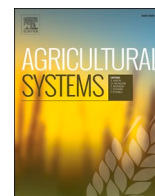




Since January 2020 Elsevier has created a COVID-19 resource centre with free information in English and Mandarin on the novel coronavirus COVID-19. The COVID-19 resource centre is hosted on Elsevier Connect, the company's public news and information website.

Elsevier hereby grants permission to make all its COVID-19-related research that is available on the COVID-19 resource centre - including this research content - immediately available in PubMed Central and other publicly funded repositories, such as the WHO COVID database with rights for unrestricted research re-use and analyses in any form or by any means with acknowledgement of the original source. These permissions are granted for free by Elsevier for as long as the COVID-19 resource centre remains active.



Immediate impact of COVID-19 pandemic on farming systems in Central America and Mexico

Santiago Lopez-Ridaura^{a,*}, Arie Sanders^b, Luis Barba-Escoto^a, Jennifer Wiegel^c, Maria Mayorga-Cortes^d, Carlos Gonzalez-Esquivel^e, Martin A. Lopez-Ramirez^f, Rene M. Escoto-Masis^g, Edmundo Morales-Galindo^h, Tomas S. García-Barcenaⁱ

^a Sustainable Intensification Program (SIP) International Maize and Wheat Improvement Center (CIMMYT), Mexico

^b Zamorano University, Honduras

^c Alliance of Bioversity International and the Center for International Tropical Agriculture (CIAT), Nicaragua

^d U.S. Soybean Export Council (USSEC), Mexico

^e Instituto de Investigaciones en Ecosistemas y Sustentabilidad (IIES), Universidad Nacional Autónoma de México (UNAM), Mexico

^f Universidad de las Américas Puebla (UDLAP), Mexico

^g Servicio de Información Mesoamericano sobre Agricultura Sostenible (SIMAS), Nicaragua

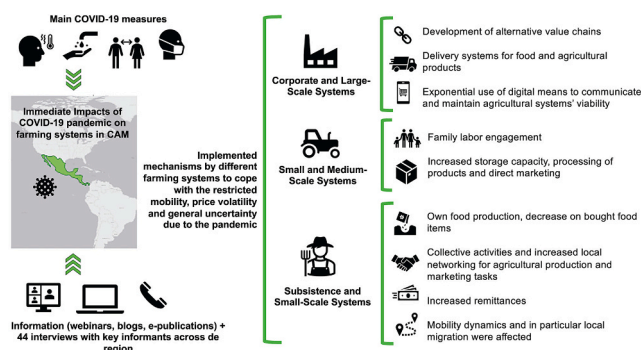
^h Pan American Health Organization (PAHO/WHO), Mexico

ⁱ Centro Regional de Investigación del Altiplano Occidental, Instituto de Ciencia y Tecnología Agrícolas (ICTA), Guatemala

HIGHLIGHTS

- COVID-19 pandemic has had differentiated impacts for distinct types of farming systems.
- Small and medium scale entrepreneurial systems were the farming systems most affected in the CAM region.
- Large scale and smallholder farming systems showed greater resilience to COVID-19 pandemic.
- Great diversity of mechanisms was implemented by farmers and other actors in the agri-food system.
- Special features of the agri-food system in the CAM region mediated the effect of COVID-19.

GRAPHICAL ABSTRACT



ARTICLE INFO

Editor: Dr Emma Stephens

Keywords:

Resilience
Mexico
Guatemala
Honduras
El Salvador
Nicaragua

ABSTRACT

CONTEXT: The COVID-19 pandemic has affected all sectors and human activities around the World.
OBJECTIVE: In this article we present a first attempt to understand the immediate impact of COVID-19 and the sanitary measures taken by governments on farming systems in Central America and Mexico (CAM).
METHODS: Through a review of information generated in these initial months of the COVID-19 pandemic (webinars, blogs, electronic publications, media) and 44 interviews with key informants across the region, we have identified the main impacts felt by different types of farming systems in the region.
RESULTS AND CONCLUSIONS: From corporate agricultural production systems, to small and medium scale entrepreneurs and smallholder subsistence farm households, all types of farming systems were impacted, more or

* Corresponding author at: International Maize and Wheat Improvement Centre (CIMMYT), Carretera México-Veracruz, Km. 45, El Batán, 56237 Texcoco, México.
E-mail address: s.l.ridaura@cgiar.org (S. Lopez-Ridaura).

<https://doi.org/10.1016/j.agsy.2021.103178>

Received 12 October 2020; Received in revised form 4 May 2021; Accepted 12 May 2021

Available online 18 May 2021

0308-521X/© 2021 The Author(s).

Published by Elsevier Ltd.

This is an open access article under the CC BY-NC-ND license

(<http://creativecommons.org/licenses/by-nc-nd/4.0/>).

Costa Rica
Panama

less severely, by the different measures implemented by governments such as reduced mobility, closure of public and private venues and restrictions in borders. Larger corporate farming systems with vertical market integration and high level of control or coordination within the supply chain, and smallholder or subsistence farming systems with important focus on production for self-consumption and little external input use, were both relatively less impacted and showed greater adaptive capacity than the medium and small entrepreneurial farming systems dependent on agriculture as their primary income and with less control over the upstream and downstream parts of their supply chain. All types of farming systems implemented a series of mechanisms to cope with the COVID-19 pandemic including the development of alternative value chains, food and agricultural products delivery systems and the exponential use of digital means to communicate and maintain the viability of the different agricultural systems. Collective action and organization of farmers also proved to be an important coping mechanism that allowed some farmers to acquire inputs and deliver outputs in the context of restricted mobility, price volatility, and general uncertainty. Some features of the CAM region played an important role in mediating the impact of COVID-19 and associated sanitary measures. We identify as particularly relevant the nature of agricultural exports, the current structure of the agricultural sector, the diversified livelihood strategies of rural households, and the importance of mobility for rural livelihoods.

SIGNIFICANCE: The results presented focus only in the immediate effect of COVID-19 pandemic and the mechanisms implemented by farmers in the first months. Whether these impacts and response mechanisms will result in a transformation of the farming systems towards greater resilience and sustainability is still an open question.

1. Introduction

The COVID-19 pandemic has affected every populations and sector in the world. Through February 28th, 2021, more than 2.53 million deaths have been registered as a result of COVID-19, and more than 114.1 million people have been infected ([Johns Hopkins Coronavirus Resource Center, 2021](#)). The pandemic is expected to lead to long-term structural changes in all kinds of human activities. The agricultural, and more widely, the agri-food sector has not been spared from this phenomenon, playing a crucial role in the magnitude of the pandemic impact; it will undoubtedly go through essential transformations in the future due to this global phenomenon.

Two aspects of the agri-food sector are tightly interlinked with the impact of the COVID-19 pandemic. One is related to the fact that, independent of health status and the dynamics of infectious diseases like COVID-19, all the planet's inhabitants need to eat. Households in both urban and rural environments, whether affluent or low-income, need to have food available even during times of significant limitations on non-essential activities, lockdowns, and quarantines, as seen during the first semester of 2020. Secondly, non-communicable chronic diseases related to food and nutrition have been clearly associated with aggravated cases of COVID-19, with the leading co-morbidity causes involving diabetes, high blood pressure, overweight, and obesity, all of which are tightly linked to the quantity and quality of food available and consumed by both urban and rural families.

This article deals with the immediate effects of COVID-19 on the agricultural systems of Central America and Mexico (CAM), presenting a descriptive analysis of the most critical immediate effects of COVID-19 for different kinds of agricultural systems and their associated value chains. It covers the period from the start of the pandemic in CAM in March 2020 through the end of August of the same year. This study intends to serve as a benchmark, providing a basis for analyzing the longer terms effects and adaptation strategies developed by farmers and other relevant actors in agri-food systems. Ultimately, this study aims to contribute to identifying measures for improving the resilience and adaptive capacity of different farming systems in the CAM region to COVID-19 and other similar global phenomena.

Section 2 describes the CAM region in relation to agriculture and other aspects related to the agri-food system. It also describes main farming systems in CAM where we distinguished three broad categories according to their level of integration in the market: corporations and large farmers, medium and small entrepreneurial farmers, and smallholder and subsistence farmers. This characterization is especially relevant as it sets the stage for the arrival of the COVID-19 pandemic to the region.

Section 3 describes the i) main measures taken by governments to mitigate the spread of COVID-19, emphasizing those measures that would potentially impact agricultural systems, rural livelihoods in the region, and generally on the agri-food system ii) their main impacts on farming systems in CAM and ii) some response measures implemented by the different categories of farming systems. In **Section 4** we discuss initial impressions of how the pre-COVID-19 characteristics of the agri-food system in CAM shaped initial impacts and identify major response trends. Finally, in **Section 5** we point at what implications the pandemic might have moving forward for the agri-food system in CAM.

