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Food security of agri-food system actors during the COVID-19 pandemic in the Philippines: Post-pandemic implications to sustainable development

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ABSTRACT

The COVID-19 pandemic had global reach and widespread effect, particularly concerning food security. As food supply chains become disrupted, food producers struggle to access markets. Thus, there is a need to examine the factors affecting the food security of agri-food system actors, particularly smallholder farmers in the Philippines. Utilizing the eight-question survey module of the FAO's Food Insecurity Experience Scale (FIES) and questions regarding their socio-demographic profile, 215 agri-food system actors including smallholder farmers, processors, logistic providers, and traders were surveyed from February to May 2021. An ordered probit regression was used to determine the factors affecting the severity of the food insecurity of agri-food system actors. Smallholder farmers, larger households, and Indigenous Peoples' groups experience an increase in food insecurity. Conversely, the determinants of reduced severity of food insecurity include other agri-food system actors, reporting profitability during the COVID-19 lockdown period, older age, being married, having more employed household members, and having savings. Results reflect farmers being among the severely impacted sectors during the pandemic. The findings shed light on several resilience and post-pandemic implications to sustainable development, such as designing resilient food systems by securing farmers' access to inputs and markets and improving their profitability. Furthermore, there is a need to transform current food systems into being more inclusive by targeting younger farmers, Indigenous Peoples' groups, and poor farmers having limited means to increase their financial capital to improve food security in rural communities. This study is the first empirical evidence documenting the extent of food insecurity among agri-food system actors during extreme shocks.

1. Introduction

The COVID-19 pandemic created disruptions [1–3], particularly concerning mobility restrictions [4,5]. Agri-food systems, encompassing the interconnected food supply chain from food production to consumption and the associated social activities and natural resources [4], were negatively affected [1,3,5]. Food insecurity became apparent due to the income loss as a consequence of the exclusion of agri-food system actors from markets and their resulting descent into poverty [6]. The need for income generation necessitated individuals to leave home notwithstanding the risk of COVID-19 transmission [7]. Consequently, agri-food systems experienced disrupted crop planting and harvests, logistics constraints, and reduced marketing ability [2,5].

While largely exempted from lockdowns [3,4,8], agri-food system actors were still affected by the restricted mobility during the COVID-19 pandemic in the form of income shocks and reduced purchasing power [5]. Of these actors, smallholder farmers are among the most vulnerable and poorest [9], such as in low- and middle-income countries (LMICs) [2,4]. People in rural areas are commonly employed in the agriculture sector [10], and farmers have faced numerous challenges during the pandemic, such as wastage of harvest due to oversupply [11] and lack of farm labor [5]. Moreover, while there were COVID-19 pandemic-related policies, these had varying impacts across the sustainable livelihoods capital [12].

The Philippines' first COVID-19 case was on the January 30, 2020 [13]. By June 2, 2024, the reported cases increased to 4,140,383 [14]. As in other nations that implemented measures to curb rising COVID-19 cases, the Philippines implemented lockdown measures, such as the

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enhanced community quarantine (ECQ) which started on 17 March 2020 for Luzon [15]. Most areas were removed from the strictest lockdown restrictions by 1 June 2020 [16]. Agri-food systems in the country were largely exempted from lockdown restrictions and other essential services [8]. In the Philippines, food security was seen to be affected by the COVID-19 pandemic [17] and the agri-food systems were shown to be vulnerable to external shocks [4], aggravating food insecurity [17]. The rank of the Philippines in the 2023 Global Hunger Index [18], 66th place out of 125 countries with a score of 14.8 or moderate hunger for 2023, supports the need to examine food security levels of the agri-food system actors.

Extending some earlier and related papers of Ouoba and Sawadogo [6], Angeles-Agdeppa et al. [17], Alpízar et al. [19], Elsahoryi et al. [20], Kansiime et al. [21], Villanueva et al. [22], and de Haro Mota et al. [23], this study employs a quantitative approach in determining the extent of food insecurity and its determinants. This paper contributes to the emerging body of literature on food insecurity by examining the determinants of food insecurity during the COVID-19 pandemic on agri-food system actors in the Philippines, where some agri-food system actors such as on the upstream nodes (i.e., farmers) were seen to be heavily affected by the pandemic [8]. This also aims to contribute to the quantitative empirical literature on the impacts of the COVID-19 pandemic on agri-food system actors' food security, focusing on farmers, processors, logistics, and traders. This paper focuses on mainstream food insecurity metrics amongst agri-food system actors and their relationship to households' capital during the COVID-19 lockdown period. The implications from this study could also contribute to post-pandemic insights to sustainable development, in light of the 2030 Sustainable Development Goals (SDGs) on zero hunger of the United Nations (UN) [24] and discussions on strengthened resilience of agri-food systems [3]. Furthermore, findings from this paper also present relevant policy implications regarding food security in the Philippines.

Section 2 reviews the related literature on agri-food systems in the Philippines during the COVID-19 pandemic, the concept of food security, and the food security of agri-food system actors. Section 3 discusses the materials and methods used in this study, including the Food Insecurity Experience Scale (FIES), data sampling and collection, and empirical model. Section 4 presents the results of the study, while section 5 provides a discussion of the results on the determinants of food insecurity and implications to food security and sustainable development. The last section (6) offers concluding statements and identifies policy recommendations.

2. Review of related literature

Studies have been conducted that examined the level of food security during the COVID-19 pandemic. Angeles-Agdeppa et al. [17], Rivera et al. [25], and Pavo et al. [26] are among the studies in the Philippines that examined the food security of individuals and households but these were from the lens of consumers, rather than the agri-food supply chain as a whole. This study aimed to disaggregate the food security status of the general population, focusing on each agri-food system actor from production to distribution that may have been affected by income loss and supply chain disruptions due to the COVID-19 pandemic. Sections 2.1 to 2.3 present the literature on the agri-food system actors and food security.

