmers' income, and increased rural poverty. Prosper Bright et al. [10] have conducted a study to assess the impact of COVID-19 pandemic on agricultural extension and food supply in Zimbabwe and pointed out that agricultural extension and food supply was grossly affected by COVID-19. Seneshaw et al. [3] have tried to assess the immediate effects of COVID-19 on the vegetable value chain in Ethiopia. The finding suggests that producer prices for vegetables have been on the decline, and farm losses and shortage of farm inputs and their prices have been increased. Also, it stated that labor has been becoming scarce. Lagiso [5] has conducted a study to investigate challenges and opportunities of COVID-19 in the agricultural economy of Ethiopia and stated aggravation in food security, slowdown of service sectors, the decline in foreign currency, etc. as challenges. Also, import substitution and innovation have been pointed out as opportunities. Besides, no study conducted before related to the issue in the study area. The information generated from the study could be used at regional, national, and international levels to circumvent the problem of food security ahead by improving the agricultural sector.

2. Research Methodology

2.1. Study Area, Study Population, and Data Collection. This study was conducted at the Bale zone, Sinana district, Oromia regional state, Southeast Ethiopia (Figure 1). Robe, the zonal city, is 430 km from Addis Ababa, the capital of Ethiopia with 7° 08′ N (latitude), 39° 59′ E (longitude). Sinana district (woreda) was selected because of the wider agricultural practices in the area and its proximity to Robe town, the zonal capital, and hence larger registered COVID-19 cases.

This study involved 991 household farmers (study population) sampled from the source population (all individuals in the district engaged in the farming process) using cluster-sampling technique. Accordingly, the target population was divided into different groups called clusters assuming heterogeneity in responses among members within the clusters. Thus, a randomly selected sample cluster is representative of the whole target population. Primary data were collected from the selected farmers using a well-structured questionnaire, which was prepared carefully from the related literature studies.

2.2. Research Hypothesis

(i) H_0: there is no association between the response variable and particular predictor

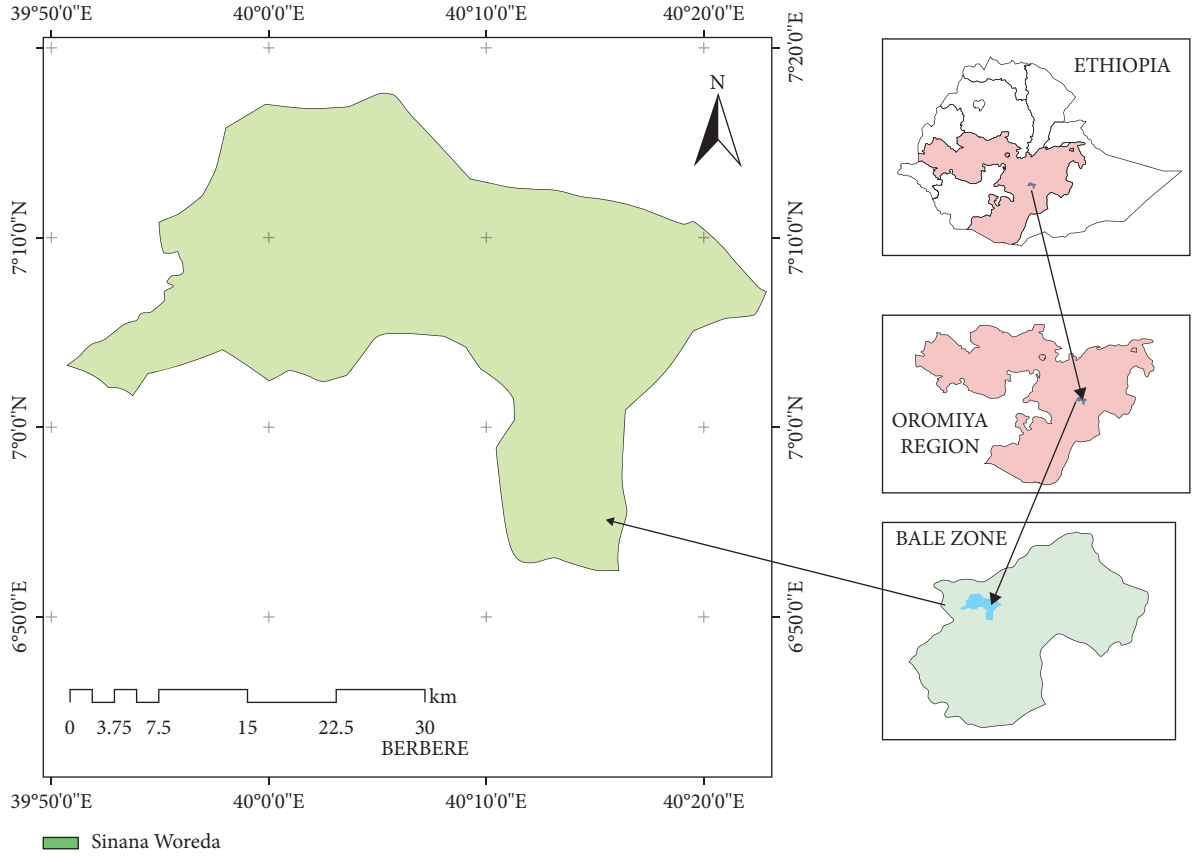

Figure 1: Map of the study area. Source: drawn by ArcGIS expert in 2020 EC.

