URBAN AGRICULTURAL ACTIVITIES, A FOOD SYSTEM RESILIENCE STRATEGY DURING COVID-19 IN HAITI

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ABSTRACT

The COVID-19 crisis is impacting the reconfiguration of food systems at different scales. In poor countries where food insecurity had already been a major problem, the urban population under the lockdown often had to cope alone with shortages of food and access to it. In the poorest country in the Americas, the urban population adapted the food system by intensifying the practice of urban agricultural activities. In this exploratory research, using a sample including urban dwellers that were engaged in urban agriculture and those who were not, we investigated the following question: Did urban agriculture linked to COVID-19 represent an appropriate and innovative strategy for the urban food system resilience? Our results confirm that the Haitian urban population used urban agriculture as an innovative and appropriate food resilience strategy. They produced varieties chosen for their very rapid production character and were able to cope successfully with the crisis, and also have lessons to share with other actors and countries.

ГОРОДСКАЯ СЕЛЬСКОХОЗЯЙСТВЕННАЯ ДЕЯТЕЛЬНОСТЬ — СТРАТЕГИЯ ЖИЗНЕСПОСОБНОСТИ ПИЩЕВОЙ СИСТЕМЫ ВО ВРЕМЯ COVID-19 В ГАИТИ

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АННОТАЦИЯ

Вызванный COVID-19 кризис оказывает влияние на реконфигурацию пищевых систем различного масштаба. В бедных странах, где отсутствие продовольственной безопасности уже являлось большой проблемой, городское население в условиях локдауна часто должно было само справляться с нехваткой продовольствия и доступа к нему. В беднейшей стране Северной и Южной Америки, городское население адаптировало пищевую систему путем интенсификации практики городской сельскохозяйственной деятельности. В данном поисковом исследовании с использованием выборки, включающей городских жителей, которые осуществляли эту деятельность, и тех, которые ее не осуществляли, мы изучали следующий вопрос: является ли городское сельское хозяйство, связанное с COVID-19, пригодной и инновационной стратегией для жизнеспособности городской пищевой системы? Наши результаты подтверждают, что городское население Гаити, использовало городское сельское хозяйство как инновационную и пригодную стратегию жизнеспособности пищевой системы. Они выращивали культуры, выбранные из-за их высокой продуктивности, и были способны успешно справляться с кризисом, а также извлекли уроки, которыми они могут поделиться с другими субъектами и странами.

1. Introduction

Agricultural activities in urban areas are attracting greater attention in poor countries. In many poor countries, agriculture remains a rural activity. This is particularly the case in countries where urbanization is growing fast. But with rural migration to cities, it should not be surprising to find even limited agricultural activities in urban or suburban areas where there are new urban settlements. While urban agriculture plays an important role in addressing food security issues in different geographical contexts [1,2,3], it has not received much attention as either a political or major research issue.

In 2020, COVID-19 came as a particular shock that not only created loss of members in many families but also, through the lockdown and mobility restrictions, implied a shortage in na-

tional economies and local food systems [4]. In Low & Middle Income Countries (LMIC), the majority of the rural and urban poor population relies on these local food systems to feed themselves [4]. They are reputed to buy mainly on open-air and informal wet markets. With the government COVID-19 related restrictions, the purchasing power of the poor decreased and many of those markets were forced to close. The poor had to depend on more distant and possibly more expensive supermarkets. These impacts of COVID-19 on local food systems and the poor still receive very little formal analysis, although they were recently observed by Christophe Béné from the Consultative Group on International Agricultural Research (CGIAR). His literature review shows works on the macro or national level on food system resilience in times of crisis. He focused on "local food system resilience" and recommended specific strategies that actors can be engaged in to strengthen their actual resilience [4].

At another level in terms of "global health", the resilience of the food system is also an element of the population's resilience to COVID-19. Indeed, the impact of the pandemic is much greater for malnourished populations. To our knowledge, no field research has been undertaken to analyze such strategies at a micro-level of the actors, as a response to the COVID-19 shock, apart from [5] for the case of France. The present exploratory research intends to contribute to fill this gap, particularly for the south country, by analyzing a particular strategy implemented by the urban population in Haiti, during this crisis. Actors' strategies are important alternatives when the government is unable to address living issues. For example, taking into account that COVID-19 and its economic fallout were spreading in the poorest parts of the world, Laborde et al. [6] anticipated the increased number of poor and food-insecure people and estimated in a scenario analysis that globally, in the absence of interventions, over 140 million people could fall into extreme poverty in 2020 — a 20% increase from the levels of the beginning of 2020.

In Haiti, America's economically poorest country, the situation is compelling. The food security system is characterized by chronic food insecurity that becomes endemic and is regularly exacerbated mostly by political crises and natural disasters. Those disruptions lead to limited rural agricultural production to feed the whole population. The urban population mostly relies on imported food. It should be noted that import increases as long as cities are growing, and the prospects are difficult [7,8]. When in March 2020, the formal markets were protected from COVID-19 by the related restrictions, urban people in Haiti had to face more severely the disruption of the local food systems caused by COVID-19 because of their poverty. In this context, people living in peri-urban areas were literally disconnected from the food market.

In this particularly vulnerable food system, shocks and crises often have sound effects [9]. From the mid of 2018 to the end of 2019, Haiti faced a continued political crisis. Just after a two-month break, at the beginning of 2020, it had to face a severe and unprecedented shortage. On March 19, the government announced a complete lockdown after the first two reported CO-VID-19 cases. In the context of poverty, urban people are more exposed to food shortages resulting from the obstruction of the flow of both rural and international products to the urban areas [10]. Both rural and urban Haitian population faced more severe food insecurity due to a continuous increase in the food basket price [11] following the recent political crisis and the COVID-19 pandemic. The aforesaid implies that the COVID-19 in particular offers the opportunity to examine how urban and peri-urban people faced the necessity to innovate by practicing agricultural activities for food and medication as an important research objective. Then, it also offers us an exceptional opportunity to study the following research question: Did urban agricultural activities represent an appropriate strategy for a food resilience system? This research question is worth studying as the poorest urban households across the globe spend between 60 and 80% of their income on food [12]. In Haiti, where we realized this exploratory research, the COVID-19 crisis raised food prices for at least 4% in April [11] and more than 10% as of August 2020, when the government released the COVID-19 restrictions. In the continuation of the literature on the innovation process in the food system [13], we made the following hypothesis: urban agriculture is an appropriate strategy to cope with shortages in food systems in poor countries.