2.1. Agri-food systems in the Philippines during the COVID-19 pandemic

The Philippine agricultural sector has long been plagued by weak growth, producers' low income, low labor supply, poor transportation, and lack of inputs and financial capital, among other constraints [16]. Some producers affected by COVID-19 lockdowns chose to sell their harvests closer to communities via small wet markets known as *talipapas* [27]. Some local government units also encouraged this approach to avoid congestion and infection in larger public markets [28]. However, like other nations [11], some farmers chose to discard their harvested produce citing low prices due to high supply and low demand, such as in the vegetable-producing province of Benguet in the northern Philippines [29]. This practice was observed even before the pandemic [30].

In the downstream nodes of the agri-food system, restaurants and the livelihood of workers especially the minimum wage earners were affected by the prohibition of dine-in options [31]. The lockdown period also led to panic-buying among some consumers [16] which was prohibited [32]. Access to markets was allowed provided that measures such as price control and anti-hoarding [32] and public health guidelines including physical distancing and shifting schedules for shoppers to avoid mass gatherings were observed [5].

Several initiatives emerged in the Philippines during this period. Similar to trends in other nations [33], there was a rise in online food selling and online shopping services of retailers [8]. Another initiative was the community pantry which involves the distribution of free vegetables, fruits, canned goods, rice, and other food items among households in the neighborhood, an act of "social charity" that became widespread across the country [34]. Operating on a "give what you can, take what you need" principle, this endeavor started through local partnerships with agri-food system actors such as growers who offered their products for free [35]. The *Kadiwa ni Ani at Kita* program of the Department of Agriculture (DA), an initiative that directly links farmers and fishers with consumers [5,36] was continued during the pandemic [37]. Another initiative of the DA, the *Plant Plant Plant Program*, was envisioned to increase food production [5].

2.2. The concept of food security

As a facet of human development, "*food security exists when all people, at all times, have physical and economic access to sufficient, safe and nutritious food to meet their dietary needs and food preferences for an active and healthy life*" [38]. The growing dilemma of securing the food needs of an expanding population has been experienced worldwide. There are concerns about the realization of the SDGs by 2030 [3,7,33], primarily SDG 2 on zero hunger with the onset of the COVID-19 pandemic [39]. A common risk factor affecting food security during the pandemic was the increase in food prices coupled with reduced incomes [40].

Food security is anchored on food availability, access, utilization, and stability [41], although agency and sustainability have been identified as additional pillars [42]. The concept of food security is of global relevance and is linked to poverty [21,33,43]. It can be equated with good nutrition only in the presence of sanitation, high-quality water, avoidance of diseases, and adequate health services [44]. Many factors determine the state of food security. In the Philippines, wild edible plants are crucial to the food security needs of Filipino Indigenous Peoples (IPs) [45], and coral reefs are linked to the food security of small fishing communities [46]. During the COVID-19 pandemic in the Philippines, government support and private donations of cash aid and food packs were among the strategies to alleviate food shortages experienced by vulnerable Filipinos [47]. However, these were seen as stop-gap solutions to the persistent issue of food security [8,43] and concerns regarding their nutritional value [47].

2.3. Food security of agri-food system actors

The concept of food security can be seen in terms of its nexus to agri-food system actors. On the upstream nodes of the chain, farmers play a major role in food production, especially in developing countries [48]. However, despite their important role in food security [9], farmers can be more susceptible to crises [49]. For instance, the findings of Alpízar et al. [19] showed that the hardships faced by farmers in Guatemala and Honduras may be indicative of the presence of ineffective strategies and coping mechanisms, which then increase the likelihood of farmers experiencing food insecurity. In a study conducted in LMICs, stricter

restrictions during the COVID-19 pandemic resulted in more severe effects on the food security and livelihood of smallholder farmers [50]. Thirty percent (30%) of the rural farmers in the last two income quintiles in Sri Lanka had to sell livestock and 20% of them had to liquidate their assets to reduce the impact of the pandemic [51]. Better policies are needed to increase the resilience of farmers to shocks in their food security [19]. In Tanzania, cassava is an important crop that contributes to the food security of smallholder farmers; however, this is challenged by several factors including pest incidence and social perception [52].

Melgar-Quiñonez et al. [53] assessed food insecurity among non-farmer actors in the agri-food system in three countries including the Philippines, using the Household Food Security Survey Module (HFSSM). Their results showed that food insecure individuals were associated with lesser food expenditure. Smith, Kassa, and Winters [54] used FIES in Latin America and the Caribbean following the multilevel linear model. Their results showed that low educational attainment, a limited social network, and residence in a poor country contributed to a higher likelihood of food insecurity. In a similar study, Smith, Rabbitt, and Coleman-Jensen [55] estimated the factors that increased food insecurity in 134 countries. Their results showed that low educational levels, low social capital, low household income, and unemployment increased the likelihood of food insecurity.

Shocks such as the COVID-19 pandemic affect people's food security [23]. Elsahoryi et al. [20] examined the effects of the COVID-19 pandemic among Jordanians and found that below poverty level monthly income and increases in the number of family members were significant factors that resulted in moderate to severe food insecurity. Regardless of other socio-economic characteristics, a study conducted in New Mexico found that individuals belonging to larger households have a greater likelihood to be food insecure [56]. Additionally, those aged 18–30 years and those renting their homes were significantly associated with severe food insecurity [20]. With the use of probit regression, Kansiime et al. [21] showed that there was an increase in food insecurity in Kenya and Uganda during lockdown in both countries, along with income shocks and changes in their dietary patterns. Lastly, individuals with higher incomes were less likely to be food insecure. In the Philippines, Villanueva et al. [22] used the Household Food Insecurity Access Scale (HFIAS) and reported that 73% of surveyed participants reported being food insecure during the COVID-19 pandemic. Additionally, Angeles-Agdeppa et al. [17] utilized both the FIES and the HFIAS in measuring food insecurity. Their findings showed a slightly lower incidence of 62% experiencing moderate to severe food insecurity. Moreover, their results showed that the poorest households had a higher likelihood of having more severe forms of food insecurity than their middle-income counterparts. In the study of Adhikari et al. [57], it was discussed that the Indigenous Peoples (IPs) were also among those found to be highly vulnerable as they lost external support during the strict mobility restrictions during the pandemic.

