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Agricultural household resilience strategies against climatic and health shocks: Drought and Covid-19 in the Niayes area of Senegal

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Abstract

Agriculture employs the poorest populations in developing countries and must ensure food security in a continent marked by a high prevalence of famine. However, it is one of the most vulnerable sectors to shocks. This article studies the behaviour of farmers facing drought and Covid-19 in Senegal. More precisely, we seek to highlight the effectiveness of two endogenous resilience strategies (off-farm activities and farm good sales) and an exogenous resilience strategy (accessing government and/or NGO support) applied by farmers who suffered from drought as the most severe shock during the 2017-2018 agricultural campaign. We then further analyse the resilience strategies put in place by food system actors in the Niayes area to cope with the negative effects of Covid-19 and associated policy restrictions. The results show that endogenous resilience strategies were less effective than exogenous strategies in coping with both drought and Covid-19. For drought, off-farm activities appear effective when applied as a secondary resilience strategy to complement another resilience method. However, the sale of farm assets made it difficult for farmers to cope with the drought – indeed; this strategy reduces the production capacity of farmers and can cause a decline in farm income. When it comes to the Covid-19 shock, the resilience strategies adopted were very diverse, depending on the main source of revenue but also on the farm's spatial location and socio-demographic characteristics. Overall, however, based on these results, government and NGO support appears to have most effectively enabled farmers to adapt to climate shocks, and these supports also helped farmers during the Covid-19 pandemic, especially the most vulnerable.

1 Introduction

The Covid-19 crisis has had significant health impacts, as well as economic and social impacts around the world. As of September 29, 2021, 232,636,622 confirmed cases and 4,762,089 have been identified worldwide (World Health Organization, 2021). The global economy suffered a 4.4% recession, reflecting a greater impact than that of the 2008-2009 financial crisis (International Monetary Fund, 2020). The World Bank (2020) found that between 88 and 115 million people will fall into extreme poverty, and that most of these vulnerable populations will be in South Asia and Sub-Saharan Africa.

These impacts will be felt all the more as the affected zones are already poor and vulnerable (OECD, 2020). Senegalese agriculture, which employed 30 percent of the working population in 2019 (The World Bank, 2021), is critical to ensuring food security in a context marked by economic and climatic disturbances, but also is critical to the livelihoods of the poorest populations. This sector is therefore at the heart of concerns related to the Covid-19 crisis, which has revealed and accentuated problems in both national and global food systems (Swinnen & Vos, 2021; Thierno Sall, 2020).

In efforts to prevent the spread of the virus, many countries have applied restrictive response measures. In Senegal, a formal state of emergency was issued on March 23, 2020, and was accompanied by measures including a curfew, restricted mobility, and a prohibition on gatherings. These measures posed many disruptions to food systems, in particular the production stage due to reduced availability of inputs. Challenges in accessing crop storage sometimes resulted in severe crop losses. The decrease in demand caused my market closures, combined with storage problems, caused a drop in producer prices, thus reducing household agricultural incomes. The ban on social events further contributed to reduced demand and declining prices for foodstuffs. A recent survey by IPAR on a nationally representative sample of 1,182 households found that 97.4% of farm households recorded a drop in their agricultural income (Niang et al., 2020). In addition, household consumption patterns have experienced a reduction in the quality and quantity of food, falling by 70.1% in terms of quality and 62.4% in terms of quantity (Niang et al., 2020). These difficulties related to Covid-19 are compounded with pre-existing challenges related to climate shocks, thus making farm households even more vulnerable. Negative effects of the Covd-19 pandemic in food systems highlight the vulnerability of Senegalese agriculture to shocks, whether these shocks be economic, climatic, or health-related.

Nevertheless, despite their vulnerability and the severity of shocks faced, some farm households are adopting resilience strategies such as using savings, selling or slaughtering more livestock than usual, or drawing on help from relatives or friends (Sonko et al., 2020). In addition, the government

of Senegal and other institutions are implementing aid policies to support farmers through crises. Thus, two types of adaptation strategies among farm households can be distinguished: exogenous strategies and endogenous strategies. All external aid put in place by the State and other organizations to support households negatively impacted by shocks represent exogenous strategies. In the context of Covid-19, there has been aid provided by the government (donations of basic foodstuffs) as well as aid provided by NGOs or other organizations (African Risk Capacity, 2019; Comité de suivi de la mise en oeuvre des opérations du Force Covid-19, 2021; ONU Femmes Sénégal, 2020). Endogenous strategies meanwhile refer to actions taken by households themselves, without support from an external entity, to cope with shocks. These may include the sale of assets (land, buildings, crops, livestock, machines, and other equipment), off-farm income generation activities, aid received from relatives (remittances, loans) and spending cuts within households and on farms (Senegalese Annual Agricultural Surveys, 2018-2019). During Covid-19, several farm actors used other marketing techniques, such as online sales (Sek, 2020). In addition, farm households have reduced cultivated areas or pooled their operations to cope with the crisis (Niang & Faye, 2020). Finally, the development of other income-generating activities caused by the pandemic, such as the sale of masks, may have helped to compensate for the loss of some agricultural income.