(ii) H_1: there is association between the response variable and particular predictor

2.3. Study Variables. The effect of COVID-19 on agricultural production during the period of data collection was considered a response (dependent) variable and classified as yes (those who experienced the ill effect during the pandemic) and otherwise no. It was used to indicate whether one has faced the effect of COVID-19 or not and represented as follows.

The interview questions included the most important challenge and opportunity of COVID-19 in agricultural production among Sinana farmers, which was addressed using specific questions ranging from demographic data such as kebele, sex, age, marital status, educational level, family size, religion, and ethnicity of the respondents to questions that directly targeted agriculture in the area. Some of the questions were farmland size, types of effect, aggravation in food insecurity, input delay, lack of worker, slowdown of service, monthly income before and after pandemic, falling in income, modernization in the system of production, capacity to produce and distribute, wastage of product, and types of wasted product.

2.4. Multilevel Random Intercept Binary Logistic Regression Model. The simplest multilevel model has a single residual term for each level. For example, in a model for kebele effects on the outcome variable, there would be women (level 1) residuals and kebeles (level 2) residuals. This has the effect of partitioning the residual variance into a between-kebeles and within-kebele component, which is why this model is often referred to as a variance components model. The model is also called a random intercept model because only the intercept term in the regression equation is assumed to vary randomly across kebeles, meaning that the kebeles differ with respect to the average value of the outcome variable (effect of COVID-19). The effects of explanatory variables are assumed to be the same for each kebeles. In this model, the log-odds (logit) of P_{ij} can be stated as the sum of explanatory variables:

$$\log it\left(P_{ij}\right) = \log\left(\frac{P_{ij}}{1-P_{ij}}\right) = \beta_{0j} + \beta_1 X_{1ij} + \ldots + \beta_k X_{kij}$$

$$= \beta_{0j} + \sum_{h}^{k} \beta_h X_{hij}. \tag{1}$$

Here, the intercept term is random across level-2 units. So it can be expressed as

$$\beta_{0j} = \beta_0 + U_{0j}. \tag{2}$$

Then, equation (1) can be written as

$$\log it\left(P_{ij}\right) = \beta_0 + \sum_{h}^{k} \beta_h X_{hij} + U_{0j}, \tag{3}$$

$$P_{ij} = \frac{\exp\left(\beta_0 + \sum_{h}^{k} \beta_h X_{hij} + U_{oj}\right)}{1 + \exp\left(\beta_0 + \sum_{h}^{k} \beta_h X_{hij} + U_{oj}\right)}. \tag{4}$$

In equation (2), U_{0j} is considered the random part of the model, which is identically and independently distributed with mean 0 and variance σ_0^2, whereas the rest is the fixed part of the model since it is fixed in coefficients across the kebeles.

2.5. Intraclass Correlation Coefficient. The intraclass correlation coefficient (ICC) measures the proportion of variance in the response variable and is explained by the grouping structure. In this study, it was used to examine the proportion of challenges and opportunities of COVID-19 in agricultural production. In the model, the variation that occur across the study kebeles (i.e., level-2 units) was used, and hence, a two-level random intercept multilevel logistic regression model was employed as follows:

$$\text{ICC} = \frac{\sigma_0^2}{\sigma_0^2 + \sigma_e^2}, \tag{5}$$

where σ_e^2 is the individual farmers' variation at level 1.

2.6. Parameter Estimation. The maximum-likelihood (ML) method is a general estimation procedure, which produces estimates for the population parameters that maximize the probability of observing the data that are actually observed. Assuming that the conditional distributions of Y_{ij} given the random effect U_{ij} are independent of each other, the conditional density of Y_{ij} is given by p_{ij}:

$$Y_{ij}|U_j = \left(\frac{y_{ij}}{u_{ij}}\right) \sim \text{bernou.lli}. \tag{6}$$

For a two-level logistic Bernoulli response model, where random effects are assumed to be multivariate normal and independent across units, the marginal likelihood function is given by

$$l(\beta, \Omega) = \prod_i f \prod_i \left(\pi_{ij}\right)^{y_{ij}} \left(1 - \pi_{ij}\right)^{1 - y_{ij}}, \tag{7}$$

where Ω is the variance covariance matrix.

$$\pi_{ij} = \left(1 + \exp\left(-x_{ij}\beta_j\right)\right), \quad \beta_j = \beta + U_j. \tag{8}$$

$f(U_{ij}, \Omega)$, typically assumed to be the multivariate normal density, can be written in the form $\int p(U_j) f(U_j)\, \mathrm{d}u_j$.