2. Agriculture and farming systems in Central America and Mexico (CAM)

CAM covers the tropical and subtropical regions of the North American continent and includes Mexico, Guatemala, Honduras, El Salvador, Nicaragua, Costa Rica and Panama. Agriculture in the CAM region is characterized by its contrasts in biophysical as well as socio-economic conditions. Broad ranges of agroecological conditions (temperature, elevation, rainfall) generate tropical and temperate forests, lowland humid ecosystems and highland arid areas. Also, in socio-economic terms, the region has some of the largest, most productive, and technified agricultural production systems in the world with large plantations, livestock feeding operations, and intensive horticultural production systems for domestic consumption and export, as well as some highly marginalized, resource-limited (infra)subsistence farming systems. Some regions within CAM countries are among the continent's most impoverished, comparable to the world's poorest regions in Africa and Asia. For example, in the Dry Corridor, a region characterized by extensive deforestation, soil degradation and water scarcity covering parts of Honduras, Nicaragua, El Salvador and Guatemala, about 60% of the total population of ca.10.5 million people, live in poverty ([IFAD, 2016](#)). In Guatemala, a country where almost half the population cannot afford the basic food basket, the prevalence of stunting in children under 5 is one of the highest in the world ([WFP, 2021](#)).

2.1. Agriculture in the CAM region

During the past decades, the economies of Central America and Mexico have been extensively liberalized and opened to international trade. The role of governments has been reduced, and the agricultural sector has not been an exception. Export promotion of non-traditional agricultural products such as palm-oil (Guatemala and Honduras), vegetables (Guatemala and Mexico), tobacco (Nicaragua), and fruits (Costa Rica and Mexico) and the expansion of coffee production

(Guatemala, Honduras, Nicaragua) have transformed the regional production portfolio. International trade agreements also created a drastic increase in maize imports, the main staple crop in the region. Changes in the agrarian structure have led to the vast migration of (mostly young) people to urban areas and the United States and, at the same time, created a massive inflow of remittances to rural areas (Brogan and McGuinness, 2013). Off-farm income is becoming more and more critical to the total income of farmers' households. Urbanization and the growing importance of supermarkets have been parallel trends to the integration of smallholders into commercially oriented agriculture. However, access to financial (credit) and non-financial (improved seeds, agriculture extension) services has been largely limited to a small segment of medium and large entrepreneurial farmers.

All these changes have led to new forms of social relations and agricultural production, including small export-oriented coffee farmers for niche markets in Europe, USA, and Asia, contract farmers for supermarket chains, agricultural laborers in the increased development of large palm oil and sugar cane plantations or intensive vegetable production, and the consolidation of industrialized pig and poultry farming. Despite the differences in scale and internal structure, both small and large farms are becoming more integrated into global markets. However, the incidence of rural poverty has not changed, especially among indigenous populations, neither the unequal distribution of land. Costa Rica stands out with the most equitable land distribution with a Gini Index of 0.67, in contrast to Guatemala as the country with the most unequal Index (0.84) (OXFAM, 2016). According to Baumeister (2010), the smallholder sector in CAM is increasing in numbers because of the lack of alternative income sources, but its average farm size is becoming smaller.

Table 1 shows some relevant information about the CAM region including the importance of agriculture in terms of rural livelihoods and economic development, the main import and export crops as well as basic statistics related to remittances, poverty, nutrition and food security. Supplemental Material 1 provides a map of the CAM region as well as more detailed description of the main characteristics of the agri-food systems, i.e. changes over time changes over time of some key variables such as the share of rural population over total population and that of agricultural land over total land.

2.2. Farming systems in the CAM region

The agricultural sector in CAM is enormously diverse in terms of farming systems and economic importance. Its agroecological context (soil fertility, slope, and climate) determines its productivity potential as only a small fraction (less than 10%) of cultivated land is irrigated (Pomareda, 2013). Still, institutional and socio-economic factors substantially influence the optimal use of land. Within homogenous agroecological areas, differences between farming systems are primarily explained by socio-economic differences in how farmers operate.

For a general description of the diverse farming systems in Central America and Mexico, we distinguish three broad categories according to their level of integration in the market: corporations and large farmers, medium and small entrepreneurial farmers, and smallholder and subsistence farmers. In the next table, we link the types of farming systems to their position in five different markets (Table 2). The scale of production (land) and labor use increases when we move from the bottom to the first category. Market integration enters all farming systems but varies in grade and scope. These three categories are artificial markers to be able to distinguish between the diversity of farming systems and understand the differential impact of COVID-19 sanitary measures in their functioning. However, it is evident that in the CAM region, as in other regions of the World, there is a continuum of farming systems rather than easily distinguishable categories. The difference between them is blurred, and we can expect overlapping spaces and interactions. It is common to find all categories coexisting within the same geographic area, which indicates that agroecological and production-related

characteristics, as well as specific local socio-institutional conditions pose obstacles and opportunities for the existence of different farming systems.

The corporate and large farming type mainly involves large plantations linked to the agro-export model or large-scale horticultural production systems and livestock operations for domestic and export markets. Its development goes back to nineteenth century plantations (coffee, bananas, sugarcane) and *haciendas* in the most fertile regions. Together with coffee, the sugar cane industry is now the largest temporary employer in the agricultural sector. The rising global demand and increasing price for palm oil have recently stimulated large production farms, in some cases replacing banana production (Pomareda, 2013). While corporate farms are owned by large companies, large farms are generally family-owned, generally specialized in a small number of (export) crops or livestock activities, use modern and capital-intensive technology, and often have irrigation. Production is externally financed and insured and produced under contract.

An important subgroup is the livestock sector. Cattle raising in central America is extensive, using large areas and low paid labor. A relatively new corporate farming system is industrialized poultry and swine production. The rapid growth in poultry inventories reflects the increasing demand for low-cost animal protein to feed a rising population with higher incomes, and more urbanized. In this case, there is an overall trend to integrate the supply chain vertically. This has allowed reducing the production cycle length and having more control over each aspect of food safety by maintaining strict biosecurity measures.

However, not all corporations are totally vertically integrated. Contract farming is a common practice in the region for high value and labor-intensive crops such as fruits and vegetables. The growing importance of contract farming in CAM has to do with a global agricultural industrialization trend to mainstream farming methods to standardized production, food safety concerns, and traceability (Reardon et al., 2009).

Entrepreneurial farming is of smaller size and has a distinct market focus and a logic of financial and industrial capital integration. We distinguish two sizes, medium and small, related to farm size and labor and capital intensity. Because of shirking problems in large scale production, small and medium producers are better prepared to monitor their labor effort. The use of family labor is essential for most farmers in this group. There is also a broader range of high-value crops in this specific group, including the production of vegetables, fruits, and quality coffee. Farmers have often a direct contract with their buyer, but a relatively large number established their association to manage their processing and marketing activities.

The high rate of urbanization in the region due to population pressure and infrastructure development has created an emerging growth of medium and small sub- and peri-urban farming systems. Those systems produce high-value crops, mainly vegetables, for supermarkets and wet markets. Often these farmers complement their livelihood with jobs and service provision in the nearby towns and cities.

Smallholders and subsistence farms form the largest group in CAM. They rely on their family labor and means of production, have low use of external inputs, limited access to financial services, and generate a substantial share of their income outside the farm. Their productivity is low, and most farmers in this category struggle to make a decent living. The production of maize and beans is an important strategy to maintain household food security. According to Baumeister (2010) there are about 2 million subsistence farmers in Central America, and about 2.1 million in Mexico (UNCTAD, 2013). These farming systems often occupy a low share of the agricultural area in the CAM region. For example, although representing around 76% of the farms, these farmers cultivate only 21% of the agricultural land in Nicaragua; even more extreme figures are found in El Salvador where they account for 86% of the farms and occupy 17% of the land (Gómez et al., 2017).

Within this category we find a wide range of farming systems. In Mexico and Guatemala, the largest group are indigenous farmers based

Table 1
Basic characteristics of pre-pandemic agriculture in Central America and Mexico (CAM).

Country	Total population ^a	Rural population ^c	Country area and % of agricultural area ^b	% of GDP from agriculture ^d	Main agricultural imports ^e	Main agricultural exports ^f	Population under the national poverty lines ⁱ	Remittances received and % of GDP ^k	Prevalence of moderate and severe food insecurity ^j	Adult overweight/obesity ^g	Child overweight / underweight ^h
	Million	Million (%)	Million ha (%)	%	Crops	Crops	%	Million USD (%)	%	%/%	%/%
Costa Rica	5.0	1.02 (20)	5110 (35)	4.2	Cereals, Fruits and vegetables,	Coffee, Sugar and honey, Bananas and plantains, pineapples, oil palm.	21.0	553 (1)	23.2	37 / 27	8.1/1.1
El Salvador	6.4	1.79 (28)	2104 (76)	5.1	Cereals, Fruits and vegetables,	Coffee, Sugar and honey, beverages	29.2	5656 (21)	40	37 / 25	6.4 / 5
Guatemala	17.2	8.44 (49)	10,889 (36)	9.4	Cereals, Fruits and vegetables, Meat, Fodder	Coffee, Sugar cane, Bananas and plantains, oil palm	59.3	10,656 (14)	43.6	36 / 22	4.9 / 12.4
Honduras	9.6	4.04 (42)	11,249 (31)	10.7	Cereals, Fruits and vegetables Fodder	Coffee, Sugar, Bananas and plantains, Tobacco, Oil palm	48.3	5401 (22)	49.3	35 / 22	5.2 / 7.1
Mexico	126.2	25.9 (21)	196,437 (55)	3.5	Cereals, Fruits and vegetables Meat, Oilseeds,	Avocados, Tomatoes Fruits and vegetables, Beer of barley	41.9	38,629 (3)	28	37 / 30	5.3 / 4.2
Nicaragua	6.5	2.61 (40)	13,037 (42)	15.4	Cereals, Fruits and vegetables, fodder	Coffee, Sugar, Tobacco, Meat, Fruits and vegetables	24.9	1654 (13)	-	35 / 24	8.3 / 4.6
Panama	4.2	1.34 (32)	7532 (31)	2.1	Cereals, Fodder, Meat	Coffee, Sugar, Bananas and plantains, Fruits and vegetables, Beverages	22.1	581 (1)	-	37 / 24	9.7 / 3.9
* Central America or Latin America & Caribbean	175.5	45.4 (26)	248,655 (50)	4.9	Maize, Soybeans, Wheat	Coffee, Sugar, Avocados, Bananas, Tomatoes Beer of barley,	-	97,198 (2)	37.1	37 / 28	7.5 / 2.7
World	7631.1	3413.0 (45)	13,486,028 (36)	4	-	-	-	653,323 (1)	25.4	26 / 13	5.6/13

^a FAO (2020a) unit: million inhabitants. yr. 2018.