The main objective of this paper is to analyse the effectiveness of farm household resilience strategies against climate shocks. Furthermore, it seeks to see if the most effective measures to ensure the resilience of households against climatic shocks are similarly effective at coping with the Covid-19 shock, including policy measures such as government lockdowns. This will help decision makers to better support farm households, but will also help ensure food security for rural and urban populations in the face of economic, social, climatic, and health shocks. More specifically, we seek to respond to the following questions:

- What is the association between resilience strategies and the vulnerability of agricultural households to shocks?
- What was the level of effectiveness of resilience strategies adopted against droughts by farm households during the 2017-2018 agricultural campaign?
- How have farmers responded to the Covid-19 pandemic in terms of resilience strategies adopted?

We use the annual AgriSurvey conducted by the Directorate of Analysis, Forecasting and Agricultural Statistics (DAPSA) for the "before Covid-19 period" and an original survey dataset collected by Initiative Prospective Agricole et Rurale (IPAR) for the "since Covid-19 period". Propensity Score Matching (PSM) and descriptive statistics are applied to analyse the effectiveness

of resilience strategies against climate shocks in Senegal in the pre Covid period, and we then separately examine the utilization of these resilience strategies during the Covid-19 period with a focus on the Niayes Region. The Niayes Region is an important agricultural area in Senegal. It covers four administrative zones and supplies Senegal with 80% of its horticultural products (Direction de la Gestion et de la Planification des Ressources en Eau (DGPRE), 2017). Food systems in this area are very vulnerable to shocks because of problems related to storage, water access, financing, and technical support (Arnoldus et al., 2020; Cisse et al., 2021; Oussouby Touré & Sidy Mohamed Seck, 2005). As a result, Covid-19 has affected the Niayes area deeply, with recent reports suggesting farm households have suffered a drop in their income, increasing their vulnerability (Niang & Faye, 2020).

The following section presents a brief literature review on Sub-Saharan African farm households' vulnerability to shocks, as well as common resilience strategies and their various levels of effectiveness. Section 3 presents the survey data and methodology, and the fourth section summarizes key results. Finally, the fifth section discusses the study findings and provides some policy recommendations aimed at improving Senegalese farm households' resilience against shocks.

2 Farm Households' Vulnerability to Shocks and the Effectiveness of Resilience Strategies

Agriculture is the most vulnerable sector to shocks (Frelat et al., 2016; Intergovernmental Panel on Climate Change, 2014). The impacts of climate change, including droughts, on agriculture have long been recognized, while the Covid-19 pandemic shows that other types of shock can also have serious impacts on the agricultural sector. In response to shocks, governments, NGOs, and farmers themselves apply resilience strategies. In this section, we briefly summarize the literature on resilience strategies adopted by farmers for climate shocks, and for the many other shocks introduced by the Covid-19 pandemic.

2.1 Resilience Strategies against Climate Shocks

The literature on climatic shocks and agriculture in sub-Saharan Africa is quite extensive. Farmers in many countries have already experienced more frequent and intensive droughts, floods, extreme temperatures, and tropical cyclones (Mertz, Halsnæs, Olesen, & Rasmussen, 2009). These phenomena have had adverse effects in every part of the agricultural value chain. Akampumuza & Matsuda (2017) studied exposure to climatic shocks such as drought and flood, but also to severe pests and diseases in Uganda. Their results suggest that exposure to a climatic shock significantly reduced household consumption and expenditures. Likewise, Gao & Mills (2018) found an increase in extreme temperature was linked to reduced real consumption in Ethiopia. Climatic shocks can

also have a negative effect on the level of production, food quality, water availability and disease and reproduction of livestock (Rojas-Downing, Nejadhashemi, Harrigan, & Woznicki, 2017).

To cope with these varied and idiosyncratic shocks, farmers have chosen strategies that help them smooth consumption or reduce production losses. Traditionally, farmers resorted to strategies such as migration, off-farm activities, crop diversification, remittances and sales of livestock (Mertz, Mbow, Reenberg, & Diouf, 2009). Such strategies can have different effects depending on the locality but also depending on the characteristics of farm households. For example, Ngigi, Mueller, & Birner (2020) studied the livestock composition of farmers in Kenya using a panel of 360 farmers, they found that small ruminants and non-ruminants were less sensitive to climatic shocks than large ruminants. This suggests that a diversified livestock portfolio can help withstand the effect of climatic shocks. The authors further report that farmers in the study tended to use a combination of crop sales and livestock (goat, sheep poultry and cattle) sales to cope with climatic shock. However, Akampumuza & Matsuda (2017) did not find any evidence of the effect of livestock sales on consumption per unit in Uganda. They did find a positive short-term effect of asset sales as it offered temporary insurance mechanism. As far as credit access and participation in on-farm and off-farm activities, they reported no significant effects of these strategies on consumption for farmers facing climatic shocks.