2.7. Quality Checking Methods and Statistical Analysis. The primary data obtained through questionnaires were checked for completeness and consistency, and analysis was performed using MLwin. Accordingly, descriptive statistical methods were employed to summarize the study variables, and cross-tabulation was used to identify the relationship between the variables. Similarly, a random intercept model with CCI was used to identify the variation in challenges and opportunities of COVID-19 in agricultural productions. Variables showing significant association ($P < 0.25$) in the univariate analyses were included in the multiple variables' analysis of the random intercept model. Odds ratio (OR) and corresponding 95% confidence interval (95% CI) were estimated for significant explanatory variables.

3. Results

3.1. Respondent's Sociodemographic Descriptions. Demographic data of the respondents are summarized and presented in Table 1. Accordingly, in total, 991 farmers from 22 kebeles/villages were considered, and majority of the respondents (821) (82.9%) were male and the remaining were females. Age of the respondents ranges from 31 (minimum) to 76 (maximum). Similarly, the estimated median of the farmland size in hectare and family size of farmer in number were consequently 2.5 with a standard deviation of 1.3 and 6 with a standard deviation of 2.6. With regard to ethnicity, majority of the respondents (608 or 61.4%) belong to the Oromo ethnic group. Majority of the respondents (772 or 77.9%) were married, and the remaining were single (11 or 1.1%), divorced (124 or 12.5%), and widowed (84 or 8.5%). Regarding their religious outlook, around 521 (52.6%) were Muslim followers followed by Orthodox followers (356 or 35.9%), Protestant followers (80 or 8.1%), and others (34 or 3.4%). With regard to the educational status of the respondents, majority of the farmers (558 or 56.3%) had attended primary education, whereas the remaining significant numbers (233 or 23.5%) were unable to read and write. With regard to specific kebeles within the district, the respondent farmers revealed that a larger proportion of the farmers in all kebeles have experienced COVID-19-led challenges although the extent varies among the areas. Accordingly, the largest proportion of farmers (76 or 7.7%) faced several challenges in agricultural production and productivity due to COVID-19 pandemic, which was observed in Obora kebele followed by Selka (71 or 7.2%). Ilu Sanbitu (59 or 6%), Hisu (56 or 5.7%), Hawusho (51 or 5.2%), and Shalo (51 or 5.2%) kebeles have also registered reduced agricultural production and productivity (Table 1).

3.2. Types of COVID-19 Effects on Agricultural Activities of Farmers. A summary of the types of effects of COVID-19 on agricultural production and productivity in the study area is presented in Table 2. Accordingly, the majority of the farmers (549 or 55.4%) responded that they have been adversely affected by COVID-19 and thus faced a strong challenge with regard to their agricultural production and productivity. The remaining 311 (31.4%) faced both challenges and gained opportunity partly because of the agricultural system that is modernized and their use of tractors and harvesting machines (combiner) during ploughing and

Table 1: Sociodemographic characteristics of the respondents.

Covariate	Category	Did COVID-19 have an effect on your agricultural production?		Total	Chi-sqr	P value
		No	Yes			
Sex	Male	104 (10.5%)	717 (72.4%)	821 (82.9%)	5.377	$P \leq 0.05$
	Female	33 (3.3%)	137 (13.8%)	170 (17.1%)		
Ethnicity	Oromo	59 (6%)	549 (55.4%)	608 (61.4%)	26.930	$P > 0.05$
	Amhara	50 (5%)	227 (22.9%)	277 (27.9%)		
	Others	28 (2.8%)	78 (7.9%)	106 (10.7%)		
Religion	Orthodox	70 (7.1%)	286 (28.8%)	356 (35.9%)	22.830	$P \leq 0.05$
	Muslim	63 (6.4%)	458 (46.2%)	521 (52.6%)		
	Protestant	1 (0.1%)	79 (8%)	80 (8.1%)		
	Others	3 (0.3%)	31 (3.1%)	34 (3.4%)		
Education levels	Cannot read and write	51 (5.1%)	182 (18.4%)	233 (23.5%)	36.546	$P \leq 0.05$
	Primary	82 (8.3%)	476 (48%)	558 (56.3%)		
	Secondary and above	4 (0.4%)	196 (19.8%)	200 (20.2%)		
Marital status	Married	70 (7.1%)	702 (70.8%)	772 (77.9%)	163.686	$P \leq 0.05$
	Divorced	17 (1.7%)	107 (10.8%)	124 (12.5%)		
	Widowed	50 (5.1%)	34 (3.4%)	84 (8.5%)		
Kebele of the respondent	Basaso	7 (0.7%)	35 (3.5%)	42 (4.2%)	54.851	$P \leq 0.05$
	Hamida	10 (1%)	34 (3.4%)	44 (4.4%)		
	K.x.Isleemana	15 (1.5%)	35 (3.5%)	50 (5.1%)		
	Kaso shakmara	17 (1.7%)	31 (3.1%)	48 (4.8%)		
	Hora boka	10 (1%)	37 (3.7%)	47 (4.7%)		
	Robe surround	7 (0.7%)	41 (4.1%)	48 (4.9%)		
	Gamora	7 (0.7%)	32 (3.2%)	39 (3.9%)		
	Obora	10 (1%)	76 (7.7%)	86 (8.7%)		
	Alage	7 (0.7%)	37 (3.7%)	44 (4.4%)		
	Hawusho	5 (0.5%)	51 (5.2%)	56 (5.7%)		
	Ilu sanbitu	7 (0.7%)	59 (6%)	66 (6.7%)		
	Salka	3 (0.3%)	71 (7.2%)	74 (7.5%)		
	Waltai bariso	2 (0.2%)	24 (2.4%)	26 (2.6%)		
	Hasan barera	7 (0.7%)	39 (3.9%)	46 (4.6%)		
	Hisu	11 (1.1%)	56 (5.7%)	67 (6.8%)		
	Waltai arjo	3 (0.3%)	44 (4.4%)	47 (4.8%)		
	Shawade	5 (0.5%)	29 (2.9%)	34 (3.4%)		
	Shalo	4 (0.4%)	51 (5.2%)	55 (5.6%)		
	Waltai weyib	2 (0.2%)	44 (4.4%)	46 (4.6%)		
	Basmanna	3 (0.3%)	23 (2.3%)	26 (2.6%)		