^b FAO (2020a) units: area in 1000 ha and (%). yr. 2017.

^c FAO (2020a) units: million and (%). yr. 2018.

^d The World Bank, data retrieved for 2019 except the World statistic for 2018, units: %.

^e FAO (2020a) yr. 2017,

^f FAO (2020a) yr. 2017,

^g GAIN-JHU, 2020 units: % / %. yr. 2016.

^h The World Bank (2020) units: % / %. yr. 2008 (Costa Rica and Panama), yr. 2012 (Nicaragua and Honduras), yr. 2014 (El Salvador), yr. 2015 (Guatemala), yr. 2016 (Mexico), yr. 2019 (Latin America and World)

ⁱ The World Bank (2020) yr. 2014 (Guatemala), yr. 2016 (Nicaragua and Panama), yr. 2017 (El Salvador), yr. 2018 (Honduras and Mexico), yr. 2019 (Costa Rica), – data not available.

^j The World Bank (2020) unit: %. yr. 2017

^k The World Bank (2020) units: million USD and %. yr. 2019

* Data was retrieved for Central America from FAOSTAT and for Latin America from The World Bank.

Table 2
Farming systems and market integration.

Farming category	Market integration				
	Land market	Labor market	Product market	Credit market	Input market
Corporations and large farms	Owner and lease	Hire year-round labor	Sell all outputs	Externally financed	Buy all inputs
Entrepreneur – medium and small	Owner and lease	Hire seasonal labor	Sell all outputs, produce some staple crops	Partially financed	Buy almost all inputs
Smallholder and subsistence	Owner occasional lease	Family labor and sell labor	subsistence crops, sell some outputs	Limited access, remittances and other transfers	Purchase little or none

on the *milpa*, an ancient intercropping system of maize, beans, and squash, in which each crop contributes to the growth of the other ones (Lopez-Ridaura et al., 2021). Subsistence farming is often combined with cash crop and livestock production. Farmers in the higher areas (above 1000 masl) in Guatemala, Mexico, and Honduras dedicate part of their farms and labor to coffee production or high-value fruits and vegetables (Costa Rica, Guatemala, Honduras) (Avelino et al., 2015).

3. Pandemic-related measures and their impacts and response mechanisms fro different farming systems in CAM

The first case of COVID-19 in the region was reported in Mexico on February 28, and it was quickly followed by the other Central American countries. By late March, all countries, except for Nicaragua, implemented different measures to contain the spread of the virus. Supplemental Material 2 shows different COVID-19 statistics for each country as well as other relevant information to understand the health impact of COVID-19 in the CAM region. Medical attention measures were implemented immediately, such as the fast-track hiring of medical staff in hospitals and direct acquisition of medical equipment. Beyond the medical actions, other measures were implemented by national and local governments to decelerate the spread of COVID-19 pandemic spread. These measures had essential effects on social and economic activities, and some of them had a direct or indirect effect on the functioning of the agricultural systems in the region and, more generally, on regional agri-food systems.

Based on the information provided by the Sistema de Integración Centromericana (SICA) through the SICA-COVID-19 Monitoring Regional Report (SICA, 2020) and the International Monetary Fund through its policy response tracker (IMF, 2020), main measures were identified that would most likely have an impact on agriculture and agri-food systems in the region:

To identify the effect of COVID-19 related measures on different farming systems, we carried out a series of interviews with key stakeholders, including farmers, technicians, researchers, and other actors engaged with local realities. In total 44 semi-structured interviews were conducted, mainly by phone call, covering two main points through open-ended questions: i) what were the immediate effects that sanitary measures implemented by national or local governments to reduce COVID-19 spreading on the functioning of the farming systems, notably taking into account the seasonality, and the associated value chains or farm household livelihoods?; and ii) What were the main mechanisms put in practice, mainly by farmers but also by other actors, to counteract the impact of the sanitary measures and, in case they were implemented, what support programs from governments or local organizations were available?.

Twenty-six interviews were conducted with farmers and technical promoters in different regions within CAM and with deep understanding of the local realities and first-hand information on the main effect of Covid19 sanitary measures on the functioning of local farming systems. Eighteen interviews were conducted with representative of farmers organizations, input and output enterprises and providers as well as researchers with a broader view on the effects of Covid19 sanitary measures on the sector and associated value chains. Mexico, Guatemala

and Honduras concentrated most of the interviews with 13, 11 and 10 interviews per country respectively. In el Salvador, six interviews were conducted while in Costa Rica, Panama, and Nicaragua we could only complete one or two interviews. We obtained complementary information from bulletins, news programs, webinars and other emerging documentation on the general impact of COVID-19 on the agri-food systems from national and regional organizations.

3.1. Sanitary measures implemented by CAM countries affecting agriculture

Seven main measures were identified with main impact on agriculture and agri-food systems in the region:

- i) *Restrictions and bans on non-essential private and public vehicle circulation.* All countries reduced the mobility of private and public transport services to a certain extent. Some countries implemented curfews that started in the afternoon and finished in the early morning.
- ii) *Mandatory lockdown.* Some countries maintained a state of alert and suggested that citizens leave their homes only when necessary. Other countries established a total lockdown at the national level of several days at the start of the epidemic and later installed several other lockdowns depending on the contagion's severity. Some countries allowed a proportion of the population to mobilize but only on specific days, depending on their national ID number, the initial letter of their surname, or even gender.
- iii) *Government public office closure.* At the start of the virus spread, governments considered that all non-essential activities in the public sector should remain closed and reduced public affairs to the minimum and home office for some public agents. Each country defined differently what essential activities were, and, in some countries, public offices remained open, but with limited capacity.
- iv) *Closure of schools, churches, beaches, national parks, bars, clubs, and casinos.* Immediately after the first reports of confirmed cases, all educational activities and social events, entertainment businesses, and tourism activities were restricted in most countries.
- v) *International travel restrictions, closing of national frontiers.* Many countries banned international flights but allowed only those permitted conational citizens to re-enter the country, or persons with humanitarian objectives. Transportation through terrestrial and maritime frontiers was restricted, but exports and imports were allowed to continue, especially for transportation of essential goods. Some countries closed their frontiers even to citizens entering or leaving the country.
- vi) *Prohibition of massive events or gatherings.* All massive events were restricted in all countries, including concerts, demonstrations, political rallies, religious celebrations, and, in some cases, relatively large private parties and gatherings.
- vii) *Closure of local markets, supermarkets, or street vending.* At several stages, markets were closed, especially street markets; only supermarkets could operate, and there were restrictions on opening hours, the number of people that could enter, and even on the

amount of products people could buy. Street vending was forbidden in many places and for long periods.

These measures were applied at different degrees of intensity in the different countries of CAM as well within countries as, in some cases, states and provinces implemented more strict measures than others. In Supplemental Material 3, presents more detailed information related to the implementation of these measures in the different CAM countries.

It is challenging to analyze the direct impact of each COVID-19 measure on agricultural systems in each country. The reality is that the effects are not of individual measures. We must consider the totality of actions and changes in the socio-economic context where agricultural systems operate. The nature of the impact of COVID-19 and of the sanitary measures implemented by governments differed among farming systems in relation to their context but also related to their level of integration into local or global markets, their dependency on hired occasional labor, and other characteristics. In the following paragraphs we outline the main immediate impacts felt by different types of farming systems as well as some of the mechanisms put in place, mainly by farmers, to cope with the COVID-19 pandemic crisis.

3.2. Impacts and response mechanisms for corporate and large scale entrepreneurial agricultural systems

For corporate production and some large-scale entrepreneurial agricultural production systems, the sanitary measures' immediate effect was relatively mild in most cases. According to our informants, for the moment, there do not seem to be shortages in intermediate inputs. Larger corporations purchase the imported inputs in advance for future transactions to maintain its supply, and to mitigate the risk of price or exchange rate, inherent to seasonal and volatile commodity markets. This has buffered the immediate impact however, in the long run, corporations may face difficulties due to low stocks and increasing input prices. For example, large-scale livestock production in the region witnessed some delays in securing imported inputs, such as synthetic amino acids produced in China. Their supply chain was in some cases delayed, but never interrupted as their inventories and stocks of needed inputs allowed them to continue operations during this initial stage of the pandemic. Nevertheless, prices of imported inputs were negatively affected by increasing exchange rates and rising commodities prices.