Where accessible, remittances can also help sustain consumption and mitigate financial stress due to shocks: Akampumuza & Matsuda (2017) highlighted the importance of remittances and borrowing from social groups in mitigating climatic shocks.

Other transfers such as aid from governments or NGOs can also play a significant role when facing consequences from climatic shocks. Gao & Mills (2018) showed that receiving transfers from government sources, NGOs, or other aid agencies was effective against extreme rainfall shocks, but that participation in off-farm income-generating activities was a more effective response to temperature shocks.

Other studies suggest an interdependency between various adaptation strategies. Di Falco & Veronesi (2013) studied the effect of different adaptation strategies on crop net revenues in Ethiopia. They found the impact of changing crop choices was highly significant on sustaining net revenues when it was implemented with soil or water conversation. However, when each of these strategies was taken alone, the effect on net revenue was no longer significant.

The effectiveness of adaptation strategies can also depend on the temporality of the shocks. Thomas, Twyman, Osbahr, & Hewitson (2007) found that farmers in South Africa tend to reduce farming activities or to stop farming momently and switch to livestock activities during severe dry spells. As weather conditions became more unpredictable, livestock activities thus gain more

interest from farmers. In other words, over time we can see substitution patterns between different crop and livestock activities in order to reduce the adverse effect of climatic shocks.

2.2 Resilience Strategies Against Covid-19

Many recent articles have studied the impacts of Covid-19 pandemic and restriction measures on the agricultural sector in Sub-Saharan Africa (SSA). The FAO (2020) mentions some reasons why SSA is vulnerable to negative impacts on food systems. Many countries depend on food imports and exports, and social protection measures don't reach many vulnerable households. According to FAO (2020) smallholder farmers are among the most vulnerable to the effects of the Covid-19 pandemic on food security in Sub-Saharan Africa. Indeed, because of restrictive Covid-19 policy measures, farmers faced difficulties to access to inputs, increased crop losses and food waste, a decrease in market demand for agricultural products, supply chain disruptions, and difficulties in accessing labour (CARE, 2020; Niang & Faye, 2020; OECD, 2020; SNV, 2020). As the pandemic continues, some small-scale farmers may also face a decrease in agricultural food demand in favour of non-perishable food (CARE, 2020). To cope with the negative effects of Covid-19, as with climatic shocks farmers may have access to two categories of resilience strategies: endogenous resilience strategies that are put in place by farmers themselves, and exogenous resilience strategies applied by governmental, non-governmental and private organizations to help farmers cope with shocks. Some authors also distinguish between short-term coping strategies and more forward-looking adaptive responses (Love et al., 2021 as cited in SNV, 2021).

Restrictive measures like social distancing as well as the "stay at home" policy forced food system actors to limit their participation in markets for seed and inputs, and to adapt their selling strategies. For selling their products, some turned to online services – according to the SNV (2021), many existing digital technologies have been adopted by farmers and other food system actors during the Covid-19. However, in many cases the lack of access to markets and especially inputs made farmers change their production practices, including decreasing the quantities of fertilizers applied (SNV, 2021) or reducing harvested areas (Niang & Faye, 2020). Moreover, the lockdown imposed to limit the spread of the virus highlighted the importance of savings to ensure consumption during the crisis - and many farmers responded by increasing their savings to deal with another potential lockdown. The sale of assets and support from relatives have also been used by farmers to adapt to the crisis and policy restrictions (SNV, 2021). However, despite negative effects of restrictive measures on agriculture, due in part to the broader economic impacts of the Covid-19 pandemic (more specifically employment losses) many people actually entered or re-entered the agricultural sector during the pandemic as an economic coping strategy (SNV, 2021).

Meanwhile a number of governmental, non-governmental and private sector actors provided various forms of social supports seeking to help vulnerable households during the pandemic. Food aid programs have been widely used: in Senegal, Benin, Burkina Faso, Niger, and other countries. Governments implemented different food aid programs (Banque africaine de développement, 2020; Comité de suivi de la mise en oeuvre des opérations du Force Covid-19, 2021; Secrétariat du Club du Sahel et de l'Afrique de l'Ouest (CSAO/OCDE), 2020). In Senegal, NGOs and multiple United Nations entities implemented food aid programs targeting women, children, and youth (ONU Femmes Sénégal, 2020). Many governments in sub Saharan Africa have also used cash transfers during restrictive measures (Jerving, 2020; République togolaise, 2020). In Senegal, the NGO consortium RC-Replica has implemented a cash transfer program for farmers to help them cope with climate shocks. However, farmers also benefited from that program during the restrictive policy measures surrounding Covid-19. Similarly, several other pre-existing policies and programs in Senegal intended to improve living standards of farmers and rural communities came to serve as coping strategies against the Covid-19 pandemic, including universal health coverage for poor households, recurrent cash transfers, and measures programs for people with disabilities, among others[1].