To study the above question and test our hypothesis, we collected primary data in Haitian cities, while respecting social distancing rules, and analyzed them in light of the analytical framework offered by the food system resilience approach. In the following sections, we briefly review the literature on the food system and food system resilience, and then we present the Haitian context, before developing the methodology that guides to the discussed results.

2. Background literature
2.1. Food system resilience approach

In this paper, we have applied the "food system resilience approach". This approach was adapted and used in relation with various methodological propositions and different situations [14,15,16,17]. In this framework, a food system is defined as the network of activities connecting people to their food [16]. Authors like J.-L. Rastoin and G. Ghersi [18], define a food system in a more systemic and functional view: A food system is an interdependent network of actors (enterprises, financial institutions, public and private agencies) located in a defined geographical area (region, state, multinational region), who participate directly or indirectly in the creation of goods and services which are oriented to the satisfaction of the food needs for one or several consumer groups in or outside the area [18]. A food system includes both demand and supply sides of the food value chain. For Goodman [19], the food system operates within and is influenced by the social, political, economic and environmental context. And, in our view, it is also regulated and shaped by institutional factors of this context. The food system approach is broader than the value chain approach, because it concerns the set of means, institutions, practices and actors, through which every society organizes its food supply [20].

Many international agencies (United Nations, for instance) and other organizations have embraced the food systems as an appropriate target for their interventions in developing countries. In fact, according to J.-L. Rastoin's view, a food system can be a territorialized system [21].

The concept of resilience is used to address challenges like rapid population growth, crisis, among other changing factors. Resilience, broadly defined, is the capacity to absorb, adapt, and transform in response to a disruption [22], but also **it is** an active process of the structural change in the food system [23]. Several fields, such as psychology, engineering, ecology, socio-economics use the concept. In food security, the concept of resilience is strategic.

According to [17], food system resilience is the "capacity overtime of a food system and its units at multiple levels, to provide sufficient, appropriate and accessible food to all, in the face of various and even unforeseen disturbances". For [14], a resilient food system provides a reliable source of nutritious, safe, accessible food despite disturbances. We also consider a food system needs to be appropriate in its capacity to cope with particular food chain disruption.

Coping strategies are important for food system resilience. In countries where actors of the food systems are not working in

a regulated and stable socioeconomic context, disturbances may be frequent. These disturbances can be generated by other actors. They may also have natural or climatic causes. Poor populations which rely on the food system on a day-by-day basis are particularly vulnerable to the disturbance.

In 2020, the largest disturbance of food security was caused by the effects of the COVID-19 sanitary crisis. As pointed out by [24], this crisis had systemic effects on the food value chain. As the food systems are under increasing pressure to produce sufficient food for the population, particularly in the time of crises, the food system resilience approach is a useful analytical framework to study the urban agricultural response to the COVID-19 food crisis in the world's poorest economies. In poor countries, where food security is chronically an issue, food system resilience is even a more useful approach. Cities in those countries often rely on food aids to face disruption in times of crisis. But, COVID-19 broke the international and local food systems. And there were places for alternative food system initiatives [25].

2.2. Food system resilience innovation in time of crisis

Although it is a nascent field, food system resilience is considered as a useful strategy in urban areas, particularly for urban planners [26]. It has been used in developed countries to analyze the adaptation capacity of food systems to different crisis. In cities like Baltimore, a food-insecure community already exists, according to the collaborative research [26]. Cities in poor countries like Haiti appeared to be less food-insecure than rural areas, according to official observations [11], partly because they could rely on both local and international food supply. But global crisis like COVID-19 created an obligation for them to innovate or perish. Planning was not possible at all, and innovation needed to be adaptive and/or alternative. Here, the approach proposed by Lallau [27] appears to be useful to analyze the adaptability of vulnerable food systems to crisis.

Indeed, research conducted in Africa [27] and in Europe [28,29] determined the main characteristics for effective food system resilience. These were: energy and nutrient sovereignty, transparency and dialogue in the food chain, continuous innovativeness and evidence-based learning, proximities of stakeholders in the short chain.... Himanen et al. [29] propose a codesign approach that supposes a possibility of anticipation and, at the same time, clearly sheds light on innovations in the existing food system.

Recently published work from the France experience under COVID-19 showed that food system shortage created an opportunity for adaptation of local food systems. Darrot et al. [5] found that innovation niches were used by individual and collective adaptive strategies including change in food consumption behaviors. Based on their online survey study, they concluded with the following question: will this change be sustainable? In our study on the Haitian context, we help provide a first step answer to this question, through a similar methodology research, with specific questions to this issue.

The population in poor cities like Haitian ones was literally forced to innovate food supply during the lockdown. Innovations had to be individual or family-based, since there was no urban proximity like in France. We analyzed Haitian urban agriculture experiences, considering this new phenomenon as an innovation for food security. In the continuation of C. Béné's [4] arguments, acknowledging that the COVID-19 outbreak created a severe shortage of food systems, particularly in poor and developing countries, we collected data at a micro-level to test the following hypothesis: The urban agricultural activity observed in Haiti during the COVID-19 related lockdown was used as household innovation to counter food insecurity.