While the operations of these large scale systems never stopped, they presented positive COVID-19 cases in processing and packing facilities, which made them to implement social distancing and constant sanitization measures for workers and workplaces, and to organize transport for workers as a response to disrupted public transport. In the Yaqui Valley, in Northern Mexico, interviewees reported disruption in the grain and vegetable gathering and packing facilities because of several positive cases for COVID-19 and implementation of sanitary and social distancing measures. Moreover, in April, the largest pork meat packing plant, in Panama, remained closed for 17 days in April in order to comply with the national sanitary protocols to prevent the spread of COVID-19 among the workers. Similarly, in Guatemala City, a poultry processing plant was shut down in May in response to the protocol established for positive COVID-19 case detected. On the other hand, the sugar cane industry in El Salvador reported that harvest, processing, and export was not affected at all. Harvest ended in April and there was no delay in its processing (Reyes, 2020). The production of bananas in Panama was largely not been affected by the pandemic and according to Minister of Agriculture, "The fruit market for the three exporting companies (Chiquita, Del Monte and COBANA) has not varied and is carried out uninterruptedly" (MENAFN, 2020).

The contraction in domestic and international demand and an unexpected drop in commodity prices affected revenues from commodity exports in the region. Low prices and a decrease in demand have led agro-processing companies to temporarily slow down their activities. This contraction has also led to uncertainty in investment levels for this

kind of system. According to Van Teijlingen and Hogenboom (2020) we should expect a decline in foreign investment in the region, and, during the interviews with executives of international corporations, some of them mentioned that planned investments for 2020 had been placed on standby. While most countries in the CAM region were restrictive with some activities, Nicaragua's government disregarded sanitary measures and was flexible in terms of mobilization and economic activities. Its exports incremented by 14.1% (January–May), mainly of primary products, such as coffee, beans, sugar cane, tobacco, and meat (ECLAC, 2020a).

At the domestic level, a drop in animal protein demand, specifically pork and poultry, led to extensive inventories and higher cold storage costs, affecting profit margins. Some actors in this sector reported a decrease (4–40%) in pork and poultry sales during confinement (mid-March to May) due to offices, restaurants, and tourism sector shutdown. According to the national board of pork producers in Costa Rica, the demand for pork meat was reduced by approximately 30% causing a drop in its price. In Honduras and Guatemala, poultry products' sales were reported to have fallen between 20 and 25% due to the decrease in demand from leading marketing channels such as supermarkets and wet markets. There was a spike in egg prices due to panic buying. From June onwards, pork and poultry consumption levels started going back to normal, thereby reducing inventory accumulation. In combination with logistical problems in the export chain, changes in international commodity demand are affecting large producers of products such as palm oil and sugar cane. The demand for both products dropped during the first quarter across the world, its trade was disrupted, and production was affected in Guatemala and Honduras.

Corporate and large-scale entrepreneurs implemented some procedures to counteract the negative effect of the sanitary measures taken. Some livestock operations in the region responded to the contraction of national and international markets by increasing storage and refrigerated warehouse capacity, selling packed cuts rather than whole carcasses, or started producing added value products. For instance, the pandemic served as a catalyst for *Campestre* Group in El Salvador, which as a result of the reduction in chicken meat sales and a peak in its inventory, started a chicken nuggets business unit that already has many sale points in the region. Hence, in some cases, distribution channel diversification and removing supply chain intermediaries represented an option. In Nicaragua, the poultry operation AVICASA has invested in vehicles to deliver poultry products, thus getting closer to the end-consumer, while keeping the profit margins already compressed by the pandemic. Some interviewees see further automatization and make process more efficient as means to reduce vulnerability to future shocks. In some cases, diversification, to locally produce main inputs, was mentioned as a mechanism to cope with disruptions in transport, import, and delivery of essential inputs for the firms' functioning.

Governments in the region generally allowed and facilitated the international trade of agricultural products in and out of the CAM region, but, in general, little support was received by these firms. In Panama the government responded to the crisis by buying animal products at retail prices, to be distributed to the lower-income population. In Honduras, through a joint effort between the National Association of Poultry Producers (ANAVIH), church and NGOs, regular donations of two million eggs and two million pounds of chicken meat were distributed among vulnerable populations. In Guatemala and El Salvador, interviewees saw government measures to restart the economy as unclear or ineffective. In Nicaragua, previous conflicts between the government and the business sector have made programs to mitigate the crisis's effects more difficult. In an interviewee's opinion, banks have excess cash and should be more flexible in providing credits.

Fig. 1 shows the main impacts of covid19 sanitary measures and some response mechanisms implemented by corporate and large-scale enterprises to deal with such measures.

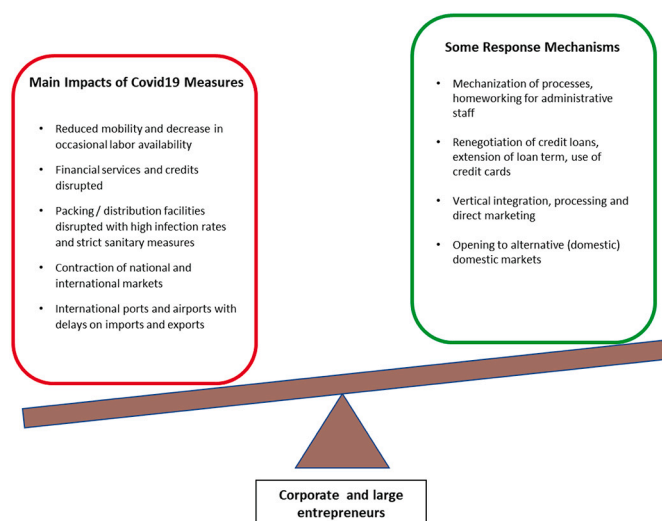


Fig. 1. main impacts of covid19 sanitary measures and some response mechanisms implemented by corporate and large-scale agricultural enterprises in CAM.

3.3. Impacts and response mechanisms for small and medium scale entrepreneurial systems

For more medium and small scale entrepreneurial agricultural systems, the impact of COVID-19 sanitary measures was considerable as they depend significantly on occasional/seasonal labor and local markets for their inputs and outputs. Disruption in transport and the general slow-down of economic activities posed significant obstacles for input acquisition at the local level. Inputs such as fertilizers, seeds, veterinary medicines, and animal feed became scarce and expensive, when available. For example, farmers in Southern Mexico reported that reduced mobility made it difficult to reach input shops. Many shops were found closed because of slowed economic activity or without the needed products because of delivery delays. According to local farmers, input prices increased by 30% and the pandemic occurred during soil preparation, sowing and basal fertilizer application time (March–June). In Guatemala, producers of basic grains and vegetables saw an increase in costs of agricultural inputs as the transport sector was heavily impacted by the pandemic, reporting a 50% decrease in demand for transport and consequent increase in costs (Ozaeta, 2020). In Honduras, producers stated that the retention of inputs in customs had created difficulties in maintaining their production: “Concerning the purchase of livestock feed, it became more difficult because the price has risen; also, transport became more expensive”. In El Salvador, the production of cabbage was affected due to the closing of small restaurants serving maize flatbread (*pupusas*). A dairy producer in Honduras mentioned that they had to reduce fresh cheese production by more than 50% and used the excess milk to feed the calves. In general, closures of offices, schools, restaurants, hotels, and local markets affected their primary source of income and the principal outlets for their products. However, even within the same country, some medium and small-scale entrepreneurs benefited from sanitary measures. For example, in Honduras, a dairy farmer stated that disruptions at the border prevented foreign milk and dairy products’ imports, reducing competition and increasing his sales.

In addition to input provision disruption, a substantial effect on small and medium sized entrepreneurs farming systems was the reduced availability of occasional labor hired for key farming activities such as sowing, harvesting, loading, sorting, and packing. Reduced mobility and disruptions on public transport, together with the local population’s fear of contagions, made labor scarce and unreliable in some regions (FAO, 2020b; FAO-CEPAL, 2020). Many of the interviewed mentioned an increased need to engage family labor, including women and children.

This, together with schools closing and kids at home all time, might represent a challenge for women to continue with their normal activities and their contribution to the household livelihood.

Closure of schools, government offices, restaurants, tourism services, wet markets, and local slaughterhouses slowed down demand for agricultural products and imposed significant obstacles for small and medium producers to commercialize their products. Brokers were offering low prices justified due to decreased demand and increased transport costs, and therefore, farmers have seen substantial negative impacts on profitability. In Mexico and Honduras fruit and vegetable producers reported having decided not to harvest their products (e.g. watermelon) as the prices offered did not justify harvesting or transport costs. Tourism is an important economic activity for the region, and its reduction, or total halt, posed significant challenges for small and medium producers to sell their products. In Costa Rica, the country where tourism represents one of the most important economic activities in the region, locally produced fresh and gourmet products were significantly reduced with important impacts on local farmers’ profitability (Marin, 2020). In Panama, producers also face limitations in selling their products due to the decrease in consumers’ purchasing power. Low prices will likely disincentivize production and will have consequences on the supply of basic foodstuffs by the sector. According to a survey done by IICA (2020), the products that would be most affected would be grains and cereals and vegetables, followed by fruits, roots and tubers, and meat.