Source: Sinana district direct field research.

Table 2: Nature of the effect of COVID-19 on agricultural production.

Covariates	Category	Did COVID-19 have an effect on your agricultural production?		Total	Chi-sqr	P value
		No	Yes			
Types of effects of COVID-19 in agriculture	Challenge	6 (0.6%)	543 (54.8%)	549 (55.4%)	907.975	$P \leq 0.05$
	Opportunity	—	—	—		
	Both challenge and opportunity	2 (0.2%)	309 (31.2%)	311 (31.4%)		
	Not both challenge and opportunity	129 (13%)	2 (0.2%)	131 (13.2%)		

Source: Sinana district direct field research.

harvesting time that is less labor-intensive as compared to those who are using oxen and human power, especially during harvesting.

3.3. Challenges of COVID-19 in Agricultural Production in Sinana District. According to the farmers' response, one of the challenges during the COVID-19 pandemic was the lack and/or

interruption of agricultural inputs such as inorganic fertilizers, pesticides, and insecticides. In this regard, about three-fourth (741 or 74.8%) of the respondents revealed that they have severely been affected and unable to get access to those agricultural inputs and thus registered very low productivity. Lack of labor work was also another challenge because of nationwide partial lockdown and restricted public movement. As a consequence, more than half of the respondents (517 or 52.2%) responded that they encountered a lack of workers to involve in their agricultural activity during the pandemic. Likewise, a large number of the respondents (632 or 63.8%) revealed that they suffered from a huge loss of postharvest, especially fruits, vegetables, and dairy products (milk, meat, and other products). As a consequence of challenges from COVID-19, larger proportions of the respondents (675 or 68.1%) have been suffering from severe food insecurity. With regard to cash income from agricultural products, there have been reductions in estimated monthly income among the farmers. The estimated median monthly income of the respondents before and during COVID-19 was 1600 and 800 Birr/month, respectively (Tables 3 and 4).

3.4. Opportunities of COVID-19 in Agricultural Production of Farmers in Sinana District. Out of the total individuals in the study, only one hundred fifteen farmers (11.6%) practiced innovation in irrigation, and 328 (33.1%) of them obtained modernization in their agricultural production system such as use of tractors and combiners (Table 5).

3.5. Multilevel Random Intercept Binary Logistic Regression Analysis

3.5.1. Test of Heterogeneity. Having prehand information regarding the heterogeneity of effect of COVID-19 on farmers' agricultural production among the study kebeles is important in analyzing the data using a multilevel approach. In this regard, chi-square test statistic was employed and the result is shown in Table 1. Accordingly, the cross-tabulated result revealed a chi-square value of 54.851 at $df = 19$, $P \leq 0.05$. The test, hence, supports the rejection of the null hypothesis and the conclusion on the existence of heterogeneity regarding the effect of COVID-19 on agricultural production among the farmers in the sampled kebeles of Sinana district, Ethiopia (Table 1).

To unwind the assumption of conditional independence among the explanatory variables for the same kebele given the covariates, a kebele-specific random intercept β_{0j} has been included to the linear predictor in order to obtain a random intercept multilevel logistic regression model. The random intercept logistic regression model is a multilevel model, which has random intercept of predictors. To identify the effect of explanatory variables, a multilevel binary logistic regression model with random intercept was estimated (Table 6).

The variance component in the random effect represents the variation between kebeles. Accordingly, there is a little change in the estimate of between-kebeles variance, suggesting that the distribution of fixed explanatory variables is similar across the kebeles in the study district. The decrement in the random effect of the variance component is attributed to the inclusion of fixed predictors considering the fixed explanatory variable extra predictive value for the effect of COVID-19 on agricultural production of farmers in each kebele. The result is basic in indicating a significant variation with regard to the effect of COVID-19 on agricultural production among farmers in the study kebeles (Table 6).