2.2.1. Food systems strategy

Urban agriculture is defined by Charvet and Laureau [30] as agricultural activities implemented in both urban and peri-urban areas. It is also considered as a strategy of community led food self-sufficiency and food system resilience [31]. It mobilizes different kinds of mediums to grow plants, including rooftops. Urban agriculture is sometimes associated with urban food system management. In countries where agricultural production is locally important as rural activity, developing urban agriculture is an alternative strategy for urban food system resilience. This strategy may be particularly appropriate in times of food system shortages.

In developing countries, where food security is an issue, urban agriculture appears as a strategy for food system resilience. Food system resilience is defined by Tendall et al. [17] as the "capacity over time of a food system and its units at multiple levels, to provide sufficient, appropriate and accessible food to all, in the face of various and even unforeseen disturbances". This well-known definition clearly indicates that resilience in a food system relates to the capacity to provide food security over time and despite disturbances. When a food system faces transportation issues, local production and territorial food system organization appear as adaptive strategies to reduce food insecurity. It may be the same for countries relying mainly on importation of food. For instance, in times of crisis like under the COVID-19 lockdown, food importation was reduced, which severely affected such countries. In such a situation, urban agriculture is mobilized as a food security strategy for urban households.

Martin-Moreau and Menascé [32] divided the different urban agriculture models into two families: outdoor, which is open-air urban agriculture, and indoor or agriculture in a controlled environment. The latter draws on aeroponic, hydroponic and aquaponic techniques. It actually implies high cost, which makes it difficult for developing economies to access. Outdoor urban agriculture is more accessible, using roofs, containers and yards.

Urban agriculture may have limited impacts on food systems when they are functioning normally and under market rules. It offers adapted alternatives to cities in times of crisis or in search of more eco-friendly agriculture with regard to both natural resources and consumer health. Martin-Moreau and Menascé [32] state for instance that "the ambition for urban agriculture is not so much to feed the world as to feed cities in a different way".

3. The Haitian food system and the urban agriculture

In many cities, urban agriculture is a growing phenomenon. It is not necessarily the case in poor countries like Haiti. Urban agriculture, as studied here, is both an answer to food insecurity and the whole agricultural decline.

De Bon et al. [33] summarized controversial debates on the role of urban agriculture in food systems. The authors cite a challenging paper in which Ellis and Sumberg [34] provided a number of reasons why scarce public resources should not target urban agriculture, because of the high cost of land in urban areas and the pollution it can attract and generate. Nevertheless, more and more data are becoming available to demonstrate the unique advantages of urban agriculture that advocate for well-targeted public support. De Bon et al [33] argue that urban agriculture is a source of food for urban dwellers particularly in terms of self-consumption. This might be more important in the context of poverty and in times of crisis.

In contrast to Ellis and Sumberg [34], authors like Hurriot [35], in application of the von Thünen model, suppose that the most profitable and intensive land use by unit area, and commodities with high value relative to transport costs are found

near the city center. There is research measuring land productivity [36] that supports the idea that *jaden lakou* types of urban agriculture practices may be more profitable than extensive farm production.

3.1. A chronically vulnerable food systems

Haiti faces the incapacity to feed the population through either production or importation. After the structural adjustment policies in the 1980s and 1990s, the Haitian agriculture was left to poor peasants to feed a rapidly growing population (with a 1.25% growth rate, as of 2019). Since the economy could not grow, in a context of institutional weakness, political instability and frequent natural disasters, the agricultural sector continuously declined from 16.58% of the GDP, as of 2020.

As this rural occupation became less and less interesting, a migration phenomenon took place. Migrants moved to cities and other regions (mostly to the Caribbean, Latin and North America). As a result, with lower local production, and with a poor capacity to import high quality food, the national food systems are really vulnerable. Additionally, in cities, with more and more dwellers (the urban population growth rate was 2.89% in 2019), waste management represents both an issue and an opportunity for agricultural activities.

In this context, people rely on remittances for food consumption, on a regular basis of an average of 150$ per month, per household [37,38]. Cities are growing with more extensive slums while reducing the agricultural areas. Tertiary and informal activities — mostly informal commerce [39] — become the main part of the economy. To feed themselves, the people have adapted their consumption to imported ultra-processed and inexpensive food. The food systems became even worse in terms of their quality. Regularly, the National Coordination of Food Security (NCFS) rings the food insecurity bells.

3.2. Recent issues in the Haitian food systems

In recent years, more and more Haitians are becoming food insecure (4.4 million from a total of 12 million Haitians) according to NCFS. At the same time, the Haitian already weak food systems were often broken by socio-political unrest, violence, among the more important shocks. From July 2018 to 2020, the country never experienced a six month of rest. Many violent armed groups were operating on the main roads on which products were shipped. When in March 2020, the first COVID-19 case was reported, the government had no choice but to lock down the country. This suddenly break was also a food system lockdown. In this particularly difficult context, rural population was at least more prepared to continue living, even with no access to appropriate medical services.

In urban and peri-urban areas, people were prisoned without sufficient access to food. The government, which had been facing socio-political unrest for four years, was unable to design any appropriate food resilience strategy. Urban and peri-urban population could have count on remittances from family abroad. However, many migrants lost their jobs and could not send remittance to Haiti. The families who were able to receive remittances could not access market freely to buy foods. Locally, many people also lost their job. In this context, urban and peri-urban households had to develop adaptive individual strategies to cope with both the sanitary and nutritional needs. Urban agriculture was an opportunity for many people who had or not previous experience in that type of the agricultural production form.

In fact, Haiti has a tradition of "jaden lakou", a type of household agriculture in the same piece of land where people live. This type of agriculture has been historically common in rural areas. Jaden lakou is documented for its economic and environmental

performance [40], on a circular economy basis. In Haitian cities, land prices are high, peri-urban areas are often slums, and there are limited possibilities to develop *jaden lakou*. But, whenever possible, some urban households try to grow medicinal and other plants or livestock, generally for their personal consumption. These practices were reinforced, and maybe created a new step for Haitian agricultural transformation, due to the shock caused by the COVID-19 related lockdown.