Small and medium-scale livestock producers had to maintain their animals for more extended periods, increasing their production costs and decreasing their cash flow. Some small and medium-size entrepreneurs specialized in niche markets overseas, such as coffee or exotic fruits were affected by lockdowns, reduced mobility, and social distancing measures implemented in countries where these products are consumed, for example in Europe, which had adverse effects on the demand and price offered to farmers. Currently the coffee market is estimated to have a 0% growth rate when the last decade has seen an annual average increase of 2% (Torero-Cuyén, 2020). In El Salvador, a coffee producer mentioned that he had to change his marketing strategy. Most of his coffee was sold before the pandemic to roasters in the USA. Because of his need for cash flow, the remaining coffee was sold on the domestic market at a much lower price.

In Mexico, by mid-April the exports of tomato and avocado, berries and other red fruits saw a decline, as only supermarkets in the US and Canada bought these products. Declines were close to 50% for tomato, 30% for avocado, and 15% for berries (Zapata, 2020). For cocoa, the price in April was estimated to have dropped 25% (from 3000 to 2200 USD/ton), and in most countries the cocoa producers had to severely decrease their operations due to mobility restrictions (CLAC, 2020). In Mexico, existing cooperatives and associations of farmers and restaurants provide a good example of the effects of lockdowns. As restaurants closed, their demand for cocoa decreased and farmers feared their cocoa production would rot in the fields, but restaurants managed to directly connect their customers with producers which were able to sell their products through home-delivery (Martin and López, 2020). Although Nicaragua’s government didn’t impose mobility restrictions, people restricted themselves. Farmers of *La Campesina* cocoa cooperative stopped selling their cacao in local municipal markets and with it restricted their access to food and even hygiene products, even technical advice was stopped. Their agroforestry systems provide food for self-consumption like citrus, bananas and avocados and even fodder for rearing their livestock (Casanova, 2020).

We did not find many reports of impacts in the sugar sector as most of the sugar producers (90%) had harvested before the end of April and prices were maintained as contracts were signed at the beginning of the year. Farms are operating at minimum levels and not carrying out maintenance activities which could affect the next harvest. Marketing for the next harvest may be impacted in the near future due to slower distribution channels, restrictions on mobility or administrative

procedures. Banana producers continue working, with an increased demand for bananas initially, but farmers are concerned that production costs may increase as producers implement extra sanitary measures, including buying hygiene products and social distancing that will increase the costs of transportation and also extend the labor required to maintain production levels. Honey producers are harvesting on time but still face restrictions in access to rural areas (CLAC, 2020).

Running out of cash was mentioned by many of the farmers interviewed. Financial services such as credit were disrupted due to high uncertainty in their economic performance. The lack of sufficient cash flow limited farm operations in the short and medium term, including the acquisition of inputs and labor. For example, in Honduras, small amounts of inputs are usually bought on 30-day credit but interviewed farmers mentioned that local input suppliers were reluctant to offer or extend the credit during the pandemic. The formal financial sector has also been more restrictive in approving new finance, including reviewing or renegotiating new credit terms. To cope with limited cash flow, farmers had to sell their possessions and even had to close their business for the lack of cash to maintain production. On various occasions, farmers mentioned the use of credit cards to maintain their operations but the high-interest rates on credit card debts will be a challenge in the near future. In Costa Rica, Honduras, and El Salvador, governments are developing measures to suspend credit and interest payments to lessen the financial pressure on small businesses and households.

Medium and small-scale entrepreneurs implemented some mechanisms to respond to marketing obstacles, including the organization among farmers and consumers to use direct marketing to construct short-circuit value chains. Borja et al. (2020) surveyed 1478 actors in South-, Central- and North America and found interesting patterns in the adoption of technology for alleviating the COVID-19 crisis. They found that 30% of actors in the value chain, dabbled in or adapted their activities to the use of digital technology (internet/apps) for their purchases and sales. Close to 38.7% of these actors modified or adapted their business for delivering their products directly to the final consumer.

Initiatives by local suppliers, such as weekly fresh produce orders for home delivery or WhatsApp groups, have contributed to keeping these farmers businesses going. For example, in Michoacán in Central Mexico, avocado and berry producers traditionally focused on the export market started home delivery schemes in cities. In most cities of the CAM region, initiatives linking producers directly with their consumers sprouted massively. These emerged as both an act of solidarity with farmers suffering disruptions in their usual value chains as well as a way to get fresh products for consumers facing the closure of markets. These mechanisms are tightly linked to the sub- or peri-urban agricultural systems where local production could be easily transported by private vehicles to where consumers live, with restricted mobility. Small scale producers of potato, broccoli, fava, vetch and cauliflower in Los Cuchumatanes Huehuetenango, Guatemala shared transportation services by truck or motorcycles to transport their products in the region. In the city of Quetzaltenango, Guatemala, agricultural input suppliers for potato, vegetables, maize and livestock farmers, saw a reduced demand for their products but were able to maintain their business by offering delivery door-to-door.

Borja et al. (2020) also found that other strategies were implemented by actors in the agri-food system such as diversification of their products (30%) and value-added practices (18%). Diversification of markets, clients and outlets, and organization and building on the scale either for input purchase or for marketing products allowed farmers to alleviate the immediate effect of sanitary measures on their functioning. Value-adding alternatives, either in export or locally consumed products such as coffee, maize, or milk, were identified as an essential mechanism to cope with market disruptions with a general trend to go further in the processing of raw materials (i.e. roasted and packed coffee, tortillas, and other maize-based products, cheese and other dairy products, meat cuts). Finally, collective, large scale input purchases worked well where

farmers were part of organizations. Some of these organizations also supported safeguard documents and logistics support for the transport of inputs and outputs.

Fig. 2 summarizes the main impacts of covid19 sanitary measures and some response mechanisms implemented by small and medium scale agricultural enterprises to deal with such measures.

3.4. Impacts and response mechanisms for subsistence and small-scale farming systems

The immediate effect on small scale subsistence farming systems were mixed during the initial phase of the pandemic for COVID-19 and the sanitary measures implemented by governments. On the one hand, their farming systems are importantly devoted to food production for self-consumption, and this feature made them more resilient to changes in food prices and markets and slowed down economic activities for their food security. Their reduced dependence on external agricultural inputs and hired labor made them less vulnerable to limited availability and price volatility. However, on-farm production represents a decreasing share of their income.

Thus, smallholders often combine subsistence with cash crop production for local markets, and also complement their agricultural activities with off- and non-farm income-generating activities; such as occasional laborers for nearby commercial agricultural entrepreneurs, urban works in construction, transport, or commerce, as well as permanent or seasonal migration for a wide diversity of activities including services, tourism, and agricultural labor. These lastly mentioned activities were particularly disrupted as a consequence of the restrictions imposed by authorities in the region. Some of the main impacts and response mechanisms are described next. In addition, Fig. XX summaries our findings.

To begin with, local markets closure reduced farmers' ability to access markets, affecting the sale of fresh products, mainly fruits, and vegetables. Also, the marketing of prepared food was heavily hit: For example, in Mexico, women often sell excess maize production in the form of *tortillas* or other traditional dishes to market-goers and merchants for on-site consumption. With the closure or social distancing restrictions imposed, this income-generating activity was significantly affected. Additionally, the restrictions imposed by governments and the following economic slow-down had a substantial effect on their off-farm jobs. For instance, labor demand in construction sector and commerce were drastically reduced in urban areas. Likewise, because of the lower

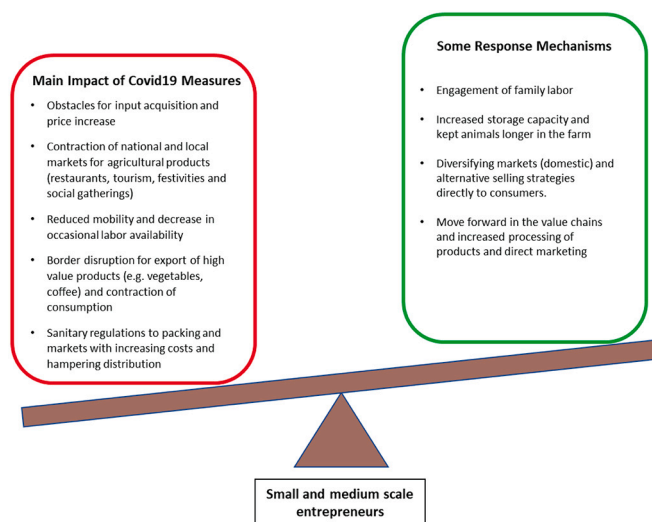


Fig. 2. main impacts of covid19 sanitary measures and some response mechanisms implemented by small and medium scale agricultural enterprises in CAM.

prices and demand for agricultural products, labor market for agricultural activities at larger farms was depressed as well.

In small rural communities, the immediate impacts of COVID-19 were mild, as most of the food consumed is produced locally. Some interviewees reported a decrease in processed foods' purchase, coupled with increased homegrown production of vegetables or poultry. Nevertheless, others mentioned that due to the lack of off-farm employment, households' cash income decreased. The immediate effect of reducing income may reduce spending on food consumption and extend periods of food insecurity.

To generate some money from their agricultural production, small scale and subsistence farm households strengthened the relationships directly with consumers and explored new alternatives to communicate around the importance of fresh, locally produced foods and food preparations. An example is the still emergent small food networks where producers sell directly to consumers. However, their evolution in the near future is uncertain.

Mobility dynamics and in particular local migration were also affected. As urban economic activities slowed down, many people from rural origin - especially the young ones (including students) - went back to their rural hometowns and engaged in agricultural activities. For example, in a sub-urban part of Mexico City, youngsters were engaged in selling locally, door to door, fresh products that local farmers had problems to get to their usual markets, as the usual intermediaries were out of business or offered extremely low prices.