3 Data and Methodological Approaches

To evaluate the efficiency of resilience strategies against climatic and health shocks, we use survey data at the household level. These data were provided by Senegal's Directorate of Analysis, Forecasting and Agricultural Statistics (DAPSA) for the "before Covid-19 period" and the Initiative Prospective Agricole et Rurale (IPAR) for the "since Covid-19 period". The optimal methodology would be to apply a fixed-effect panel econometric model, in order to include observed and unobserved heterogeneity. However, the DAPSA changes its sample of households every three years. As a result, the groups of agricultural households surveyed for the 2017-2018 and 2018-2019 campaigns are different. In addition, the survey data for the 2019-2020 campaign are incomplete due to the pandemic. Thus, we use the propensity score matching method to examine livelihood outcomes as a function of endogenous and exogenous adaptation strategies before Covid-19 with the 2017-2018 data. For the period since Covid-19, we apply a micro-econometric model on cross-sectional data with instrumental variables, based on the data collected within the framework of the COPSA project of IPAR.

3.1 Data: Household level surveys before and during Covid-19

[1] Source: Survey conducted by IPAR during Covid-19 among farm households and food systems actors.

3.1.1 Surveys for periods before and since Covid-19

To examine the effectiveness of resilience strategies against climate shocks, we use Senegal's Annual Agricultural Survey (AAS) for the 2017-2018 agricultural campaign, implemented from September 2017 to February 2018.

(i) AAS data are collected each year and serve to achieve several objectives including estimating the production of the main crops in Senegal, and tracking the physical characteristics of agricultural plots, including production technologies used (inputs, investment, soil management). The survey also collects data on the structure of agricultural households in Senegal, such as agricultural risks perceived and adaptation strategies used. For the 2017-2018 agricultural campaign, AAS data for Senegal are representative at the national level. The sample was obtained using a two-stage survey design: the primary units are the rural census districts, and the secondary units are the farm households. In total, 6,340 households were interviewed, for 1,260 districts and 42 departments.

(ii) The COPSA survey is an original dataset produced by IPAR during a project aimed to analyse the effects of Covid-19 pandemic on food systems in the Niayes area. The objective of this survey is to document the effects of state interventions during Covid-19 on local food systems and the measures taken by different stakeholders to strengthen resilience to the shock. The survey covers the 2020-2021 crop year and covers multiple stakeholders in the Niayes area food system: farmers, breeders, fishermen, processors, traders, and transporters. A two-stage stratified sampling design was used, with strata made up of the four zones of Niayes: north, south, centre, and maritime. In the first stage, two districts are drawn and in the second stage, 11 households are drawn per district. In total, 444 households were interviewed.

Both surveys provide sections on households, workers, household members, and household land plots. Therefore, we have information on farm households' sociodemographic characteristics, production technology, the shocks they faced, and any resilience strategies they adopted. We are thus able to examine if resilience strategies against droughts allowed farm households to fight efficiently against that shock, specifically looking at the impacts on farm revenue. We further seek to control for other characteristics of farm households that could relate to their vulnerability to shocks, including farm and non-farm activities, migrant transfers, consumption, food supply, household characteristics, and other factors.

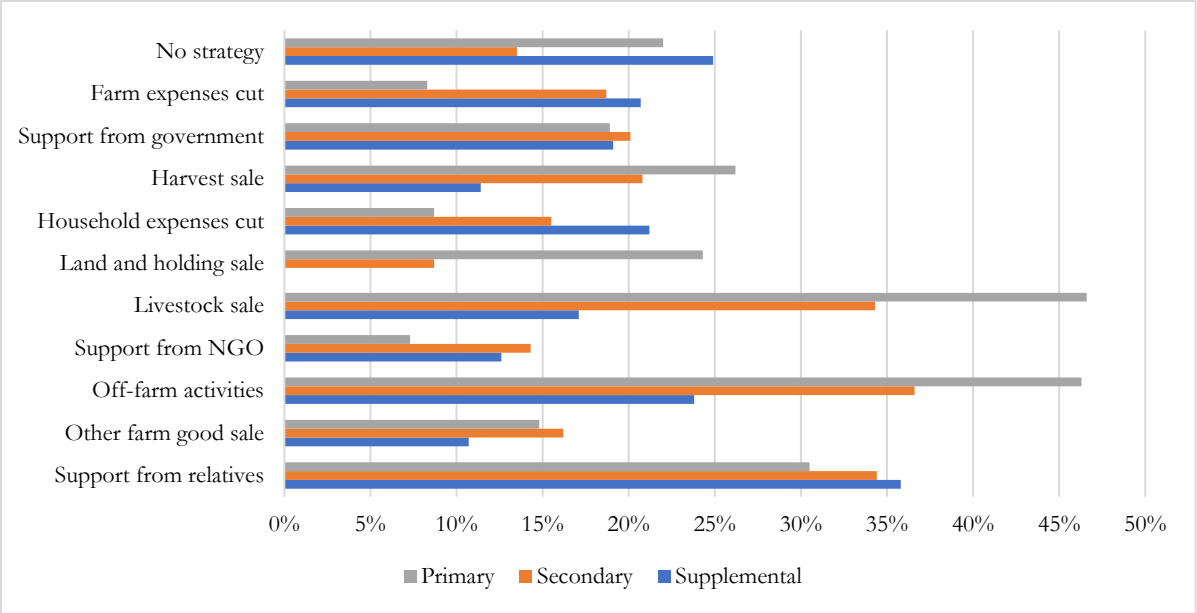
The selected proxy for farm revenue used in this study is the value of sold production, which accounts for revenue directly generated by farm activity. Farm revenue can be negatively impacted by production shocks faced by farmers; some shocks might also push farmers to sell their products at lower prices than the market price, further reducing revenue. Resilience strategies, meanwhile, can positively influence the value of sold production by limiting reductions in production, and