4. Materials and methods

In this exploratory research, we studied the experiences in urban agriculture (gardening or breeding, during the COVID-19 lockdown period). After some qualitative analysis, we conducted a formal analysis, using econometric estimation. We collected data from different categories in the most representative cities in Haiti.

4.1. The data

The data analyzed in this research are first hand fieldwork ones. We used the most appropriate tool to get information during lockdown. We developed an online questionnaire in the Google form, for the survey, while respecting social distance. The questionnaire was distributed through different networks in order to touch different socioeconomic profiles. Most Haitians, from all profiles, are connected in Facebook. We used this social network, through an account of more than 4,600 connections, to invite participants to take the survey. We also used professional networks such as LinkedIn, Haitian universities platform and mailing lists, Unions and other professionals Whatsapp groups, including agronomists. The survey took place from July 3 to August 31, 2020 (the official ending period of COVID-19 lockdown in Haiti). It consisted of 30 questions, both closed and open. The questionnaire was previously tested among faculty members and other agronomists, before the survey. In order to maximize and diversify participation, we made a weekly recall to take the survey, during the data collection period, through social media and group emails. Although the invitation to take the survey was public and largely diffused, only people living in Haitian cities could participate. The survey was anonymous and participants were able to see basic summary statistics after submission.

The collected data were downloaded from Google sheet and processed with Excel, before analysis through SPSS, after appropriate transformation of the variables. Data contained information on the urban agricultural experience and participants' characteristics. Their willingness to continue urban agricultural activities was also surveyed, as well as the precedent contact with agriculture. More specifically, the questionnaire started to ask the respondents whether they had or not urban agricultural experience during the lockdown. If the answer to this question was "yes", the rest of the questionnaire was focused on more detailed information (type of production and justification, its estimate value, its use and satisfaction, the container type, etc.) about the experience. The last part of the questionnaire was focused on respondents' socioeconomic characteristics (education, age, gender, income, family charge, and city).

A total of 208 respondents participated in the survey, but 203 questionnaires were consistent. The last ones were from more than 25 different cities, including all the metropolitan cities of Haiti. Two groups of participants answered the questionnaire: one group of 122 (60.1%) persons living in an urban setting who were engaged in urban agricultural activities during the lockdown, and another group of 81 (39.9%) respondents who were not engaged in these activities during the lockdown period. The presence of these two groups of responses allowed building a probability-based econometric model.

4.2. The models

The main model we used to analyze and compare different characteristics between urban agriculture experiencers and other participants assumes that each participant finally had two alternatives: carry out urban agricultural activities during the COVID-19 lockdown period, or not.

We considered that a participant i (where $i = 1, 2…I$) earned a utility for doing urban agricultural activities. This utility was not necessarily observable as it was a latent variable. However, it determined the choice for carrying out urban agricultural activities or not. We assumed that a participant i carried out the urban agricultural activities only if his/her utility for doing so was superior to a threshold δ, whereas he/she did not carry out these activities if his/her utility was inferior or equal to this threshold. The Utility function U_i^* can be explained by a deterministic part which was a vector X_i of observable characteristics and an error term (ε_i). For the participant i, this utility function can be written as follow:

$$U_i^* = \alpha + \beta X_i + \varepsilon_i \qquad (1)$$

The error term was supposed to be independent and identically distributed, as follow: $\varepsilon_i \sim N(0,1)$. The rule of decision, for each participant i, was to make the choice that maximized its utility function. To study the personal characteristics of the participants that explained their choice to carry out urban agricultural activities or not, we first defined a binary variable y_i that measured their choice, as follows:

$y_i = \{1$, *if* U_i^*
$> \delta$ (*the participant i carried out urban agricultural activities*) 0
$\leq \delta$ (*the participant i did not carry out urban agricultural activities*)

Although the utility of carrying out the urban agricultural activities was not observable, this was not the case for the choice of a participant. We can observe the choice of the participant to carry out the urban agricultural activities. This choice, measured by y_i, as defined below, cannot be estimated by a linear model since this endogenous variable can have only two values: 0 or 1. The variable Y_i took the value 1, if the participant carried out urban agricultural activities during the COVID-19 lockdown, and 0 if he/she did not. In this case, the endogenous variable of the model was dichotomous. The linear multiple regression standard models can be written as:

$$Y_i = \alpha + \beta X_i + \varepsilon_i \qquad (2)$$

Estimating this binary model implies to be certain that the predictions will fall into the interval (0, 1). And, as the number of observations (203) was sufficiently high, we confidently assumed that the data were distributed normally after appropriate logarithm transformation which allowed us to opt for a Probit model. The form of the equation to be estimated is then:

$$P(Y_{ij} = 1) = F(m + \beta X_{ij}) \qquad (3)$$

In this relation, F is a cumulative density function given by

$$F(m + \beta X_{ij}) = \leq \int_{-\infty}^{(m + \beta X_{ij})} \frac{1}{\sqrt{2\pi}} e^{-Z^2} \, dz \qquad (4)$$

The parameters m and β of the model were estimated using methods for numerical maximization of the logarithm of the likelihood function, which is written as follows:

$$\ln[(L, Y, \beta)] = \sum_{i=1}^{J} \left[Y_i \ln \left[F(m + \beta X_{ij}) \right] \right] + (1 - Y_i) \ln \left[1 - F(m + \beta X_{ij}) \right] \qquad (5)$$

The vector of explanatory variables includes characteristics related to respondents' profiles. It also includes variables related to their socioeconomic conditions.