The results from the random intercept model (Table 6) showed that the random intercept β_{0j} is significant implying that the average effect of COVID-19 is differing from kebele to kebele. The intercept estimation is random at the kebele level, $\mathrm{Var}(u_{0j})$. Thus, the value of $\mathrm{Var}(u_{0j}) = 0.287$ is the estimated variance component of the intercept. The multilevel logistic regression analysis result displayed in Table 6 confirmed the significance of kebele difference in the effect of COVID-19 in the agricultural production of farmers in Sinana district, Bale zone in Ethiopia.

The deviance-based chi-square value for random effects in the random intercept model was 26.94 at $P \leq 0.05$. The result implies that farmers with the same characteristics in different kebeles have faced a different pandemic effect with regard to agricultural production and a clear kebele effect. Variance in the fitted model for the random parts of level 1 and level 2 was found to be significant implying that individual farmers and kebeles variation played a key role in determining the differences in challenge and opportunity of COVID-19 on agricultural production from random intercept and fixed explanatory model point of view (Table 6).

Based on the result of the random intercept model displayed in Table 6, the estimated intrakebele correlation coefficient (ICC) was 0.08 and the result is statistically significant at the 5% level of significance. The result indicates that about 8% of the total variability due to the effect of COVID-19 on the agricultural production of farmers is due to differences across kebeles and the remaining unexplained 92% is attributable to individual differences. The result of the model also indicates the existence of variation with regard to the effect of COVID-19 on agricultural production in farmers among Sinana district. Sex, age, educational level, family size, farmland size of the farmers, exposure to food insecurity, input delay, lack of worker, slowdown of service, falling in income, modernization in a system of production, wastage of product, and types of wasted products were identified as significant factors at 5% level of significance.

4. Discussion

The demographic characteristics of the respondents involved in the present study are not evenly distributed. For example, with regard to sex, there is a significant male dominance, suggesting females' inability in taking part in agricultural activities due to pandemic fear. This finding is similar to [11] that women are more anxious about the COVID-19 pandemic than men, and they take considerable precautions to avoid contamination.

Similarly, the result suggests religious pressure that already outcasted the involvement of females in agricultural activities and owning family wealth [12]. Majority of the male farmers involved were older, and the younger farmers are very minimum in number. This may be due to the

Table 3: Challenges of COVID-19 in agricultural production.

Covariates	Category	Did COVID-19 have an effect on your agricultural production?		Total	Chi-sqr	P value
		No	Yes			
Aggravation in food insecurity	Yes	7 (0.7%)	668 (67.4%)	675 (68.1%)	290.55	$P \leq 0.05$
	No	130 (13.1%)	186 (18.8%)	316 (31.9%)		
Slowdown of service sectors	Yes	8 (0.8%)	743 (75%)	751 (75.8%)	423.756	$P \leq 0.05$
	No	129 (13%)	111 (11.2%)	240 (24.2%)		
Input delay	Yes	5 (0.5%)	736 (74.3%)	741 (74.8%)	426.331	$P \leq 0.05$
	No	132 (13.3%)	118 (11.9%)	250 (25.2%)		
Dramatic fall in income	Yes	8 (0.8%)	827 (83.5%)	835 (84.3%)	737.079	$P \leq 0.05$
	No	129 (13%)	27 (2.7%)	156 (15.7%)		
Lack of workers	Yes	4 (0.4%)	513 (51.8%)	517 (52.2%)	154.53	$P \leq 0.05$
	No	133 (13.4%)	341 (34.4%)	474 (47.8%)		
Do have farming land	Yes	137 (13.8%)	854 (86.2%)	991 (100%)		
	No	—	—	—		
Purchasing power	Increase	1 (0.1%)	8 (0.8%)	9 (0.9%)	562.500	$P \leq 0.05$
	Decrease	7 (0.7%)	781 (78.8%)	788 (79.5%)		
	Constant	129 (13%)	65 (6.6%)	194 (19.6)		
Capacity to produce and distribute food	Increase	1 (0.1%)	38 (3.8%)	39 (3.9%)	876.441	$P \leq 0.05$
	Decrease	7 (0.7%)	810 (81.7%)	817 (82.4%)		
	Not changed	129 (13%)	6 (0.6%)	135 (13.6%)		
Wastage of products	Yes	7 (0.7%)	625 (63.1%)	632 (63.8%)	236.822	$P \leq 0.05$
	No	130 (13.1%)	229 (23.1%)	359 (36.2%)		
Type of wasted product	Milk and dairy	0 (0%)	93 (9.4%)	93 (9.4%)	261.630	$P \leq 0.05$
	Fruits and vegetables	5 (0.5%)	452 (45.6%)	457 (46.1%)		
	Meat	1 (0.1%)	26 (2.6%)	27 (2.7%)		
	Others	1 (0.1%)	75 (7.6%)	76 (7.7%)		
	No wastage	130 (13.1%)	208 (21%)	338 (34.1%)		

Source: Sinana district direct field research.

Table 4: Summary statistics for continuous covariates included in the study.