limiting declines in producer prices (driven by early harvesting, distress sales, and other price-related factors). However, it is also possible that some shocks will push farmers to increase sales as a means of meeting basic short-term needs in a time of crisis. Understanding the association between production, sales and farmer welfare in a period like the Covid-19 pandemic thus requires an understanding of whether sales reflect increasing prosperity or increasing distress. To control for other factors that might also be associated with the value of sold production and other vulnerability measures we include several farm and household characteristics including education, household size, farm size, production inputs used (labour, input expenses) and other farmer characteristics such as membership in production or marketing unions, own-consumption of farm products, and property rights. We further control for other shocks faced by farm households.

3.1.2 Resilience Strategies Used for Climate and Health Shocks

Figure 1 shows Senegalese farm households' resilience strategies in response to drought for the 2017-2018 season. Almost 60% of farm households said that droughts were the most severe shock they faced (see Appendix B). Thus, for the "before Covid-19" period, we focus only on farm households facing droughts as the most severe shock. Consequently, we consider a subsample of 1,300 farm households. Figure 1 shows resilience strategies applied as primary, secondary and supplemental resilience strategies by farm households facing droughts as the most severe shock. Within the subset of households experiencing drought, the most widely adopted primary resilience strategies are endogenous strategies including livestock sales, off-farm activities, seeking support from relatives, and sale of harvests. For secondary strategies, most farmers applied off-farm activities, livestock sales, support from relatives, and harvest sales, with some engaging in the exogenous strategy of seeking support from government. Finally, support from relatives, off-farm activities, and cutting household expenses cut were reported as supplemental resilience strategies. Together these patterns suggest that farmers tend to rely firstly on their own endogenous sources of resilience before asking for external help.

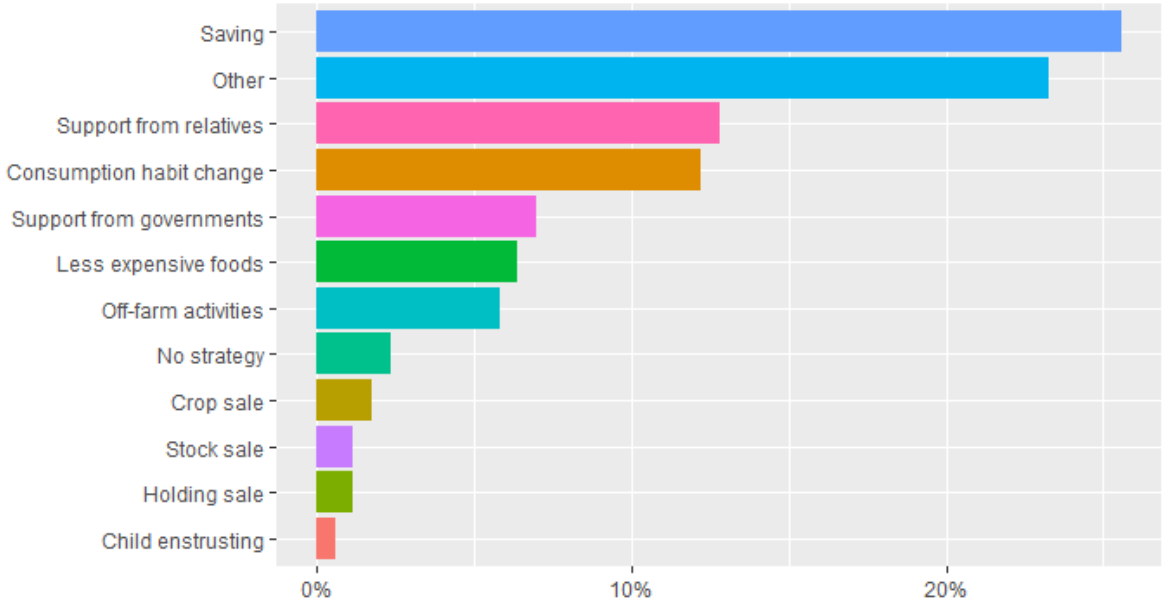
Figure 1. Resilience strategies applied against droughts (before Covid-19).