Respondents' profile included the following demographic and socioeconomic characteristics: age, gender, education, personal and family agricultural background or experience, and education in the agricultural field, family charge, and monthly income. The environmental variables were selected in order to test our hypothesis, which is: the urban agricultural activity observed in Haiti was used as household innovation to counter food insecurity. The main variable in this category was the participant's access to an existing container where to practice urban agriculture. In Haitian cities, access to a dedicated place for urban agriculture is not constant. Most of the time, urban agricultural containers were taken from the recycling process of imported food containers. Table 1 describes the exogenous variables.

Table 1. **Description of the Variables**

Variable name	Variable description	Expected sign
Lockdown UrbAgExperience	Urban agricultural activities of the respondent during the COVID-19 lockdown, 1 if yes, 0 if not	Dependent variable
Gender	Gender of the respondent, 1 if masculine, 0 if not	+ / −
Age	Logarithm of age	+/−
HeadHousehold	Status of the respondent in the household, where 1 denotes a head of the household, 0 if not	+
UrbAgExperience	Precedent urban agricultural experience of the respondent, 1 if yes, 0 if not	+
FamAgExperience	Family background in agriculture, 1 if yes, 0 if not	+
PersoAgExperience	Personal background in agriculture, 1 if yes, 0 if not	+
AgEducation	Respondent's education in agriculture, 1 if university level, 0 if not	+
FamilyCharge	Log of the number of dependents who count on the respondent for food and other expenses	+
Income	Log of respondent's monthly income (evaluated in US dollars)	−
Container	Existence of a container near or in the house where the respondent was living during the lockdown	+
ContainerAccess	Respondent's access to the existing container near or in the house	+

Source: The author

We also analyzed the auto-evaluated financial value of a product of urban agricultural activities. This variable averaged 554.5 US dollars (with a high standard deviation of 1,493). Most of the continuous variables such as age, income, urban production and family charge, were not normally distributed. However, their transformation into the logarithm resolved this distribution issue.

5. Results and discussion

First of all, we answer the following basic question: who were the participants in the survey? Our surveyed sample was represented, as an average, by a man earning a monthly income of 1,280 US dollars, head of the household, aged 40, and having at least 3 dependents who count on him for food. Participants in the survey mostly lived in large cities, and mostly the Metropolitan area (Figure 1), lodging in a house or apartment with access to a yard. They mostly had university education in different fields, but very seldom in agriculture. Most of them were men, although the women represented 34% of the sample.

Data collected from the survey shows that in the mid of 2020, under COVID-19 lockdown, from 203 respondents, 60% were engaged in urban agriculture. Among the latter, 47% declared they practiced urban agriculture because of the lockdown, although among those respondents who related their experience to the lockdown, 69% reported that it was not their first experience in urban agriculture.
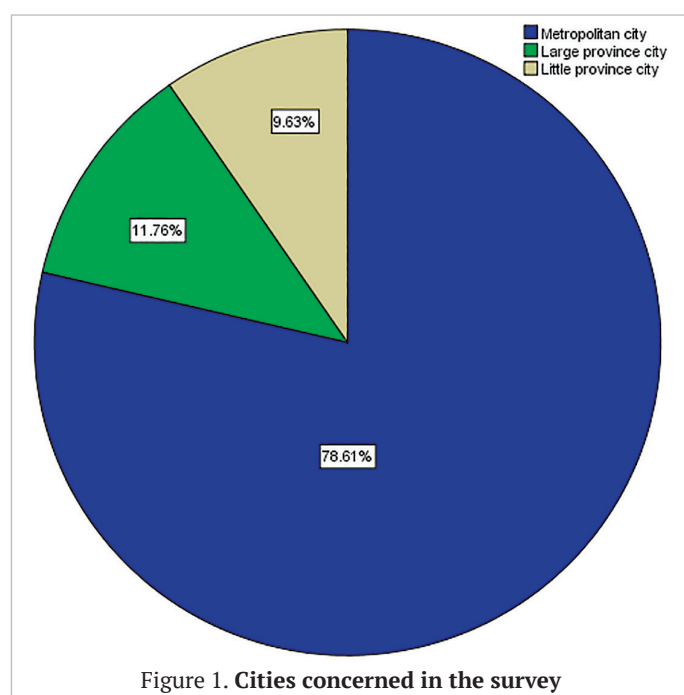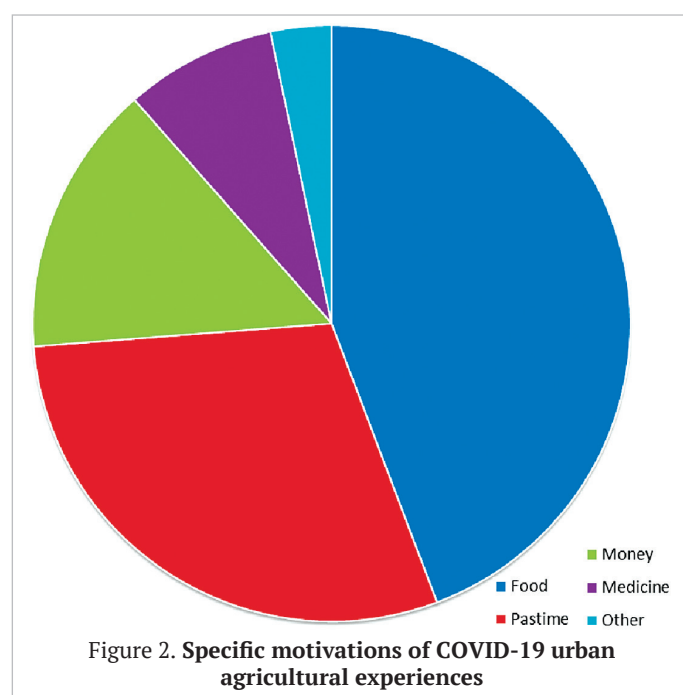
Figure 1. **Cities concerned in the survey**

Figure 2. **Specific motivations of COVID-19 urban agricultural experiences**

In the group of the participants who practiced urban agriculture for the first time (31%), all persons were satisfied with their experience. Some 86% of these new urban agriculture experiencers did that because of the lockdown, particularly for medicine, food, time killing, and money. Fifty seven percent of them did not even have this in mind before the lockdown. These people mostly lived in the Metropolitan area of Port-au-Prince and cannot practice *jaden lakou*. On the contrary, they grew plants in yards or containers (placed in yards or roofs). Although they faced land access, they took advantage of the way rooftops are built (horizontally) in Port-au-Prince. This contrasts with urban agriculture experiencers in province cities who could access *jaden lakou* or yard.