Summing up, the literature is synthesized into three key concepts. First, various shocks affect agri-food systems, especially during the COVID-19 pandemic resulting in many challenges that each agri-food system actor has to face. Second, food insecurity has been recorded even before the pandemic, and it is multi-faceted with different pillars or dimensions that need to be considered to address it. People living in LMICs are more vulnerable to food insecurity, particularly during the pandemic and other shocks. Third, food insecurity and its determinants have been widely documented in the literature using different experience-based modules such as FIES, HFIAS, and HFSSM, and among its factors are socio-demographic attributes. Food security studies conducted in the Philippines during the COVID-19 pandemic focus only on the consumers, but there has been no study conducted examining the food security level of agri-food system actors, namely, the farmers, processors, traders, and those involved in the logistics. Hence, this study investigated the food security experience of farmers, processors, logistics, and traders and identified the factors contributing to their food (in) security during the COVID-19 pandemic.

3. Materials and methods

3.1. Food Insecurity Experience Scale (FIES)

The Food Insecurity Experience Scale (FIES) of the UN Food and Agriculture Organization (FAO) records the experience of survey participants' food access [58]. In this paper, food insecurity was measured during the onset of ECQ or lockdown in the Philippines last 2020 during the early periods of the pandemic using FIES. Table 1 presents the eight-question module of FIES based on a reference time frame of 12 months. The survey tool included questions regarding the survey participants' socio-demographic profile.

3.2. Data sampling and collection

Primary data were sourced using personal interviews and online surveys of four agri-food system actors, namely, farmers, processors, logistics operators, and traders from February to May 2021. The questionnaire used for both modes of surveys had a reference period of 12 months which was characterized by COVID-19 mobility restrictions and lockdowns for 2020. A pre-test of the survey questionnaires was conducted in February 2021. A mixture of face-to-face interviews and online surveys was applied in this study. This was drawn from the literature of de Leeuw [59] which suggests a mixed-method approach to data collection. This approach was timely as the COVID-19 pandemic restricted the mobility of the participants and was in line with the public health guidelines that aimed to reduce the risk of COVID-19 transmission. Using a mixed-mode data collection approach is beneficial for time efficiency and mitigates limitations with adapting a single mode, such as coverage bias when prospective samples do not have an internet connection [59]. Furthermore, this type of data collection approach is less costly and improves sample composition [60]. As shown in Table 2, the mixed-mode data collection used in this study is the following: face-to-face interviews were conducted in Bicol Region, Central Visayas, Davao Region, and Northern Mindanao, while a Google Forms online survey was also administered containing the same set of questionnaires per actor. The areas surveyed are characterized by the presence of agri-food systems, as discussed by Malapit et al. [61], Ballesteros et al. [62], and Bayogan et al. [63]. These areas are located in the three major islands of the Philippines, namely Luzon, Visayas, and Mindanao.

For the interviews and surveys, the assistance of the local agricultural offices of the respective areas was tapped and a list of registered enterprises was gathered from the Department of Trade and Industry (DTI). Following the Declaration of Helsinki of the World Medical Association [64], informed consent was first secured from the sampled participants before the interviews proceeded. Power analysis was used to determine the sample size using G*Power [65]. Using the F-test for

Table 1
FAO food insecurity experience scale (FIES).

	During the last 12 months, *was there a time when*	Response
1	*"you were worried you would not have enough food to eat because of a lack of money or other resources?"*	Yes/No
2	*"you were unable to eat healthy and nutritious food because of a lack of money or other resources?"*	Yes/No
3	*"you ate only a few kinds of food because of a lack of money or other resources?"*	Yes/No
4	*"you had to skip a meal because there was not enough money or other resources to get food?"*	Yes/No
5	*"you ate less than you thought you should because of a lack of money or other resources?"*	Yes/No
6	*"your household ran out of food because of a lack of money or other resources?"*	Yes/No
7	*"you were hungry but did not eat because there was not enough money or other resources for food?"*	Yes/No
8	*"you went without eating for a whole day because of a lack of money or other resources?"*	Yes/No

Table 2
Distribution of survey participants.

Location	Farmer	Processor	Logistic	Trader	Total
Field visit					
Bicol Region (Luzon)	18	0	0	0	18
Central Visayas (Visayas)	16	0	5	1	22
Davao Region (Mindanao)	26	0	0	14	40
Northern Mindanao (Mindanao)	0	0	6	0	6
Online survey					
Google Forms	0	57	56	17	130
Total	60	57	67	32	215

linear multiple regression, particularly, fixed model with R-squared deviation from zero, effect size of 0.15 (medium effect), margin of error of 0.05, power of 0.95, and number of predictors of 10, the minimum sample size is 172. More samples are a better representation of the population [66]. A final sample size of 215 was used after omitting duplicate, invalid, and missing data, which was still greater than the G*Power-recommended useable sample size. Moreover, the sample size is greater than the specification of VanVoorhis and Morgan [66] which called for a minimum of ten participants per independent variable when the model utilizes six or more predictors. Of this number, 27.91% were farmers[1], 26.51% were processors, 30.70% were logistics providers, and 14.88% were traders[2] (shown in Table 5). For the software used in this paper, Microsoft Excel was used in the data curation, while Stata 13 was used in estimating the drivers of food insecurity through regression modeling.

3.3. Empirical model

FIES uses a dichotomous "yes/no" response for eight questions (Table 1). This paper extends the suggested thresholds of FAO [67], where 0 to 3 corresponds to secure-or-only-mildly food insecure, by breaking down this category into two distinct classifications, namely, food secure (0) and mildly food insecure (1–3). The categories for moderate (4–6) and severe (7–8) follow the suggested threshold of FAO [67], similar to Wambogo et al. [68] and Sheikomar et al. [69]. Other authors used the FIES raw score of 0–8 as the dependent variable, such as the papers of Grimaccia and Naccarato [70] and Grimaccia and Naccarato [71].