Covariate	Minimum	Maximum	Mean	Median	St. deviation
Age of the farmer in the year	31	76	47.3	46	8.0
Family size of the farmer in number	2	14	6.9	6	2.6
Farmland size in hectare	0.5	6	2.7	2.5	1.3
Total monthly income before COVID-19	100	6000	1923.8	1600	1169.0
Total monthly income during COVID-19	200	4500	1158	800	872.9

Source: Sinana district direct field research.

common belief that as farmers' ages increase, he/she may gain experience and improved handling capability, resulting in lack/shortage of farmland to be provided to the younger and productive age. Moreover, most of the younger males aspire to be recruited at governmental organization than involving in agricultural activities, which is of course highly labor-intensive and less mechanized. The result is in line with [13] that the productivity of a farmer increases with age, after it reaches some mid-age peak and then decreases with further aging.

Marital status of the respondents (almost all being married) suggests that agriculture is one of the top activities to support family livelihood in the area and hence the country's GDP. Almost all farmer households directly or indirectly depend on agricultural products to sustain their life and to generate cash. This result supported by [13] was found that married women were involved in the production of a relatively greater amount of output of cash crops than unmarried women since husbands prefer to have more land under cash crops than food crops. Most of the farmers in the area belong to the Oromo ethnic group, the largest group in the country as well. They are Muslims, the popular religion in the area and surrounding districts. This finding is similar to [14] that COVID-19 knows no race and has affected all ethnicities over the country. Almost all of the respondent farmers had only primary education and below, indicating the poor educational coverage of the country that left the agricultural system and other sectors backward and more of a traditional type. As a consequence, agricultural activities of the area and the country at large are of traditional type involving oxen and less productive as compared to the mechanized farming system in other countries. The result

Table 5: Opportunities of COVID-19 in agricultural production.

Covariates	Category	Did COVID-19 have an effect on your agricultural production?		Total	Chi-sqr	P value
		No	Yes			
Modernization in the agricultural system	Yes	2 (0.2%)	326 (32.9%)	328 (33.1%)	71.861	$P \leq 0.05$
	No	135 (13.6%)	528 (53.3%)	663 (66.9%)		
Innovation	Yes	1 (0.1%)	114 (11.5%)	115 (11.6%)	18.327	$P \leq 0.05$
	No	136 (13.7%)	740 (74.7%)	876 (88.4%)		

Source: Sinana district direct field research.

Table 6: Random intercept model results.

Covariate	Category	$\hat{\beta}$	OR	SE	Wald	P value	95% CI	
Age of farmers	Continuous	−0.115	0.891	0.043	−2.67	$P \leq 0.05$	−0.199	−0.031
Sex (male = Rf)	Female	−1.521	0.219	0.764	−1.99	$P \leq 0.05$	−3.018	−0.024
Family size	Continuous	−0.404	0.668	0.144	−2.81	$P \leq 0.05$	−0.685	−0.122
Types of effects of COVID-19 on agricultural production (challenge = Rf)	Challenge and opportunity	−8.062	0.000	0.899	−8.96	$P \leq 0.05$	−9.825	−6.299
	Not both	0.268	1.308	0.766	0.35	$P > 0.05$	−1.232	1.769
	Opportunity	—	—	—	—	—	—	—
Education level (cannot read & write = Rf)	Primary	1.043	2.838	0.683	1.53	$P > 0.05$	−0.296	2.382
	Secondary and above	2.857	17.411	1.234	2.32	$P \leq 0.05$	0.439	5.275
Farmland size	Continuous	0.015	1.231	0.202	0.08	$P > 0.05$	−0.381	0.411
Aggravation in FI (no = Rf)	Yes	2.360	10.59	0.735	3.21	$P \leq 0.05$	0.919	3.800
Input delay (no = Rf)	Yes	2.168	8.744	0.752	2.88	$P \leq 0.05$	0.695	3.642
Lack of worker	Yes	0.710	2.033	0.198	3.58	$P \leq 0.05$	0.321	1.098
Slowdown of service	Yes	4.749	115.51	0.387	12.28	$P \leq 0.05$	3.991	5.508
Falling in income	Yes	6.221	503.07	0.451	13.79	$P \leq 0.05$	5.336	7.105
Modernization in system	Yes	3.992	54.158	0.722	5.53	$P \leq 0.05$	2.576	5.408
Capacity to produce and distribute	Decrease	−7.098	0.001	1.209	−5.87	$P \leq 0.05$	−9.467	−4.729
	Not changed	1.149	3.155	1.097	1.05	$P > 0.05$	−0.999	3.298
Wastage of product (no = Rf)	Yes	4.001	54.628	0.402	9.96	$P \leq 0.05$	3.214	4.788
Types of wasted products (no wastage = Rf)	Fruits and vegetables	4.115	61.277	0.469	8.77	$P \leq 0.05$	3.195	5.035
	Milk and dairy	2.980	19.689	1.018	2.93	$P \leq 0.05$	0.984	4.976
	Meat	2.839	17.104	1.034	2.74	$P \leq 0.05$	0.812	4.867
	Others	3.820	45.617	1.017	3.76	$P \leq 0.05$	1.827	5.813
Constant		1.9151		1581	2.11	$P \leq 0.05$	1.605	2.225
Random effect	Var ($u$oj)	0.287		0.151			0.103	0.803
ICC	0.08							

LR test vs. logistic model: $X^2 = 26.94$ $P \leq 0.05$; Wald chi$^2 = 30.54$; $P \leq 0.05$. Source: Sinana district direct field research.

agrees with [15], which states that the education of farmers has been related to agricultural mechanization.