5.1. Variables description

The following Table 2 contains average or frequency (and standard deviation) for the variables used in the estimated model.

Table 2. **Variables' statistics**

| Variables	Experiencers	Non-Experiencers
Gender	0.647 (0.479)	0.687 (0.466)
Age	42.08 (11.64)	37.58 (11.18)
Education	0.975 (0.155)	1.000 (0.000)
HeadHousehold	0.737 (0.441)	0.605 (0.491)
UrbAgExperience	0.884 (0.321)	0.543 (0.501)
FamAgExperience	0.614 (0.488)	0.543 (0.501)
PersoAgExperience	0.721 (0.450)	0.716 (0.453)
AgEducation	0.368 (0.484)	0.358 (0.482)
FamilyCharge	3.689 (2.666)	3.086 (2.186)
Income	1253 (1357)	1310 (1896)
ContainerExistence	0.934 (0.248)	0.963 (0.190)
ContainerAccess	0.815 (0.389)	0.617 (0.489)
UrbanAgProduct	554.5 (1493)	0
N	122	81

As preliminary observations, the analysis from the 122 experiencers shows that 107 (88.43%) had previous experience in urban agriculture. This means that the experiences were a kind of innovative strategy only for the remaining 11.57%. In fact, before this special need for urban agricultural products, most of experiencers had been growing plants for leisure purposes. But COVID-19 brought two new reasons: medicine and food. Although the rate of new experiencers appears pretty low, it indicates a promising step, considering the fairly high willingness to continue (50% for the first-time experiencers and 75.36% for all the experiencers). However, one of the most important results is that 39 (31.97%) participants declared that they did urban agricultural activities because of the lockdown following the COVID-19. Most of the 115 (94.26%) participants lived in large cities (Metropolitan or Department capitals) and already had in mind a project to do urban agricultural activities. In this case, the COVID-19 lockdown might have had some positive effects on urban people's activities and behaviors.

Food production accounted for an important share (44.26%) of urban agricultural activities. This result brings a first part of confirmation to our research hypothesis. The other purposes were time-killing, money, medicines, and others (including education and research), as shown in Figure 2.

As a food resilience strategy, urban agricultural experiencers produced specific agricultural products, including 1) market garden crops, 2) meats and eggs, 3) medicinal plants, etc. Figure 3 shows details about the urban agricultural production under the COVID-19 lockdown in Haiti. The reason for those choices was mainly the rapid growth and short production cycle (55%) as a food shortage was sudden and severe.

Participants who did urban agriculture activities explained their satisfaction by 1) the socioeconomic output, 2) health benefits, 3) environmental or social advantage, and 4) education and recreation. A respondent who talked about socioeconomic benefits of his experience said: "I get healthy products while reducing expenses and being occupied", when another stated: "the experience allowed me to take care of my family". In fact, during the lockdown, the urban population looked to find the home activity and food, as two basic needs. As a health benefit, a respondent to the survey stated: "I got healthy products and had the opportunity to take care of myself at home". In Haiti, access to health services has always been an issue. This was reinforced during the lockdown, and vaccines were not available. A respondent who considered environmental benefits said: "the experience helped me transform the kitchen wastes into high quality products", while another explained: "the experience provided me with a sense of autonomy, and an opportunity to socialize with my

Figure 3. **Group of products retrieved from COVID-19 urban agricultural experiences**
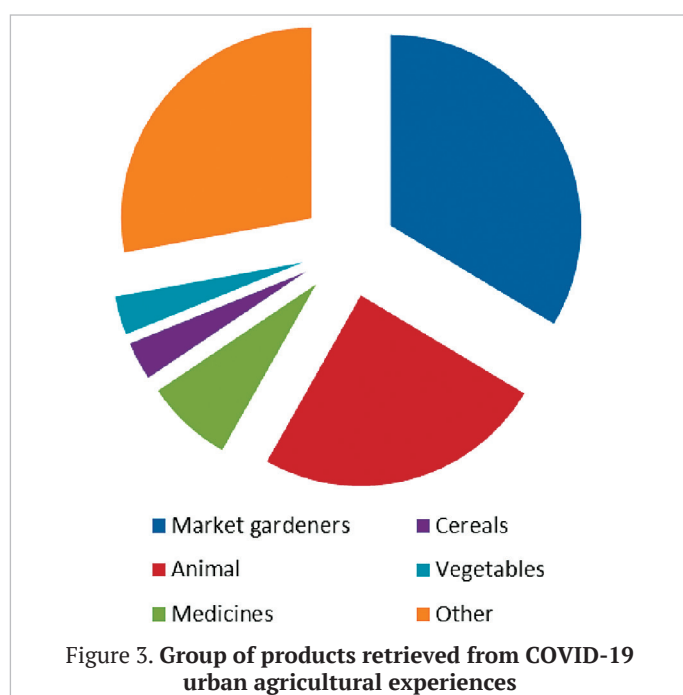
neighborhood". The respondents who considered recreation and education affirmed: "it was an opportunity to do a handy-craft activity at home, reducing stress and letting the children learn". Stress was an issue not only for adults, because all the schools were closed and access to online education was limited, parents were busy finding alternative occupations for their children.