This paper follows previous studies that have utilized ordinal regression in identifying factors of food insecurity [70,71]. In this case, both ordinal logit and probit regression models were estimated, with the Akaike Information Criterion (AIC) and the Bayesian Information Criterion (BIC) used as post-estimation statistics to determine the appropriate model. Thus, the ordered logit/probit regression has categories as its dependent variable, namely, 0, 1, 2, and 3 for households with food secure and mildly, moderately, and severely food insecure status, respectively (Equation (1); Table 3):

$$Y_i = \begin{cases} 0, \ if \ Y_i^* \le k_0 \\ 1, \ if \ k_0 < Y_i^* \le k_1 \\ 2, \ if \ k_1 < Y_i^* \le k_2 \\ 3, \ if \ Y_i^* > k_2 \end{cases} \quad (1)$$

where Y_i, the level of food insecurity, is a representation of a latent variable Y_i^* defined by cut-off values k_0, k_1, and k_2, which is not measured but can be estimated as [72]:

Table 3
Description of the variables.

Variable	Type of variable	Description	References
Dependent variable			
Food insecurity threshold	Ordinal	0 = Food secure; 1 = Mildly food insecure; 2 = Moderately food insecure; 3 = Severely food insecure	FAO [67]; Wambogo et al. [68]; Sheikomar et al. [69]
Independent variables			
Agri-food system actor	Binary	1 = Farmer; 0 = Otherwise	Alpízar et al. [19]; Kansiime et al. [21]
Profitability during lockdown	Binary	1 = Profitable; 0 = Otherwise	Béné [4]; Béné et al. [73]
Sex	Binary	1 = Male; 0 = Female	Alpízar et al. [19]; Elsahoryi et al. [20]; Kansiime et al. [21]; Grimaccia and Naccarato [70]; Grimaccia and Naccarato [71]
Age	Continuous	Number of years	Alpízar et al. [19]; Elsahoryi et al. [20]; Kansiime et al. [21]; Smith, Kassa, and Winters [54]; Smith, Rabbitt, and Coleman-Jensen [55]; Grimaccia and Naccarato [70]; Grimaccia and Naccarato [71]; Magaña-Lemus et al. [74]; Kent et al. [75]
Education	Ordinal	1 = Elementary level; 2 = Elementary graduate; 3 = Secondary level; 4 = Secondary graduate; 5 = College level; 6 = College graduate; 7 = Post-graduate	Alpízar et al. [19]; Elsahoryi et al. [20]; Kansiime et al. [21]; Smith, Kassa, and Winters [54]; Smith, Rabbitt, and Coleman-Jensen [55]; Grimaccia and Naccarato [70]; Grimaccia and Naccarato [71]; Magaña-Lemus et al. [74]; Kent et al. [75]; Knueppel et al. [76]
Civil status	Binary	1 = Married; 0 = Otherwise	Elsahoryi et al. [20]; Smith, Kassa, and Winters [54]; Smith, Rabbitt, and Coleman-Jensen [55]; Grimaccia and Naccarato [70]; Kent et al. [75]
Household size	Continuous	Number of household members	Elsahoryi et al. [20]; Kansiime et al. [21]; Knueppel et al. [76]; Manyong et al. [77]
Number of employed household members	Continuous	Number of employed household members	Elsahoryi et al. [20]; Smith, Kassa, and Winters [54]; Smith, Rabbitt, and Coleman-Jensen [55]
Affiliation to an IP group	Binary	1 = Yes; 0 = No	Willows et al. [78]
Having reserve funds or savings	Binary	1 = Yes; 0 = No	Kansiime et al. [21]; Manyong et al. [77]

$$Y_i^* = \sum_{k=1}^{K} \beta_k X_{ki} + \varepsilon_i = Z_i + \varepsilon_i \quad (2)$$

where the parameter β_k are the coefficients of the independent variable X_{ki} and ε_i is the random error term. Table 3 also shows the independent variables used in the ordered logit/probit regression, wherein the model

[1] Since the size of smallholder farms varies, this paper operationalizes the terminology based on Hazell [9], which defines smallholder farms as less than 2 ha (ha) in size.

[2] The wholesalers and retailers are included in the count for traders.

estimates Z_i above using:

$$Z_i = \beta_1 actor_i + \beta_2 profitability_i + \beta_3 sex_i + \beta_4 age_i + \beta_5 education_i + \beta_6 civstatus_i + \beta_7 hhsize_i + \beta_8 employedhhmembers_i + \beta_9 indigenous_i + \beta_{10} savings_i \quad (3)$$

where the parameters $\beta_1, \beta_2, \ldots, \beta_{10}$ are the coefficients of the independent variables agri-food system actor, profitability during the lockdown, sex, age, education, civil status, household size, number of employed household members, affiliation to an IP group, and having reserve funds or savings, respectively.

Since the ordered probit regression model has the less AIC (528.77) and BIC (572.59) values compared to the ordered logit regression model (AIC of 529.77) and (BIC of 573.58), the former was used in the empirical model of determining the factors affecting food insecurity among agri-food system actors.

3.4. Robustness test

A corresponding robustness test was also conducted to determine the robustness of agri-food system actors as a determinant of household food insecurity. The robustness test involved running the ordinal probit regression, wherein non-core variables were removed from the baseline model [79,80] as shown in Equation (3). Since this paper focuses on the food security of agri-food system actors, this is selected as the core variable. The other independent variables were selected from the baseline model as non-core variables. Using the *checkrob* command of Stata [81], 2^9 or 512 regression models were estimated for the robustness test of agri-food system actors. The *checkrob* command in Stata presents the summary statistics of the robustness test of the 512 regressed models, similar to what has been reported in studies that utilized the same procedure by showing the summary statistics of the results from the robustness test (see Barslund et al. [79]; Bhimavarapu et al. [82]; and de Arce and Mahía [83]).