Source: Author's Calculations

Appendix C shows the production sales for groups adopting different strategies to cope with shocks. Farmers with lower production sales are more likely to engage in *livestock sales* and *off-farm activities* as an adaptation strategy. On the other hand, very few farmers with low production sales adopt the strategies of *reducing operating expenses, cutting household expenses*, or engaging in the *sale of other farm goods*. These farmers often do not engage in large expenditures in their production processes and therefore will have difficulties reducing expenses related to the household or farm. Shocks may have especially serious long-term implications for these households, as they adopt mainly the *sale of livestock* as a response strategy. This strategy can be seen as a versatile form of wealth (useful for credit access but also for production of animal products that is lost following sale), as well as off-farm activities (which can provide income but reduces the labour force on the farm). In contrast, farmers with higher production sales adopt a broader suite of adaptation strategies, including increasing *harvest sales*, increasing *livestock sales*, and *cutting household expenses*. Unexpectedly, farmers with more value of production also choose more aid from government and/or NGO sources as an adaptation strategy. Even though farmers overall tend to rely more on endogenous strategies (livestock sales, harvest sales, etc.), exogenous support can clearly complement other coping mechanisms in response to shocks.

Figure 2. Resilience strategies during the Covid-19 pandemic.



Source: Authors' calculations

Figure 2 shows resilience strategies applied by Niayes area farm households for the since-Covid-19 period, mainly to cope with the negative effects of restrictive policy measures. The first three resilience strategies are endogenous and concern use of *savings*, *changes in consumption habits*, and *cutting household expenses*. Exogenous strategies such as seeking *support from relatives* and *government* are the fourth and fifth most adopted resilience strategies. We also notice that *off-farm activities* were not used as a coping strategy by Niayes' farm households during Covid-19, even though that resilience strategy was one of the most widely used by Senegalese farm households before the pandemic. Furthermore, these households rarely applied *livestock sale* during the Covid-19 pandemic, and government support was predominant as an exogenous strategy compared to support from NGO.

3.2 Methodology

Analyses were undertaken using Stata 17 and R version 4.0.2. Initial bivariate tests include pairwise correlations. To evaluate the effect of resilience strategies against drought, we then use Propensity Score Matching (PSM), with a focus on various measures of farm vulnerability (value of sold production, consumption, productivity, and a vulnerability score) as a function of adaptations undertaken in response to drought. Matching techniques have gained with a great deal of popularity through the credibility revolution (Angrist & Pischke, 2010). The main idea of matching is to find non-treated observations similar to treated observations based on pre-treatment

characteristics (Caliendo & Kopeinig, 2008). If the condition is respected, the effect of the treatment can be assessed by estimated the difference between the outcomes of the two groups.

We compare vulnerability measures among those who adopted a resilience strategy against drought versus those who did not adopt any strategy at all. The propensity score, i.e., the probability of receiving the treatment (in our case adopting a certain resilience method), is computed with logistic regressions based on observable characteristics as follows:

$$(X) = prob\ (T = 1 \mid X) = (T \mid X)$$

Where X is a vector of variables that might relate to the probability of adopting a strategy (education and age of the household head, farm region of activity, household size (and its quadratic term)) and $T = 1$ for farmers who adopted a resilience strategy and 0 for others. With this propensity score, we match farmers that adopt resilience strategies with farmers who did not.[2] We use the nearest neighbour method, with other matching methods (neighbour, kernel, radius, stratification) for robustness checks. We assume that the vulnerability outcomes are independent of the adopted strategy, conditional on X:

$$Y_0, Y_1 \perp T \mid X$$

Therefore, comparing the two groups allows us to identify the average treatment effect of adaptation strategies:

$$ATE = (\Delta) = (Y_1 \mid X, T = 1) - (Y_0 \mid X, T = 0)$$

In this study, a household is part of the treatment group if it has experienced drought as the most severe shock and adopted a given strategy. Households that have also experienced drought as the most severe shock but have not adopted any resilience strategy are considered as members of the control group.

We consider the following strategies separately:

- **Non-farm activities**: this strategy is considered as endogenous and does not depend directly on the main activity of households, which is agriculture.

[2] We acknowledge that the strategy adopted might also be influenced by the level of vulnerability of the farmer, resulting in possible bias if we compare two sets of farmers with different levels of vulnerability – however, descriptive statistics suggest all farmers in the sample have relatively similar levels of climatic vulnerability whether they adopt a strategy in response to shocks or not.

- **The sale of farm assets**: this strategy is also endogenous but may have a negative impact on the productivity of the farm household because it involves a sale of goods normally intended for the main activity.
- **Government aid**: this strategy is considered as exogenous because it does not depend on the household but on the State's social protection policy.

These strategies allow us to compare endogenous strategies, which are decided on a farm and by farmers depending on their characteristics, and exogenous strategies that decided outside the farm by mostly the government or NGO agencies.

The 2017-2018 AAS data in Senegal contains information on different shocks that affect farmers (both severe and minor shocks) as well as the main adaptation strategies used for each shock.