As for the statement that urban agriculture helps value little space, a respondent declared: "this experience made me learn how possible it was to produce the needed food with limited pieces of land". Those using containers as support in their experience were also happy to grow vegetables or medicinal plants.

Experiencers who lived in metropolitan areas or large province cities either used containers (flowerpots) or their courtyard. In contrast, those living in little province cities or peri-urban areas where access to a piece of land was possible used *jaden lakou* as support for the urban agriculture activities. Both of the categories were able to value waste while producing organic food, such as market garden crops and animals, as shown in Figure 3.

Market garden crops, including tomato, cabbage, beans, etc., were the most important varieties produced. This is consistent with the previous observation done by [33] according to the fact that cultivation of short-cycle leafy vegetables was most common in tropical urban agriculture.

The experiencers who used containers mostly focused on medicinal plants such as Wormwood (Artemisia), Aloe vera, Citronella, Melissa, Mint, Ginger, etc. Few of them grew tomatoes, pepper, black pepper. Those who had a courtyard grew maize, beans, cherry, banana, and poultry. Finally, those who could access a *jaden lakou* produced cabbage, maize, beans, banana, poultry and rabbits. The last had the opportunity both to value waste and practice integrated agriculture.

The respondents who did not practice urban agriculture were not necessarily constrained in terms of access to the courtyard. Many of them declared having access to a space where they could practice urban agriculture. According to Table 2, they had more or less the same profile as experiencers.

Additional statistical comparison between experiencers and non-experiencers shows no significant difference in terms of income. In fact, experiencers with or without enough income suddenly turned to be in a similar situation regarding the food system shortage during the lockdown. In terms of strategies, two

differences could be noticed: those who had access to remittance from the family or relatives living abroad could smooth their food consumption under the condition that they had a provider in their neighborhood; and the others who could not enjoy this kind of financial solidarity, were obliged to reduce their food consumption. In both cases, access to a medium for agricultural production was an opportunistic strategy. In reality, remittances were reduced during the lockdown, because COVID-19 affected migrants' sources of income as well.

Urban people engaged in agriculture, as we modeled the phenomenon, made their choice based on both observable and unobservable determinants. When we run the econometric analysis to test the significant determinants, the model estimates showed both expected and unexpected results regarding people's experience in urban agriculture (Table 3).

Table 3. **The model estimates**

Binary Probit estimates for the experience (across groups) as the dependent variable		
Variables	**Coefficient**	**p-value and significance**
Intercept	−3.27867	0.0648*
Gender	−0.303544	0.3224
Log of Age	0.843950	0.0999*
HeadHousehold	0.349719	0.2779
UrbAgExperience	1.22040	<0.0001***
FamAgExperience	0.482808	0.0489**
PersoAgExperience	−0.347237	0.2420
AgEducation	0.176937	0.4835
Log of FamilyCharge	−0.145784	0.4643
Log of Income	0.0451824	0.6609
ContainerExistence	−1.10289	0.1178
ContainerAccess	0.404740	0.1131
N	160	
Log-likelihood	−85.79772	
McFadden R-squared	0.200121	

Significance threshold: * significant at 10%, ** significant at 5%, and *** significant at 1%.

First, we have analyzed the quality of the estimated model. According to the test for normality of residuals, we have found, after appropriate transformation in the model, that the statistical test for the null hypothesis (the error is normally distributed) is as follows: Chi-square = 5.14695, with p-value = 0.0762702. The McFadden R-squared equals 0.200, the Akaike criterion equals 195.5954, and Schwarz criterion equals 232.497. With these results, the model is suitable enough since prediction returned is 119 cases, in other words 74.4%.

As shown in Table 3, the respondent's education level was not a discriminant characteristic. Most of the respondents had a university level. Likewise, the respondent's gender and the variables such as *existence of a container near the house* and *access to this container* did not play a significant role in the probability of carrying out or not carrying out urban agricultural activities. In fact, people living near an appropriate container for urban agriculture did not necessarily have access to it. And some people who did not carry out the urban agricultural activities had access to containers.

Instead, urban agricultural antecedent, urban agricultural experience, and age were significant explanatory factors for the probability of carrying out urban agricultural activities. Also, the estimated coefficient for these factors has the expected sign. This result is consistent with Davies and Garrett [41] who argued that the next generation of urban producers would not necessarily have grown up on a farm.

Curiously, *agricultural education, income,* and *family charge* were not significant determinants. In fact, in Haiti, few agriculture graduates were involved directly in agricultural production. On the contrary, the respondent's income and family charge are in contradiction with our expectations, both for significance and sign. One of the explanations for this observation can be found in the low sample size and the high dispersion of the data for these variables (see Table 2).

As additional in-depth analysis, we estimated a second model where the dependent variable was the willingness to continue the experience after the COVID-19 lockdown. With the same method (binary Probit), we found that it correlated significantly with agricultural education (positively), income level (negatively), and access to a container (positively). This is consistent with the assumed sustainability of this innovative strategy to create food system resilience in urban areas. But, a deeper analysis of the urban agricultural production shows correlation (according to OLS estimates) with a city size (Metropolitan or Department capital =1 / other =0). In fact, food systems function differently in cities with different sizes. And, for experiencers, the average (554$) urban agricultural production represented 44% of their monthly income (1253$), which confirms the first hypothesis since this monthly income level is not enough to feed daily the households with 3 to 4 members. As such household generated food helps smooth consumption, these results are consistent with the previous research that showed evidence for households resilience in the context of food security crisis [4,42].