4. Results

The majority of the participants were either food secure (30.23%) or mildly food insecure (31.16%) while the remaining participants were moderately (17.21%) and severely (21.40%) food insecure (Table 4). Most of the participants were food processors, logistics, and traders (72.09%) while the farmers make up 27.91% of the participants. More than half of the sampled agri-food system actors reported being profitable during the lockdown (55.81%). The majority of the participants were male (56.74%) while 43.26% were female. The average age of the participants was 37.98 years old, while most (26.51%) of the participants completed college, followed by those who did not complete college level (22.79%), secondary level graduates (19.07%), participants who did not complete secondary level (15.35%) and did not complete elementary (8.37%), and elementary graduates (6.51%). Lastly, only 1.40% of the participants completed post-graduate education. Around 54.42% of the participants were married. The average household size was almost five and the mean number of employed household members was almost two. Most participants were unaffiliated with any IP groups (89.77%). Lastly, more than half of the participants (56.74%) reported having savings.

Food secure individuals, which had a FIES raw score of zero (0), were composed of 30.23% of the total sample while 31.16% were mildly food insecure that is, having a FIES raw score of 1–3 (Table 5). Moderately food insecure individuals with a FIES raw score from 4 to 6 were 17.21% of the total sample while severely food insecure individuals with a raw FIES score of 7–8 comprised 21.40% of the total sample. The total number of participants who reported having mild, moderate, and severe food insecurity was 69.77%.

Table 4
Summary statistics of the variables.

Variable	%	Mean	SD
Dependent variable			
Food insecurity threshold			
Food secure	30.23		
Mildly food insecure	31.16		
Moderately food insecure	17.21		
Severely food insecure	21.40		
Independent variables			
Agri-food system actor			
Farmer	27.91		
Otherwise	72.09		
Profitability during lockdown			
Profitable	55.81		
Otherwise	44.19		
Sex			
Male	122		
Female	93		
Age		37.98	13.54
Educational attainment			
Elementary level	8.37		
Elementary graduate	6.51		
Secondary level	15.35		
Secondary graduate	19.07		
College level	22.79		
College graduate	26.51		
Post-graduate	1.40		
Civil status			
Married	54.42		
Otherwise	45.58		
Household size		4.98	2.17
Number of employed household members		1.62	1.22
Affiliation to an IP group			
Yes	10.23		
No	89.77		
Having reserve funds or savings			
Yes	56.74		
No	43.26		

Table 5
Percentage of agri-food system actors according to their food insecurity threshold.

Agri-food system actor	Food insecurity threshold				Total (%)
	Food secure (%)	Mildly food insecure (%)	Moderately food insecure (%)	Severely food insecure (%)	
Farmer	2.32	13.95	6.05	5.58	27.91
Processor	13.02	6.98	3.26	3.26	26.51
Logistic	8.37	6.05	5.12	11.16	30.70
Trader	6.51	4.19	2.79	1.40	14.88
Total (%)	30.23	31.16	17.21	21.40	100

Taking the level of food insecurity from equation (1), the ordered probit regression function was estimated using Equation (3). The overall model was statistically significant, X^2 (10) = 81.06 with a p-value of 0.00 (Table 6). There was no degrading multicollinearity issue as suggested by the variance inflation factor (VIF) with a maximum value of 1.82, values which are less than what is recommended in the literature [84]. Farmers were more likely to have experienced increased severity of food insecurity during the lockdown than other agri-food system actors such as processors, logistics, and traders at a 1% significance level. Agri-food system actors who reported being profitable during the lockdown are more likely to have food security at a 10% level of significance. Among the sociodemographic variables, age and married individuals were negative contributors to higher thresholds of food insecurity at a 10% significance level. In addition, having more employed household members during the lockdown and having any form of savings also lessened the likelihood of belonging to a higher food insecurity category

Table 6
Results from the ordered probit regression.

Variable	Estimate	Standard Error	P>|z|	
Agri-food system actor	0.6058	0.2273	0.008	***
Profit during lockdown	−0.2847	0.1581	0.072	*
Sex	0.1489	0.1580	0.346	
Age	−0.0134	0.0075	0.077	*
Education	−0.0556	0.0624	0.374	
Civil status	−0.3230	0.1887	0.087	*
Household size	0.1037	0.0386	0.007	***
Number of employed household members	−0.1862	0.0690	0.007	***
Affiliation to an IP group	0.6079	0.2793	0.030	**
Having reserve funds or savings	−0.8547	0.1618	0.000	***
Cut 1	−1.6970	0.5166		***
Cut 2	−0.6895	0.5111		
Cut 3	−0.0471	0.5075		
AIC	528.7682			
BIC	572.5865			

Note: N = 215; $X^2(10) = 81.06$; P > $X^2 = 0.0000$; Pseudo $R^2 = 0.1388$; Average VIF = 1.33, Maximum VIF = 1.82. ***, **, and * under P>|z| denote significant independent variables at 1%, 5%, and 10%, respectively.

at a 1% level of significance. On the contrary, higher household sizes (significant at 1% level) and affiliation with IP groups (with 5% significance) increased the likelihood of a higher food insecurity threshold.

In the summary statistics showing the robustness test (Table 7), the results show no significant change in the models. For the core variable, agri-food system actors, it is statistically significant ($p < 0.05$) in approximately 70% of the estimated results and has the same coefficient sign. Thus, for the core variable, the resulting robustness test of agri-food system actors has largely consistent results with the baseline regression model (shown in Table 6). The signs of the non-core variables that were statistically significant in the baseline regression model, namely, profitability during the lockdown, age, civil status, household size, number of employed household members, IP group affiliation, and monetary savings were the same as those in the baseline regression model. Moreover, Appendix A.1 presents 10 out of the 512 regression models of the full robustness test. The specification shows only agri-food system variable (Model 1), the agri-food variable with each non-core variable added one at a time (Models 2 to 9), and all the independent variables corresponding to the full model (baseline model). Consistent with the results in the full robustness test, it shows that the baseline regression model is robust to various specifications of regression models.