Finally, to evaluate the effectiveness of similar resilience strategies on farm vulnerability outcomes for the period since Covid-19, we rely primarily on descriptive statistics, presenting comparisons between different groups adopting different strategies. The main goal with these preliminary analyses is to understand the changes in coping strategies used by farmers when they faced both the health crisis and other related shocks, and to consider possible (though not necessarily causal) associations between socio-demographics, geographic factors, farming activities, and coping strategies used in response to the pandemic.

4 Results: Are Niayes farm households' resilience strategies effective against climate and health shocks?

In this section, we explore the effectiveness of resilience strategies adopted by agricultural households to fight against climate and health shocks. In the first subsection, we focus on three resilience strategies identified as the primary strategies when the most severe shock was drought. We then examine if the same resilience strategies have had a significant impact on agricultural households' resilience facing Covid-19.

4.1 Farm households' resilience against climate shocks (before Covid-19)

Appendix tables A1-A7 present descriptive statistics and pairwise correlations of variables used and the main shocks and resilience strategies of interest. Table A1shows that the mean of production sales in the AAS sample is 169,653 CFA. However, the standard deviation (571,796) shows that there is high heterogeneity across households. Even though the main target of these surveys are family farms, there may be some which have high commercial activities (the largest has more than 20 million CFA in sales reported). Most farms (65%) are small, however, with a total area less than 0.5 ha.

Most household heads surveyed have no education (82%) and very few reach the college level (5.8%). Heads of households are also older, roughly 51 years on average. The total number of working days amounts to 198 per year on average, with a great dispersion. Households seem to be labour-intensive, reaching more than 3000 working days for some. The correlation matrix of Table A2 shows the gender of the head of household, the total farm size, the total household expenditures, and the NPK, urea and fertilizer have significant and positive associations with production sales ($p<0.05$). Farmers with a female household head on average sell less than farms with a male household head.

To examine the effects of resilience strategies in response to drought using PSM methods, we start by performing a difference of means tests to look at the difference between the means of the two groups (those adopting adaptation strategies (treatment) and those adopting no strategies (control)). We then estimated the propensity scores with a logit model and several covariates, mainly representing the sociodemographic characteristics of households. The test of balancing property of the propensity score confirmed that the balancing property was satisfied (full results of the PSM estimation model are presented in the Appendix). Finally, we made the matching between the treatment and control groups using the nearest neighbour method with replacement, with the outcome variable being the value of production sales. Results of the matching are presented in Appendix E.

Table 2 presents the results for the impact of three selected resilience strategies on production sales (log), including 402 households for *off-farm activities* (56 non-treated and 346 treated); 61 households for *sale of assets* (39 non-treated and 22 treated); and 87 households for *government aid* (47 untreated and 87 treated).

The Average Treatment effect on the Treated (ATT) for *off-farm activities* and *assets sale* are not significant. Among households that experienced drought as the most severe shock, there was no significant difference between those who adopted *off-farm activities* or *asset sales* and those who did not apply any resilience strategy at all. This result is in line with Akampumuza & Matsuda (2017) who did not find a significant effect for off-farm activities. This suggests that the endogenous resilience strategies were not effective in helping households better manage drought for the 2017-2018 crop year. In contrast, the ATT for government aid is significant and positive. This suggests that exogenous strategies may be more effective than endogenous strategies in the event of a climate shock. This result is in line with the findings of Gao & Mills (2018) who showed that government and NGO support was effective as a strategy against climatic shock in Ethiopia. An explanation of this result can be the exogenous nature of this strategy. However, it should be noted

that this resilience strategy was only effective for the farmers who applied it as the primary strategy. When *government aid* is used as a secondary or supplemental strategy, there is no significant effect.

Table 2. Effects of primary resilience strategies on production sales (log) for droughts.

Resilience strategies	Nearest Neighbor	Primary		Secondary		Supplemental	
		r(att)	N	r(att)	N	r(att)	N
Off-farm activities	(1)	-1.531	402	**4.182****	153	0.00423	155
		(1.536)		(2.043)		(1.560)	
	(2)	-1.061	402	**4.077****	153	0.471	155
		(1.469)		(2.012)		(1.371)	
Sale of assets	(1)	-0.648	61	-0.106	24	1.404	48
		(3.368)		(4.674)		(3.784)	
	(2)	0.861	61	2.117	24	2.939	48
		(3.441)		(4.297)		(3.224)	
Government aid	(1)	**4.774*****	87	4.486	47	0.546	122
		(1.753)		(3.670)		(1.951)	
	(2)	**4.628*****	87	3.842	47	0.617	122
		(1.531)		(3.802)		(1.917)	

Source: Author's calculations

Finally, although *off-farm activities* do not have a significant association with production sales when used as a primary resilience strategy, we do note that when *off-farm activities* are used as a secondary resilience method, they have a significant positive association with production sales. This suggests that for this adaptation strategy to be effective, it must come as a complement to another adaptation strategy, but when used as a primary strategy, it is less effective.