According to the farmers' response, the outbreak of COVID-19 has severely affected the entire agricultural production and productivity in the study area and the country at large. The partial lockdown and restriction of public movements during the pandemic has halted supply of fertilizers, selected seeds, pesticides, and insecticides. Similarly, as agricultural activities in the area are more of traditional and require larger human power, the restrictions due to the pandemic have left most of the farmlands idle and more of the products were wasted during harvesting. The finding agrees with [16] that market factors such as price volatility, high labor costs, or lack of labor availability have contributed to waste of products at the time of pandemic, and [17] as an increase in pandemic has increased labor scarcity in agricultural sectors. As a consequence, most of the subsistence farmers in the area were subjected to food insecurity and gained an ever-minimum income. Likewise, food price in the entire country has raised by more than a double in the last few months, and it keeps rising as the pandemic has still remained a public concern, which concord with [18].

With regard to the study kebeles, there have been slight variations in the effects of COVID-19 pandemic on agricultural production and productivity. The variation is largely attributed to the application of mechanized farming in few kebeles, which are very close to the capital of Bale zone, Robe town; otherwise, the pandemic was common to all the study kebeles.

Random intercept multilevel estimation model has been employed to detect the extents and levels of variation. Accordingly, the bivariate association between the effect of COVID-19 on agricultural production of farmers and all the predictors used indicate a strong association. The result suggests direct and indirect ill effects of the pandemic in reducing

agricultural production and productivity in the area and the country at large.

Similarly, the cross-tabulated result generated using multilevel binary logistic regression models revealed a significant (chi-square = 54.851, df = 19, $P \leq 0.05$) heterogeneity among farmers in the study kebeles in Sinana district with regard to the effect of COVID-19 on agricultural production. Accordingly, the model revealed that all the explanatory variables such as farmer's sex, age, educational level, family size, farmland size, exposure to food insecurity, input delay, lack of labor worker, slowdown of service, falling in income, lack of modernization in the agricultural system, and wastage of product were significant factors at 5% significance level. The model detected the extents of variation in the explanatory variables considered due to the study kebeles, which was about 8% of the total and the rest (92%, which was unexplained) were attributable to individual differences.

Odds ratio interpretation of ordinary logistic and multilevel logistic regression is almost similar except that the multilevel logistic regression models bear additional information (random part) than single-level regression model. For example, relying on the result of random intercept model depicted in Table 6, the odds of female farmers were 0.219 (adjusted OR = 0.219, 95% CI = (−0.199, −0.031)), by controlling other covariates constant including random effect. This shows that the odds of effect of COVID-19 on agricultural production of female farmers were 0.219 times lower than those of male counterparts.

In the same manner, the odds of farmers who attended primary-level education and above are 17.411 times that of those who cannot read and write (adjusted OR = 17.411, 95% CI = (0.439, 5.275)). The result suggests that the effect of COVID-19 on the farmers' agricultural production is higher in those farmers with primary-and-above-level education when compared to the reference category (who cannot read and write).

In the same way, the odd of farmers who face a lack of workers due to the pandemic was 2.033 (adjusted OR = 2.033, 95% CI = (0.321, 1.098)) times more likely than those farmers who have not faced. Similarly, farmers who have faced wastage of products have odds of 54.628 (adjusted OR = 54.628, 95% CI = (3.214, 4.788)) times than those who have not. The parameter estimate for the family size of farmers is −0.404; the negative sign indicates the decreasing rate of effect of COVID-19 in agricultural production.

Pearson chi-square test was applied to know predictors having a strong association with the response variable. For each predictor, a test of association was carried out using the Pearson chi-square at 25% level of significance. A high value of Pearson chi-square for a given predictor indicates that there is a strong association between dependent and independent variables keeping the effect of other factors constant.

5. Conclusion

The main purpose of this study was to estimate the challenges and opportunities of COVID-19 on agricultural production among farmers in Sinana district, Bale zone, Ethiopia. The study revealed a huge negative impact on the agricultural production and productivity of the farmers and the country at large. Of the 991 farmers, 549 said COVID-19 had only challenges in their agricultural production, and 311 had both challenges and opportunities. About 632 (63.8%) of the farmers said that there was wastage of products such as milk, dairy, fruits, and vegetables. Three hundred twenty-eight (33.1%) of the participants obtained modernization in their agricultural production system like use of tractors and irrigation systems. This study further demonstrated the potential of a multilevel random intercept model for the study of COVID-19 effect variation within and between the kebeles. The majority, about 92% variation of the effect, is due to the disparity of individuals (farmers). Farmers with a large family size and high capacity to produce, and whose sex is female were negatively related to the effect of COVID-19 in agricultural production. The odds of farmers who did not face both challenges and opportunities due to the pandemic was 1.308 (adjusted OR = 1.308, 95% CI = (−1.232, 1.769)) times more likely than those farmers who did face only challenges. This study also contributes to the literature by statistically examining challenges and opportunities for agricultural producers in Sinana district in reflection to COVID-19 and its countermeasures based on the variation within individuals and between kebeles that have been explained, which can provide more targeted implications for policymakers.