Using the baseline model in Table 6 for the marginal effects, for food secure agri-food system actors, the statistically significant variables are as follows: (1) non-farmers, (2) profit, (3) age, (4) civil status, (5) household size, (6) number of employed household members, (7) affiliation in an IP group, and (8) having any form of savings or reserve funds (Table 8). Farmers are 17.16% less likely to be food secure than non-farmers. They are more likely to be moderately and severely food insecure by 4.53% and 13.70%, respectively. Being profitable during the COVID-19 lockdown increases the probability of agri-food system actors being food secure by 8.07%, while it lessens their chances of being moderately food insecure by 2.13% and severely food insecure by 6.44%. Older age increases the chances of food security by 0.38% and lessens their probability of being moderately food insecure by 0.10% and severe food insecurity by 0.30%. Married civil status increases food security by 9.15%, and lessens moderate and severe food insecurity by 2.41% and 7.30%, respectively. Having more household members during the COVID-19 lockdown decreases food security by 2.94% and increases moderate food insecurity by 0.77% and severe food insecurity by 2.34%. An increase in the number of employed household members during the lockdown increases the likelihood of food security by 5.28% and reduces the likelihood of moderate and severe food insecurity by 1.39% and 4.21%, respectively. The affiliation to IP groups lessens the likelihood of food security by 17.22% and increases the probability of being moderately and severely food insecure by 4.54% and 13.75%, respectively. Lastly, monetary savings increase the chances of food security by 24.22% and lessen the likelihood of moderate food insecurity by 6.39% and severe food insecurity by 19.33%.

5. Discussion

5.1. Determinants of food security

The results of this study show that there is a diversity identified

Table 7
Summary statistics of the results from the robustness test.

Variable	Max	Min	Mean	AvgSTD	PercSigni	Perc+	Perc-	AvgT	Obs
Core independent variable									
Agri-food system actor	0.8060	0.0659	0.4811	0.20	0.70	1.00	0.00	2.40	512
Non-core independent variables									
Profit during lockdown	−0.1907	−0.4146	−0.3001	0.15	0.47	0.00	1.00	1.95	256
Sex	0.3062	0.0847	0.1901	0.15	0.01	1.00	0.00	1.24	256
Age	−0.0094	−0.0246	−0.0167	0.01	0.76	0.00	1.00	2.41	256
Education	−0.0153	−0.1595	−0.0853	0.06	0.16	0.00	1.00	1.42	256
Civil status	−0.1828	−0.4864	−0.3403	0.18	0.50	0.00	1.00	1.96	256
Household size	0.1376	0.0732	0.1049	0.04	1.00	1.00	0.00	2.82	256
Number of employed household members	−0.1278	−0.2370	−0.1799	0.07	0.98	0.00	1.00	2.69	256
Affiliation to an IP group	0.9482	0.5861	0.7547	0.27	1.00	1.00	0.00	2.80	256
Having reserve funds or savings	−0.8479	−0.9866	−0.9143	0.16	1.00	0.00	1.00	5.75	256

Note: The column *Max* shows the maximum value of the estimated coefficients for the core and non-core variables, *Min* shows the minimum value of the coefficients, and *Mean* shows the average estimated coefficient of the independent variables. *AvgSTD* shows the average standard deviation of the estimated coefficients, *PercSigni* shows the share of the regression where the variable is significant at 5%, *Perc +* shows the share of the regression where the variable's sign is positive, *Perc-*shows the share of the regression where the variable's sign is negative, *AvgT* shows the average *t*-values of the variables in the regressions, while *Obs* shows the presence of the variable in the estimated regression models.

Table 8
Marginal effects of the independent variables from the ordered probit regression model.

	0 = Food Secure				1 = Mildly Food Insecure				2 = Moderately Food Insecure				3 = Severely Food Insecure			
Variable	dy/dx	SE	P>|z|		dy/dx	SE	P>|z|		dy/dx	SE	P>|z|		dy/dx	SE	P>|z|	
Agri-food system actor	−0.1716	0.0632	0.007	***	−0.0106	0.0102	0.297		0.0453	0.0181	0.012	**	0.1370	0.0511	0.007	***
Profit during lockdown	0.0807	0.0444	0.069	*	0.0050	0.0052	0.339		−0.0213	0.0123	0.084	*	−0.0644	0.0355	0.070	*
Sex	−0.0422	0.0445	0.343		−0.0026	0.0037	0.486		0.0111	0.0119	0.348		0.0337	0.0358	0.347	
Age	0.0038	0.0021	0.075	*	0.0002	0.0002	0.339		−0.0010	0.0006	0.089	*	−0.0030	0.0017	0.075	*
Education	0.0157	0.0177	0.373		0.0010	0.0014	0.485		−0.0042	0.0047	0.380		−0.0126	0.0141	0.373	
Civil status	0.0915	0.0529	0.084	*	0.0057	0.0061	0.350		−0.0241	0.0144	0.094	*	−0.0730	0.0426	0.086	*
Household size	−0.0294	0.0107	0.006	***	−0.0018	0.0017	0.295		0.0077	0.0031	0.011	**	0.0234	0.0087	0.007	***
Number of employed household members	0.0528	0.0190	0.006	***	0.0033	0.0032	0.301		−0.0139	0.0054	0.010	**	−0.0421	0.0156	0.007	***
Affiliation to an IP group	−0.1722	0.0793	0.030	**	−0.0107	0.0099	0.284		0.0454	0.0229	0.047	**	0.1375	0.0614	0.025	**
Having reserve funds or savings	0.2422	0.0418	0.000	***	0.0150	0.0134	0.264		−0.0639	0.0140	0.000	***	−0.1933	0.0358	0.000	***

Note: N = 215; ***, **, and * under P>|z| denote significant independent variables at 1%, 5%, and 10%, respectively.