Some communities engaged in collective labor arrangements. In the State of Mexico, for instance, farmers grouped to carry outcropping tasks in a collective and rotating way. This is an ancient practice linked to local cultural values and social organization that had been partially lost but saw a revival in response to labor scarcity during COVID-19, with many farmers above 60 years old and with recommendations to stay at home.

An important off-farm activity and source of money for small and subsistence farmers is migration to other countries, specially to USA. In 2019, an estimated 700,000 people left the region in search of better living conditions (Coll, 2020), migrant caravans were organized where thousands of people would walk through borders and countries towards the north. The border restrictions or closures, curfews and lockdowns in the different countries and fear of infection stopped such a trend. However, at the moment of submitting this article, a new caravan has crossed the border between Honduras and Guatemala and is heading towards Mexico with an estimated 2000 people. The closure of borders halted the migration of rural workers. However, remittances from migrants in the US, which for years have become an essential source of external income in the CAM region (see Table 1) saw considerable increases in Guatemala (9,2%), El Salvador (9,8%) and Honduras (15,2%) when comparing June 2019 and June 2020, while Mexico had a dramatic increase of remittances from February to March of 2020 of 35% (Arroyo, 2020). Such an increase is believed to have played a key role in mitigating the immediate effects of COVID-19 on poverty and food insecurity in rural areas.

State interventions in the region mainly focused on social assistance, and therefore this type of system was the most supported during the initial stages of the COVID-19 pandemic. In Mexico, social programs were paid three months in advance to avoid farmers traveling too often to towns for their checks. Panama, Honduras, El Salvador, y Guatemala distributed food to the most impoverished families.

Fig. 3 summarizes the main impacts of covid19 sanitary measures and some response mechanisms implemented by subsistence and small scale farming systems to deal with such measures.

4. Resilience of farming systems in the face of the immediate impacts of the COVID-19 pandemic in CAM

During the last decades, agricultural development in CAM has created a dynamic and successful export sector, involving numerous

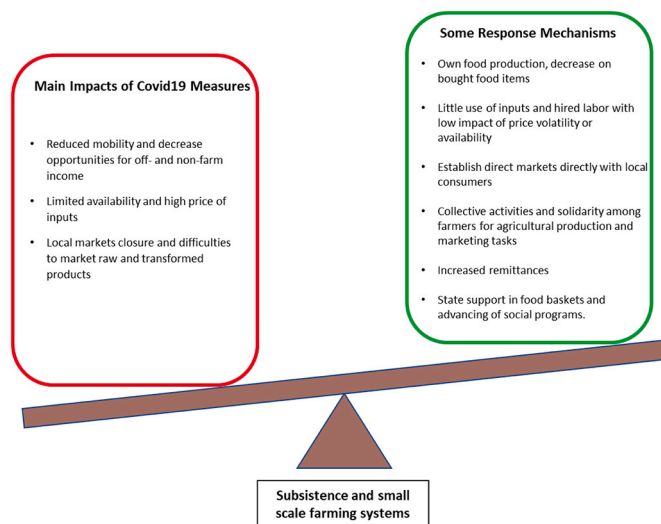


Fig. 3. Main impacts of covid19 sanitary measures and some response mechanisms implemented by subsistence and small-scale farming systems in CAM.

high values crops. By improving its productivity and increasing production, CAM became a significant leading exporter in avocado, palm oil, coffee, and vegetables. However, this success has not been generalized for the whole agricultural sector. Millions of subsistence producers are still struggling to make a decent living. All that different farming systems' resilience was put to the test during the last year because of the pandemic.

Immediate impacts of COVID-19 in agricultural systems in the CAM region were different for different farming systems due to their particularities and the context where they operate. From corporate and large-scale systems to small-scale subsistence systems, all agricultural systems were impacted, more or less severely, closely linked to their level and form of integration with input, output, and labor markets as well as their general livelihood strategies. However, as discussed in the next sections, we can expect smallholder poverty and financial hardship to increase in the medium term.

Based on our interviews and review, we find that those systems more vertically integrated or coordinated seemed better able to ensure business continuity and were able to more quickly reorganize with their suppliers/buyers, even across borders, to respond to the crisis. We also observed that better-resourced farmers with more extensive stocks of supplies were similarly better able to ensure business continuity, at least in the first months of the pandemic. Farming systems more dependent on local markets for commercialization of their products, locally purchased inputs, and dependent on temporary or occasional hired labor were probably the most affected because of the decreased availability and volatility in the price of agricultural inputs at the local level and the closure of local markets, schools, offices and restaurants that slowed down their capability to sell their products. Subsistence systems or smaller producers were better able to adapt by producing more or less of different crops (i.e., the amount produced for market versus consumption) and ability to produce with greater or lesser levels of purchased inputs, more or less hired labor flexibly. In sum, larger corporate farming systems, due to their control or coordination within the supply chain, and smaller subsistence farming systems were relatively less directly impacted. They showed greater adaptive capacity, while medium and small entrepreneurial farming systems dependent on agriculture as their primary income and less control over the upstream and downstream parts of their supply chain were more affected by the pandemic's immediate effects. With this in mind, in this section, we discuss initial impressions of how the pre-COVID-19 characteristics of the agri-food system have shaped initial impacts, identify major response trends, and ponder what implications the pandemic might have

moving forward for the agricultural systems in CAM.

4.1. How the characteristics of the CAM agri-food systems influenced the impacts of COVID-19 on farming systems?

Some features of the CAM region played an important role in mediating the impact of COVID-19 and associated sanitary measures imposed by governments on agri-food systems. We identify as particularly relevant the nature of agricultural exports, the current structure of the agricultural sector, the diversified livelihood strategies of rural households, and the importance of mobility for rural livelihoods as four characteristics that shaped the pandemic's immediate impacts on agriculture in CAM.

4.1.1. Importance of exports of non-essential agricultural goods

An essential feature of the CAM agricultural sector is the trend over the past decades towards a focus on high-value agricultural exports of luxury or niche products such as coffee, cacao, fruits, and vegetables to markets in North America, Europe, and Asia (Piñeiro, 2005). Agricultural exports represent significant parts of the total exports in the region. Due to lockdowns, mobility reduction, and economic slowdowns in importing countries, the demand for these products abroad has considerably contracted, compounded by port and airport disruptions, affecting many agricultural entrepreneurs' livelihoods in the region. According to FAO-ECLAC (2020a), the value of exports of the agricultural sector fell by 7.0% compared with 2019. The most affected sub-sectors were fresh products, including fruits, vegetables, fish, and live animals. Coffee is particularly emblematic for the region. On the supply side, the lockdown restricted export activities, including the function of warehouses and ports. Honduras and Guatemala reported a decrease of 7% and 4% in shipping, respectively (Hernandez et al., 2020). On the demand side, the COVID slowed down economic growth in Europe and the United States, affecting the overall coffee consumption. This crisis may also affect the demand for the specialty and certified coffees produced in the region as consumers demand shifts to cheaper brands (Hernandez et al., 2020).

4.1.2. High dependency on imports for food

CAM countries became highly dependent on imports of foods to meet their population's basic dietary needs. Rice, maize and wheat imports from outside the region are essential, particularly for El Salvador, Panamá, and even Honduras. Dairy, beans, meat, and even vegetables are the most critical food products traded within the region. The initial news of global trade disruptions and considerations of border closings brought into focus the high level of dependency within CAM on food imports for basic food security, and governments responded diversely with increased imports, grain stores, and incentives for production in the context of COVID-19 with differing effects (FAO-CELAC, 2020).

4.1.3. Rural households increasing dependence on off-farm income

Rural households in the region, mainly smallholders, combine farming with other income sources, including wage labor in the agricultural sector, employment in other sectors, value-added, migration, and remittances (Taylor et al., 2010). In the context of COVID-19, these diverse income streams allowed these farmers greater flexibility to increase or reduce agricultural production versus time dedicated to other income-generating activities. Remittances dropped during the first six months of the pandemic but then rebounded (Noe-Bustamante, 2020). On the negative side, the pandemic's effect on employment directly affected the income streams that these households use to invest in agriculture.

4.1.4. The importance of mobility for farming and farm households

Rural livelihoods and mainly farming ones are notably dependent on mobility – farmers' ability to travel to markets to purchase inputs or seeds, sell agricultural products, access financial services, and provision

for their households (FAO-CEPAL, 2020). The interruption of public transportation services, the mobility restrictions, and the concern for infection with COVID-19 affected many of the primary activities involved in farming, notably as the crisis continued into May, which for many farmers in the region is the start of one of the primary annual planting seasons.

4.1.5. Tight integration of agri-food systems within Central American countries

A significant portion of food exports and imports from Central American countries are to other Central American countries. Early on in the pandemic, the Presidency of the Central American Integration System (SICA), together with presidents of the region, discussed measures needed to ensure continuity of food supply (and commerce) in the region. This led to early measures between countries to facilitate trade and transport of food within the region, including handling COVID-19 transmission across borders with the transport sector. The intraregional trade for the Central American countries (without Mexico) fell by 8.8%, far below the 26.6% average export drop of other regional trade blocks in Latin America (ECLAC, 2020a, 2020b). In this case, the strength of the regional integration mechanisms allowed for an early and compelling dialogue and response that provided some level of stability to agricultural systems across the region when countries were already talking about closing borders and restricting food exports.