This study contributes to filling the gap noticed in the recent literature [4] on food system resilience by providing field evidence from a micro-level study. Using the exceptional context created by the COVID-19 lockdown and related food shortage, we analyzed urban actors' strategies to face the food crisis. While the government tried to use cash transfer to people during the lockdown, our results show urban people were able to create rapid and appropriate home-made production through urban agriculture with higher value (an average of 554.5$, which is more than a monthly wage in many cities) than the 3,000 gourdes (less than 30 dollars) transferred by the government program. In Haiti, urban agriculture is an innovation, since it is a new agricultural activity for many urban people with a significant economic value. Its adoption was forced by COVID-19, according to our survey.

In response to a question raised by Darrot et al. [5] in their French experience, our results announce a sustainable impact on local or urban food system resilience, since three out of every four urban Haitians who carried out urban agricultural activities declared that they were willing to continue this practice. They might need a governance of this new part of the food system, while the latter became less critical after the lockdown and the reopening of the traditional food supply. However, this innovative strategy can be governed as a pillar of the cities' food system resilience, particularly because they are used to facing regular crises. This is consistent with Charvet and Laureau [30], who consider that urban agriculture is intimately linked to the choice of food governance in metropolitan areas.

The result also supports the claim for introducing urban agriculture into agricultural studies, both technical and scientific. Actually, from more than twenty agricultural faculties in the country, a very limited number has been teaching urban agriculture in their curriculum.

Urban agricultural experiencers did not only produce food. They also tried to face income disruption because economic activities were impossible. And overall, one of the aspects of resilience during the lockdown was a possibility of caring for the urban households. We observed that more than 8% of the experiencers were motivated by the necessity to have natural medicines, while around 30% were motivated by pastime which was also psychologically important in time of lockdown. Natural medicine specialists, both Haitian [43] and foreign researchers [44] acknowledge the importance of natural medicine. And urban agriculture was that innovative strategy, for which our study demonstrates usefulness with regard to food system resilience, not only in the case of Haiti, but for other developing countries, where the food system is vulnerable.

In the case of Haiti, the government could have a great interest in the spread of urban agriculture as an innovative strategy developed by the actors to face the crisis. If COVID-19 is an exceptional crisis, political and natural crises are common in Haiti as in many other developing countries. Haiti faced unofficial lockdown in 2019 due to a political crisis. More regularly, natural disasters such as hurricanes create disruption in food distribution in different cities. Urban agriculture could be supported both as a strategy to reduce food insecurity in times of crisis, and an urban transforming strategy.

In some other countries, urban agriculture is a kind of government-supported program. In LMIC, urban agriculture appears as an appropriate strategy to create food system resilience, as suggested by Béné [4]. In this connection, the implication of this exploratory research goes beyond the COVID-19 response to shed light on actors' level research streams in the field of food system resilience analysis and intervention.

6. Conclusion

In this exploratory research, we surveyed different urban cities in the poorest country of Americas (Haiti) during the exceptional period of the COVID-19 lockdown. The collected information (203 responses) allowed comparative analysis of the urban agricultural strategy developed by households living in different cities of Haiti. The results provide evidence that people living in cities in Haiti developed appropriate and innovative strategies to cope with a food shortage during the COVID-19 related lockdown. By doing urban agricultural activities, particularly those that produced food and medication in the very short run, urban households in Haiti were able to face "the monster" as noticed by Rouzier et al. [43]. Although the government faced a budget deficit and therefore was unable to help the population, people living in different cities across Haiti showed interesting resilience.

Urban participants who were engaged in urban agriculture, for the first time or not, were highly satisfied. They were also more likely to feed themselves during the lockdown, using appropriate crops to produce food. As good news, they were also willing to continue urban agriculture after the crisis. This result brings an answer to Darrot et al. [5] who questioned the sustainability of COVID-19 new food behaviors, albeit they are rooted in different contexts. Although public health analysts argue that such urban agriculture experiences also created health resilience in the face of COVID-19 [44], a new issue to be addressed is the possible sanitary limits of urban agriculture in relation to the supports, on which it is practiced. This is particularly the case in peri-urban slum areas where sanitary conditions are very bad in developing countries. This raises concerns about how authorities will manage such a food system resilience strategy to keep it alive and safe for consumption.

The results of this exploratory research provide important insights for researchers, urban policy-makers, and food system strategists. For researchers, there is a need to deepen the subject by enlarging the sample and try to track the evolution of the urban agriculture phenomenon across different regions, particularly in the urban areas of the world's poorest economies. There is also a place for research on natural medicines in poor countries where access to pharmaceuticals is limited, even in times of sanitary crisis. For food system resilience strategists, the results

provide interesting insights on innovative strategies that can be prioritized when the public sector is weak and participation of the civil society, professionals, and population is crucial. For instance, urban agriculture is an important innovative strategy to help create food system resilience in cities, particularly in a time of acute crisis such as the case of the COVID-19 lockdown. For urban policy-makers and urban planners, urban agriculture appears not only a food system resilience strategy but also an innovative strategy for greening cities, improving quality of life, time saving and urban community cohesion. In our exploratory works, people were particularly satisfied because of making plants grow, producing high quality foods, etc. One of the appropriate public interventions can be to support the observed innovative strategies and behaviors. For that, as argued by Aubert et al. [45] in the case of Mayotte, adapted institutions are needed to support urban agriculture in the Haitian context where agricultural lands are being used for construction. Public sector has interest in urban agricultural practices which use composting [46,47] in order to help manage waste.

As an exploratory research, our work suffers some limitations. Some of them are related to the context of the study implementation. In fact, the survey was conducted during the lockdown, and therefore was administered online. The sample size is limited, although it is geographically well distributed in more than 25 Haitian cities. Haiti is a small country with a high poverty rate; research from it limits the likelihood for reasonable generalization. However, the discussed food system resilience strategy can be tested again in other countries. Also, our results can be useful to inform policies in poor countries, particularly when they are regularly facing food crises.

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Conflict of interest	**Конфликт интересов**
The author declares no conflict of interest.	Автор заявляет об отсутствии конфликта интересов.