among chain actors for food insecurity along the agri-food system. Smallholder farmers are more likely to experience more severe forms of food insecurity. Farmers, particularly smallholders, are more exposed to the effects of shocks [54]. More severe forms of food insecurity are linked to catastrophes [43]. The lockdown measures may hinder farmers from selling their products [5] resulting in the wastage of produce due to a lack of buyers [2,11], reducing revenues [39] and profitability [4,73]. This adversely affects their income and their ability to purchase and access food [4,7,85]. This may also be exacerbated by the higher rate of subsistence in farming [7]. During challenging periods, farmers' experiences in food insecurity may indicate their ineffective coping strategies [19], mirroring some of the difficulties poorer populations faced during the pandemic [86]. The pandemic's impact on smallholder farmers' food security seems to be rather different than might be expected from a superficial understanding of their proximity to food. Midstream agri-food system actors such as processors, logistics, and traders have a lesser likelihood of being more food insecure as compared with farmers. These actors are better supported compared to upstream actors [48] who may have limited opportunities to market their products [87]. Much of the value addition in agri-food systems is in the downstream nodes [88] where higher margins are typically received. Hence, midstream agri-food system actors may be relatively better insulated from shocks posed by the pandemic and the corresponding impact on food security.

The reported profitability of agri-food system actors during the lockdown is found to be a significant contributor to food security as less profit may translate to reduced access to food [4,73]. Analogous to this is that lower incomes lessen food security [21]. There is a link between enterprise profitability and food security, which reflects more familiar influences such as income and household size, but these studies are nonetheless significant because profitability relies on market access in the very specific context of a pandemic. Households with limited financial capacity brought about by less profits may have more vulnerability in food accessibility, especially if their usual food sources are affected by closures [85]. This can either reduce their expenses for food or lead to a shift to lower quality food [4]. Age is a contributing factor to food security. This supports the literature that younger individuals tend to have a greater likelihood of food insecurity [75], as older individuals have increased capabilities in managing household resources [74]. Being married may increase the household income available to purchase food [75], while unmarried individuals may have burdens as the sole providers in the household [89]. A larger household size contributes to food insecurity, which is aligned with the study of Knueppel et al. [76]. Manyong et al. [77] suggested that more household members constitute a proportional increase in food needs. IPs have a higher likelihood of experiencing food insecurity, which corroborates the results of Willows et al. [78]. There has been an increase in displacement amongst IPs in the Philippines [90], which has been linked to their ability to access food. The results also suggest that a larger number of employed household members during the lockdown lowers the likelihood of more severe forms of food insecurity. Smith, Kassa, and Winters [54] posit that unemployment and part-time employment increase the likelihood of food insecurity. Lastly, having monetary savings is a factor in reducing food insecurity in the household during the lockdown, similar to the findings of Manyong et al. [77]. Enhanced awareness of the importance of having savings can help households minimize the effects of crises on food consumption, such as the COVID-19 pandemic [21].

Several econometric studies were conducted to assess the food security and insecurity levels during the COVID-19 pandemic among households in general [91], in rural areas [92], in rural areas but with households exhibiting the characteristics of urban slum areas [93], and in urban areas [94]. However, very few studies are conducted specifically about the farming households [95]. There is also a dearth of literature that discusses food security among households in IP communities during the pandemic, one of which was the study of Clapp et al. [42] which briefly mentioned the IPs using the literature in a pre-pandemic period. IP groups might have been considered less reliant on market access than other population groups, but this study identifies their reliance on the market system. No quantitative studies were conducted to assess the food security or insecurity levels that would cover not only the farmers and households, but all agri-food system actors, which this current study has addressed.

5.2. Implications to food security and sustainable development

Midstream agri-food system actors are more food secure due to proximity to market, better prices and ability to negotiate price, volume and quality of produce. Although farmers may have coped with the COVID-19 pandemic by consuming their produce [21], this may imply that there is a lack of diversification in the food consumed by farmers. Deriving calorie intake from a single food type affects their nutrition [96] which is then associated with food insecurity [55]. This relates to the study of Pinstrup-Andersen [44] wherein food security is not just having access to food but also having access to food variety that is consistent with social and cultural background.

Since smallholder farmers' food insecurity may be linked with ineffective coping strategies during crises [19], support strategies must be devised for farmers. Improved productivity and marketability of the produce [97] and public funding may be allocated to farmers to support local production [7]. Shortened agri-food systems bolster the resilience of the actors [97] and connect farmers with marketing channels that may lessen the cost and improve profitability [11]. Bringing different stakeholders of agri-food systems together may benefit farmers [87]. Capacity building for farmers and support to enhance their innovations may also help them recover [3]. Overall, these resilience measures can help mitigate the impacts of crises on vulnerable sectors of society, such as smallholder farmers in the agri-food system.

From a sustainable development perspective, several studies have highlighted that the accomplishment of the SDGs by 2030 may be affected by the pandemic [3,7,33], including tackling food insecurity (SDG 2) [39]. While the Philippines has improved its standing according to the 2023 Global Hunger Index [18], more solutions must be implemented to reduce hunger and improve food security, especially as the world moves to a post-pandemic stage. Foremost, reporting food insecurity levels is crucial in solving this problem [98]. Addressing SDG 2 entails social protection for the basic necessities of vulnerable communities mired in poverty and malnutrition [7] which in turn lessens food insecurity. The policies that are aimed to help end food insecurity should be long-term [43] such as a national food security plan [8], and should include monitoring food security and initiatives for improved nutrition [44] and increased productivity [43]. Moreover, the adoption of indigenous foodways may be an aspect of improving food security [99], as indigenous foods such as wild edible plants already play a role in the food security needs of IPs [45].

6. Conclusion

This paper examines the determinants of food insecurity during the COVID-19 pandemic on agri-food system actors in the Philippines. Smallholder farmers are the agri-food actors that are most burdened with food insecurity. In summary, some of the findings include not being profitable due to lack of market access, younger age, not being married, having more household members, having fewer employed household members, being affiliated with IP groups, and not having monetary savings. Similar to existing studies, food insecurity is linked with socio-demographic variables, along with financial performance during the lockdown. The findings suggest that farmers face increased severity of food insecurity during the lockdown. While it is putative that farmers farm, they are not invulnerable to problems posed by food insecurity, particularly during the pandemic and its associated lockdowns. This highlights that more concrete solutions must be implemented to create resilient agri-food systems and to ensure sustainable development with a particular focus on SDG 2. The complexity of interacting policies from a post-pandemic perspective offers valuable lessons for the design of resilient systems and factors within those systems that trigger food insecurity.