4.2. Major response trends observed within the agri-food systems

After the first sanitary measures were implemented in the countries of the CAM region, all actors in the agri-food systems, including farmers, governments, the private sector, and civil society, implemented a wide range of mechanisms to palliate the effect of these measures in the functioning of the agri-food systems. With those measures, they wanted to ensure food availability for all social sectors and protect the poorest and vulnerable in this unparalleled time. Shifts in consumer behavior in response to the pandemic and associated measures also provoked agri-food system actors' shifts. They sought to respond to these ongoing shifts in both demand and operating environment, with implications back into farming systems. For example, in many places, consumers increased consumption of staples such as rice and processed foods are given decreased access to markets and other venues for fresh local foods such as vegetables, fruits, and animal products (FAO-ECLAC, 2020a, 2020b). Consumers increased reliance on supermarkets for food purchases, and many purchased larger volumes of food less frequently due to mobility restrictions. In some cases, imports were interrupted (either due to border complications or lockdowns in other production countries), allowing for expanded domestic or local producers' expanded opportunities. It is in this context that we highlight in this section four response trends with important implications for the agricultural sector.

4.2.1. Alternative value chains for food products

One of the most stunning effects of the COVID-19 pandemic was the growth of alternative food chains, procurement, and provisioning strategies. This trend was driven by all actors, including producers, brokers, and consumers. Many short value chains emerged, some through local grocery stores and producers/processors moving further up the value chain to reach customers in their homes. Most of these new business models were more direct, local, and shorter value chains than previously. Direct marketing and delivery services played a crucial role in facilitating food availability to the general population and new outlets for farmers' products.

4.2.2. Collective action by farmers

Social networks showed a vital asset of the agri-food system to overcome the pandemic's limitations in the CAM region. Organization and solidarity among farmers in the purchase of inputs, commercialization of products, and technical and financial support have been critical

in supporting alternatives for accessing markets, inputs, and agriculture services. The integration of networks between farmers and consumers has also emerged. Both have strengthened the social capital across all types of farming systems in the CAM region and played a crucial role in alleviating the immediate impact of the sanitary measures imposed to fight COVID-19.

4.2.3. Digital innovation

A breakthrough was resulting from the social distancing and sanitary measures promoted by governments in the CAM region during this initial stage of the COVID-19 pandemic was the proliferation and expanded use of digital mechanisms and information and communication technologies (ICT's). ICT helped facilitate information, transactions, and new business models within the sector to respond to households, businesses, and farmers' needs (FAO, 2020c). Innovative solutions for farmers' services were an essential part of this trend as governments, NGOs, and private extension services were forced in the early months to innovate in digital forms for reaching farmers and continuing to provide information services and technical assistance. Tools used ranged from educational platforms to essential messaging services, as well as financial and commercial platforms. In addition to facilitating transactions at a distance, the explosion in digital platforms' use by different actors introduced new possibilities for communication, business transactions, and information that may have taken many years to emerge without the pandemic. This trend will likely have important implications for many areas of work in the sector beyond the pandemic (FAO, 2020c).

4.2.4. The growth of the role of delivery services in the agri-food system

With the desperate need from consumers to acquire food products and the need for food sector businesses to sell their products, existing but incipient delivery services found an opportunity to grow. Delivery platforms, which offer a digital means for ordering and paying for products from diverse providers, expanded their clients in terms of households and businesses (Martinez et al., 2020). Many restaurants, stores, and even supermarkets began to offer delivery services, and the range of what one could purchase from the home grew exponentially. While these delivery services have grown mainly in urban areas serving retailers or restaurants, they have allowed many smaller food-related businesses to continue operating, ensuring demand for their farmer suppliers and reopening those market linkages. As these services mostly use digital payment forms, they are likely expanding digital financial services within the sector.

4.2.5. A more visible role of the state

The state's role in regulating the sector became much more visible. They implemented policies and programs that impacted and went beyond most countries the kind of state intervention seen or imagined in the past. Strict regulation of the mobility of people, transport, retail, food service, and unprecedented social programs like cash transfers and food distribution were quickly put in place by governments. At the regional level, the Central American Integration System also became a more visible actor, facilitating regional responses and, in particular, early commitments and work on how to ensure within region commerce, COVID-19 monitoring, and responses to the immediate effects of the COVID-19 pandemic.

5. What's next for the agri-food systems in the CAM region?

If the uncertainties and disequilibrium generated by the pandemic in these first months were already very large, what the future would look like after this shock is difficult to imagine. Would changes associated with the response to the COVID-19 emergency such as the shortening of value chains, the strengthening of local markets and forms of organizations and the overwhelming role of ITC's linking producers, processors and consumers remain in the longer term? Would governments

in the region continue to collaborate and generate coordinated actions to improve the resilience of the agri-food systems in the region and protect the livelihood of farmers, notably those most vulnerable? How would the different types of farming systems look like in a post-COVID-19 era and what changes are needed to maintain their viability and their contribution to the agri-food system? Would all these changes entail a transformation in the long term for agri-food systems in the CAM region for increased resilience?

While these questions remain open, there are a few hypotheses we would like to propose vis a vis future trends to prepare for. First, it is clear that progress on the SDGs in the region will be severely affected. While in most countries in the CAM region focus within the rural sector has slowly shifted from food security (zero hunger) to economic development (no poverty) with increasing attention to climate adaptation and mitigation (Climate Action), we think it is safe to say that the focus will quickly shift back to food security (zero hunger) as the economic effects of the crisis throw many more households back below the poverty line, with important implications for the investments needed to sustain advances in economic development and climate resilience in rural areas. Second, the COVID-19 pandemic has put a spotlight on vulnerabilities in the health sector and funding for the near future may be focused on SDG 3, good health and wellbeing, but given the correlates between COVID-19 impact and overall nutritional status, including diet related non-communicable diseases (NCDs), there will likely be more attention to these kinds of health issues. This could drive increased consumption of more healthy, non-processed foods which could favor domestic agricultural producers so could spill over into the agricultural sector in a positive way. Third, the heightened realization of import dependence for some countries for basic foodstuffs may lead governments to promote domestic production and consumption and shorter value chains which would benefit smaller farmers who produce food crops.

The COVID-19 in the CAM region has showed some of the flaws of the agricultural systems as well as the strength of some actors within the agri-food systems to innovate and improve their resilience. It calls for a moment of reflexivity to address the dominant agricultural development strategy and to devise an alternative development model based on the sustainability of the agri-food systems where all actors, including the large diversity of farming systems, contribute producing enough local healthy food as well as economic growth in a culturally and ecologically appropriate way, for a region in important need of it.

Declaration of Competing Interest

The authors declare no conflict of interest.

Acknowledgments

We would like to acknowledge the 44 interviewees who shared their time, experience and knowledge to provide first-hand information for this study as well as the several colleagues that shared with us information on the immediate effect of COVID-19 in the agricultural systems for specific sectors, regions and systems. We would like to thank the support from the CGIAR Research Program on Maize (MAIZE) for making this publication open access to all.

Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.agsy.2021.103178>.

References

- Arroyo, L., 2020. Las remesas salen al rescate de las familias golpeadas por el coronavirus. <https://elpais.com/mexico/2020-07-25/las-remesas-salen-al-rescate-de-las-familias-golpeadas-por-el-coronavirus.html> (accessed on October 1st, 2020).
- Avelino, J., Cristancho, M., Georgiou, S., Imbach, P., Aguilar, L., Bornemann, G., Läderach, P., Anzueto, F., Hruska, A.J., Morales, C., 2015. The coffee rust crises in