Abbreviations

CSA: Central Statistical Agency
FAO: Food and Agricultural Organization
GDP: Growth domestic product
ICC: Interclass correlation
Rf: Reference
UN: United Nations.

Data Availability

The datasets supporting the conclusions of the study are included in the article, and the datasets used for analysis during the current study are available from the corresponding author on reasonable request.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

Authors' Contributions

MA, AL, and MH developed the strategy for the review, screened titles and abstracts, conducted the quality assessment, supported data extraction, contributed to the writing of the manuscript, and undertook data extraction. MA, AL, and FG conducted the quality assessment and contributed to the writing of the manuscript.

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References

[1] C. Cevher, B. Altunkaynak, and M. Gürü, "Impacts of COVID-19 on agricultural production branches: an investigation of anxiety disorders among farmers," *Sustainability*, vol. 13, no. 9, p. 5186, 2021.

[2] D. Varshney, A. Kumar, A. K. Mishra, S. Rashid, and P. K. Joshi, "IndiasCOVID-19 social assistance package and its impact on the agriculture sector," *Agricultural Systems*, vol. 189, Article ID 103049, 2020.

[3] S. Tamru, K. Hirvonen, and B. Minten, *Impacts of the COVID-19 Crisis on Vegetable Value Chains in Ethiopia*, International Food Policy Research Institute, Washington, DC, USA, 2020.

[4] FAO, *Impact of COVID-19 on Agriculture, Food Systems and Rural Livelihoods in Eastern Africa: Policy and Programmatic Options*, FAO, Rome, Italy, 2020.

[5] D. Lagiso, "Challenges and opportunities of Covid-19 in agricultural economy: the case of Ethiopia," *Journal of Asian and African studies*, vol. 65, 2020.

[6] FAO, *COVID-19 and its Impact on Agri-Food Systems, Food Security and Nutrition: Implications and Priorities for the Africa Region*, FAO, Rome, Italy, 2020.

[7] FAO, *FAO–WFP Crop and Food Security Assessment Liberia*Food and Agriculture Organization of the United Nations, Rome, Italy, 2014.

[8] H. Y. Jiang, C. Yang, and C. Guo, "Impact of novel coronavirus pneumonia on agricultural development in China and its countermeasures," *Journal of Food Safety and Quality*, vol. 11, no. 22, 2020.

[9] H. Zhang, L. X. Hu, and Z. Hu, "Attach great importance to the Impact of the new crown disease on the agricultural rural economy—proper response, precise measures, insurance, supply and increase income," *Farmers Daily*, 2020.

[10] P. Muvhuringi, N. T. Kudzai, and C. Ngavaite, "The impact of COVID-19 on agricultural extension and food supply in Zimbabwe," *Cogent Food & Agriculture*, vol. 7, no. 1, 2021.

[11] F. Hesham, H. Riadh, and N. K. Sihem, "What have we learned about the effects of the COVID-19 pandemic on consumer behavior?" *Sustainability*, vol. 13, no. 8, p. 4304, 2021.

[12] U. Monica Ejim, *Religion and Gender Roles in Africa: A Case Study of Agricultural Patterns in Nike Primal Community*, 2017.

[13] T. Kiriti and C. A. Tisdell, "Marital status, farm size and other influences on the extent of cash cropping in Kenya: a household case study," *Social Economics, Policy and Development Working Papers*, Article ID 105586, 2003.

[14] L. M. Beyene, T. Ferede, and G. Diriba, *Ethiopian Economics Association (EEA) the Economywide Impact of the COVID-19 in Ethiopia,*Ethiopian Economics Association, Addis Ababa, Ethiopia, 2020.

[15] D. L. Debertin, A. Pagoulatos, and A. Aoun, "Determinants of farm mechanization in Kentucky: an econometric analysis," *North Central Journal of Agricultural Economics*, vol. 4, no. 2, pp. 73–80, 1982.

[16] B. Ellison and M. Kalaitzandonakes, "Food Waste and Covid-19: Impacts along the Supply Chain," *Department of Agricultural and Consumer Economics*, University of Illinois, Champaign, IL, USA, 2020.

[17] A. Ulfa, A. Nugroho, T. H. Pospos, G. Suherman, and N. Ariyati, "Global pandemic and agriculture in Aceh province, Indonesia: an initial impact," *IOP Conference Series: Earth and Environmental Science*, vol. 667, no. 1, Article ID 012099, 2021.

[18] FAO, *Anticipating the Impacts of COVID-19 in Humanitarian and Food Crisis Contexts*, FAO, Rome, 2020.