The government must improve its support to agri-food systems by securing farmers' access to markets, especially during extreme shocks. This can be achieved by implementing models of linking farmers to markets including establishing supply chain linkages, through co-operatives and producer associations, and private, non-government organization, and government-supported market-based extension programs. Farm-to-market roads and internet coverage in rural areas need to be improved to promote market participation. Improvement of existing government programs and more targeted distribution of irrigation, fertilization, machinery, and labor-saving and climate-resilient technologies will improve farmers' profitability and sustainability of their livelihood. These approaches will improve the food security of farmers and consumers in rural communities. There is also a need to transform the current food systems into more inclusive models to improve food security. Younger farmers, Indigenous Peoples' groups, and poor farmers having limited means to increase their financial capital need to be capacitated to improve their food production and market participation. Increasing their ability to invest savings in profitable farm ventures and providing non-farm opportunities as additional sources of regular income or cash inflow for the household will raise farm households' food security. Lastly, capacitating these vulnerable groups to participate in agriculture, forestry and management of natural resources can be supported through university and vocational training programs by bringing these programs to rural areas through distance and remote learning.

CRediT authorship contribution statement

Francis Levi Durano: Writing – review & editing, Writing – original draft, Visualization, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Jon Marx Sarmiento:** Writing – review & editing, Visualization, Validation, Supervision, Project administration, Methodology, Investigation, Conceptualization. **Glory Dee A. Romo:** Writing – review & editing, Visualization, Supervision, Project administration, Methodology, Investigation, Funding acquisition, Conceptualization. **Geraliza D. Wahing:** Writing – review & editing, Visualization, Investigation, Data curation. **Adonis M. Traje:** Writing – review & editing, Investigation, Conceptualization. **Derek Baker:** Writing – review & editing, Supervision, Methodology, Investigation, Conceptualization.

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.

Data availability

Data will be made available on request.

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Appendix A.1

Selected regression models of the robustness test.

Variables	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7	Model 8	Model 9	Baseline model
Agri-food system actor	0.3768** (0.1631)	0.3570** (0.1637)	0.3609** (0.1637)	0.6789*** (0.1926)	0.4225* (0.2192)	0.4549** (0.2208)	0.5616** (0.2245)	0.5722** (0.2246)	0.5410** (0.2258)	0.6058*** (0.2273)
Profit during lockdown	–	−0.3046** (0.1500)	−0.3121** (0.1502)	−0.3619** (0.1517)	−0.3852** (0.1525)	−0.3953*** (0.1528)	−0.4146*** (0.1535)	−0.3568** (0.1553)	−0.3333** (0.1562)	−0.2847* (0.1581)
Sex	–	–	0.2478* (0.1503)	0.3004** (0.1518)	0.2594* (0.1531)	0.2558* (0.1532)	0.2213 (0.1542)	0.1986 (0.1550)	0.2181 (0.1557)	0.1489 (0.1580)
Age	–	–	–	−0.0210*** (0.0065)	−0.0234*** (0.0066)	−0.0196*** (0.0073)	−0.0167** (0.0074)	−0.0171** (0.0074)	−0.0168** (0.0075)	−0.0134* (0.0075)
Education	–	–	–	–	−0.1453** (0.0597)	−0.1487** (0.0597)	−0.1380** (0.0599)	−0.1214** (0.0604)	−0.0921 (0.0617)	−0.0556 (0.0624)
Civil status	–	–	–	–	–	−0.2288 (0.1830)	−0.2559 (0.1840)	−0.3021 (0.1852)	−0.3099* (0.1863)	−0.3230* (0.1887)
Household size	–	–	–	–	–	–	0.0953*** (0.0368)	0.1168*** (0.0376)	0.1024*** (0.0381)	0.1037*** (0.0386)
Number of employed household members	–	–	–	–	–	–	–	−0.2029*** (0.0677)	−0.1967*** (0.0679)	−0.1862*** (0.0690)
Affiliation to an IP group	–	–	–	–	–	–	–	–	0.7094*** (0.2744)	0.6079** (0.2793)
Having reserve funds or savings	–	–	–	–	–	–	–	–	–	−0.8547*** (0.1618)
Cut 1	−0.4154*** (0.1008)	−0.5974*** (0.1350)	−0.4635*** (0.1578)	−1.1902*** (0.2752)	−2.0167*** (0.4392)	−2.0142*** (0.4382)	−1.4090*** (0.4967)	−1.5911*** (0.5033)	−1.4511*** (0.5090)	−1.6970*** (0.5166)
Cut 2	0.4092*** (0.1014)	0.2361* (0.1324)	0.3741** (0.1569)	−0.3373 (0.2709)	−1.1528*** (0.4331)	−1.1480*** (0.4322)	−0.5296 (0.4939)	−0.6879 (0.4996)	−0.5334 (0.5061)	−0.6895 (0.5111)
Cut 3	0.9093*** (0.1084)	0.7426*** (0.1361)	0.8855*** (0.1616)	0.1980 (0.2680)	−0.6058 (0.4276)	−0.5950 (0.4267)	0.0336 (0.4908)	−0.1126 (0.4960)	0.0573 (0.5032)	−0.0471 (0.5075)
X^2	5.35**	9.48***	12.20***	22.69***	28.63***	30.19***	36.94***	46.08***	52.91***	81.06***
Average VIF	1.00	1.01	1.01	1.17	1.33	1.40	1.38	1.36	1.35	1.33

Note: ***, **, and * denote significance at 1%, 5%, and 10%, respectively. Values in parentheses denote standard errors.

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