- Colombia and Central America (2008–2013): impacts, plausible causes and proposed solutions. *Food Security* 7 (2), 303–321. <https://doi.org/10.1007/s12571-015-0446-9>.
- Baumeister, E., 2010. Pequeños productores de granos básicos en América Central: Cuantificación, caracterización, nivel de ingresos, pobreza, y perfiles demográficos, socioeconómicos y ocupacionales. FAO-RUTA.
- Borja, I., Carpio, C., Castillo, M.J., García, M., Palma, M., Pequero, F., Ribera, L., Sánchez, M., Sandoval, L., Zapata, S., 2020. Impacto del COVID-19 en la cadena agroalimentaria de Latinoamérica. Technical Report. Texas A&M. <https://doi.org/10.13140/RG.2.2.34409.11365>.
- Brogan, K., McGuinness, E., 2013. Assessment of Remittances in Honduras: The Role of Remittances Along the corredor seco (FIELD Report No. 19). Washington DC. USAID-ACDI/VOCA-FHI360.
- Cassanova, S., 2020. Diversification: Key Word in Times of Covid-19. <https://www.rikolt.org/en/news/diversification-key-word-times-covid-19> (accessed on October 5th, 2020).
- CLAC (Latin American and Caribbean Network of Fair Trade Small Producers and Workers), 2020. Statement on Effects of COVID-19 in Latin America and the Caribbean. <http://clac-comerciojusto.org/en/2020/04/statement-on-effects-of-covid-19-in-latin-america-and-the-caribbean/> (accessed on October 5th, 2020).
- Coll, M.F., 2020. La despoblación de Centroamérica por el Covid-19. *Forbes Mexico*. <https://www.forbes.com.mx/la-despoblacion-de-centroamerica-por-el-covid-19/>.
- ECLAC (Economic Commission for Latin America), 2020a. The Effects of the Coronavirus Disease (COVID-19) Pandemic on International Trade and Logistics (Special Report COVID-19 no. 6). Santiago de Chile. https://repositorio.cepal.org/bitstream/handle/11362/45878/1/S2000496_en.pdf.
- ECLAC (Economic Commission for Latin America), 2020b. Statistical Bulletin: International Trade in Goods in Latin America and the Caribbean - second quarter 2020–40. Available in. https://www.cepal.org/sites/default/files/publication/files/46518/Boletin_40_ingles.pdf.
- FAO, 2020a. FAOSTAT. <http://www.fao.org/faostat/en/#data> (accessed on August 2nd, 2020).
- FAO, 2020b. Repercusiones de la enfermedad por coronavirus (COVID-19) en los trabajadores informales. <http://www.fao.org/3/ca8560es/CA8560Es.pdf>.
- FAO, 2020c. Food Systems and COVID-19 in Latin America and the Caribbean: The Opportunity for Digital Transformation. <http://www.fao.org/3/ca9508en/CA9508EN.pdf>.
- FAO-CELAC, 2020. Seguridad Alimentaria bajo la Pandemia de COVID-19. Santiago, FAO. <https://doi.org/10.4060/ca8873es>.
- FAO-CEPAL, 2020. Sistemas Alimentarios y COVID-19 en América Latina y el Caribe: Impacto y Riesgos En El Mercado Laboral. https://repositorio.cepal.org/bitstream/handle/11362/45581/1/ca9237_es.pdf.
- FAO-ECLAC, 2020a. Food systems and COVID-19 in Latin America and the Caribbean: trade performance during the crisis. Bulletin 12. <https://doi.org/10.4060/cb0583en>. Santiago, FAO.
- FAO-ECLAC, 2020b. Food systems and COVID-19 in Latin America and the Caribbean: Food consumption patterns and malnutrition. In: Bulletin 10. FAO, Santiago. <https://doi.org/10.4060/cb0217en>.
- GAIN-JHU (Global Alliance for Improved Nutrition (GAIN) and Johns Hopkins University (JHU)), . The Food Systems Dashboard. Geneva, Switzerland. <https://www.foodsystemsdashboard.org>. <https://doi.org/10.36072/db>.
- Gómez, I., Cartagena, R., Ortiz, X., Díaz, O., 2017. La agricultura familiar campesina en Centroamérica: una apuesta estratégica frente a los desafíos de los territorios rurales. Realidad: Revista De Ciencias Sociales Y Humanidades 137, 511–525. <https://doi.org/10.5377/realidad.v0i137.3092>.
- Hernandez, M.A., Pandolph, R., Sängler, C., Vos, R., 2020. Volatile coffee prices: Covid-19 and market fundamentals. International Coffee Organization-International Food Policy Research Institute (IFPRI). Coffee Break Series N° 2, May 2020, p. 11. <http://www.ico.org/news/coffee-break-series-2e.pdf>.
- IFAD (International Fund for Agricultural Development), 2016. To Reduce El Niño's impact on Central America's Dry Corridor, Build Resilience and Invest in Sustainable Agriculture. <https://www.ifad.org/en/web/latest/news-detail/asset/39066637>.
- IICA (Inter-American Institute for Cooperation on Agriculture), 2020. Family Farming and Agrifood Supplies in Latin America and the Caribbean Amidst the COVID-19 Pandemic. <https://iica.int/sites/default/files/2020-07/Family%20farming%20and%20agrifood%20supplies%20in%20Latin%20America%20and%20the%20Caribbean%20amidst%20the%20COVID-19%20pandemic.pdf>.
- IMF (International Monetary Fund), 2020. Policy Responses to COVID-19, Policy Tracker. <https://www.imf.org/en/Topics/imf-and-covid19/Policy-Responses-to-COVID-19> (accessed on August 20th, 2020).
- Johns Hopkins Coronavirus Resource Center, 2021. <https://coronavirus.jhu.edu/map.html> (accessed on March 1st, 2021).
- Lopez-Ridaura, S., Barba-Escoto, L., Reyna, C., Sum, C., Palacios-Rojas, N., Gerard, B., 2021. Maize intercropping in the milpa system. Diversity, extent and importance for nutritional security in the Western highlands of Guatemala. *Sci. Rep.* 11, 3696. <https://doi.org/10.1038/s41598-021-82784-2>.
- Marin, J.D., 2020. 7ma. Conferencia online FAO: Agricultura familiar: situación y desafíos frente al COVID-19. <https://www.youtube.com/watch?v=uxj1iC9ChSE>.
- Martin, C.D., López, G.J., 2020. Chocolate in the Time of Covid-19 ReVista, Harvard Review of Latin America. <https://revista.drclas.harvard.edu/book/chocolate-time-covid-19%C2%A0> (accessed on October 5th, 2020).
- Martinez, C., Pasteiner, D., Barrozo, T., 2020. COVID-19 Delivers Investment Boom For Latin America's Online Delivery And Logistics Startups. *Forbes*. <https://www.forbes.com/sites/mergermarket/2020/08/26/covid-19-delivers-investment-boom-for-latin-americas-online-delivery-and-logistics-startups/?sh=e1368527779f>.
- MENAFN (Middle East North Africa Financial Network), 2020. Panama Banana Exports not Affected by Pandemic. <https://menafn.com/1100292891/Panama-banana-exports-not-affected-by-pandemic> (accessed on October 6th, 2020).
- Noe-Bustamante, L., 2020. Amid COVID-19, Remittances to Some Latin American Nations Fell Sharply in April, then Rebounded. *Pew Research Center*. <https://www.pewresearch.org/fact-tank/2020/08/31/amid-covid-19-remittances-to-some-latin-american-nations-fell-sharply-in-april-then-rebounded/>.
- OXFAM (Oxford Committee for Famine Relief), 2016. Unearthed: Land, Power and Inequality in Latin America. <https://www.oxfam.org/en/research/unearthed-land-power-and-inequality-latin-america>.
- Ozaeta, P.M. Pomareda, 2020. Coronavirus: Las 5 Preocupaciones De Los Agricultores Guatemaltecos Ante El COVID-19. <https://forbescentroamerica.com/2020/04/06/coronavirus-las-5-preocupaciones-de-los-agricultores-guatemaltecos-ante-el-covid-19/> (accessed on October 6th, 2020).
- Piñero, M., 2005. Rural Development in Latin America: Trends and Politics. *Grupo CEO, Argentina*, p. 42. <http://citeserx.ist.psu.edu/viewdoc/download?doi=10.1.1.470.6727&rep=rep1&type=pdf>.
- Pomareda, C., 2013. Innovations in the Agriculture of Central America: Progress. Institutional Capacity and Policy Needs, CIAT-FAO, p. 85. <http://www.fao.org/3/b1732e/b1732e.pdf>.
- Reardon, T., Barrett, C.B., Berdegue, J.A., Swinnen, J.F.M., 2009. Agrifood industry transformation and small farmers in developing countries. *World Dev.* 37 (11), 1717–1727. <https://doi.org/10.1016/j.worlddev.2008.08.023>.
- Reyes, M., 2020. ¿Sabes cuál fue el producto salvadoreño que más se exportó a pesar de la pandemia? El Salvador.com 25 Sept 2020. <https://www.elsalvador.com/noticias/negocios/azucar-sector-azucarero-exportaciones/757228/2020/> (accessed on October 4th, 2020).
- SICA (Sistema de la Integración Centroamericana), 2020. Observatorio Regional SICA-COVID 19. <https://www.sica.int/coronavirus/observatorioSICACOVID19>.
- Taylor, J.E., Yunez-Naude, A., Jesurun-Clements, N., 2010. Does agricultural liberalization reduce rural welfare in less developed countries? The case of CAFTA. *Appl. Econ. Perspect. Policy* 32 (1), 95–116.
- The World Bank, 2020. World Bank Open Data. <https://data.worldbank.org/> (accessed on August 1st, 2020).
- Torero-Cuyen, M., 2020. 1era conferencia FAO Covid19 y su impacto sobre la agricultura y la alimentación; “El COVID-19 y su impacto sobre la agricultura y la alimentación en América Latina y el Caribe”. <https://www.youtube.com/watch?v=QOwCB5k2ik> (Streamed April 9th, 2020).
- UNCTAD (United Nations Conference on Trade and Development), 2013. Mexico's Agriculture Development: Perspectives and outlook, p. 184. https://unctad.org/system/files/official-document/ditctnd2012d2_en.pdf.
- Van Teijlingen, K., Hogenboom, B., 2020. COVID-19 Impact on the Value Chain in Latin America. CEDLA, Amsterdam, p. 15. <https://www.jstor.org/stable/resrep25676>.
- WFP (World Food Programme), 2021. Guatemala. World Food Programme, Rome, Italy. <https://www.wfp.org/countries/guatemala>. accessed on 01-03-2021.
- Zapata, B., 2020. La pandemia de coronavirus afecta las exportaciones de tomate y aguacate de México. *CCN News*. <https://cnnespanol.cnn.com/video/exportaciones-coronavirus-estados-unidos-jitomate-aguacate-productores-economia-belen-zapata-perspectivas-mexico/> (accessed on October 5th, 2020).