The *sale of farm assets* was not effective as either a primary, secondary, or supplemental resilience strategy. This might be explained by low market prices for farm assets, which do not allow households to benefit from such sales. Several past studies have also found that after a shock, households may urgently need funds to meet their needs, which pushes them to sell assets at low prices. Moreover, selling goods can reduce the activities on farm or constrain farmers to stop a part of the production process, leading to reduced production and reduced sales downstream. Indeed, Thomas, Twyman, Osbahr, & Hewitson (2007) showed that many farmers tend to stop their farming activities and allocate their time to other activities less sensitive to the shock. This substitution process can be detrimental for production sales.

4.2 Farm households' resilience against health shocks (after Covid-19)

To examine how farm households coped with the Covid-19 pandemic, compared to the "before Covid-19" period, we summarize the characteristics of households adopting resilience strategies

according to socio-demographic characteristics, value of production sales, main farm activities, and other shocks faced beside the Covid-19 pandemic among our sample of farm households in the Niayes area.

Appendix F present descriptive statistics for main variables for the "since Covid-19" period. The average household size in the sample is 16 members per household, higher than the average for Senegal (see table A.1). Most households (90%) are male-headed the average age of heads of household is 55 years, similar to the average age of heads of agricultural households for the before Covid-19 sample. Most surveyed households are located in the Thies Region (57%), followed by 22% for the region of Louga and 9% for each of Saint-Louis and Dakar regions. Roughly 20% of heads of household have not received an education, 21% have had a French education (21%), and nearly 50% have attended Koranic school. In terms of farm activities, 66% of households named agriculture as their main activity, followed by 9% fishing, 4% animal husbandry and 5% focusing on trade. As regards the main source of income, agriculture is the primary income source for 58% of the households in the sample, followed by fishing (13%), trade (6%) and livestock (4%).

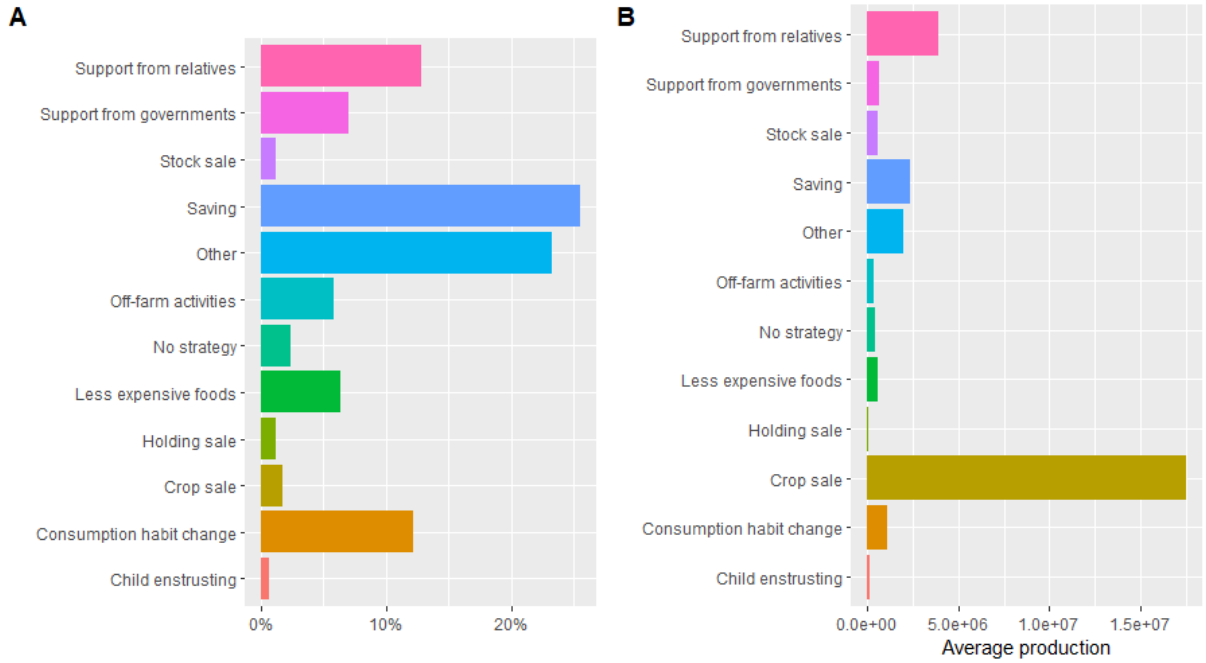
In terms of access to other forms of support, 19% of households received transfers from migrants, with an average sum of 244,137 FCFA, and a wide variation in amounts ranging from 10,000 to 2,400,000 FCFA. Finally, in addition to Covid-19, households reported experiencing a number of other economic, social and climatic shocks. In total 54% of households in the sample declared having suffered a shock other than Covid-19 during the 2020-2021 crop year. The most common shocks are the scarcity of fishery products, the loss of jobs, increasing market prices, declining migrant transfers, and the loss of livestock.

We begin by looking at the average production sale for each resilience strategy during the health crisis. Figure 3 compares average production sales for each type of resilience strategy. Panel A shows different coping strategies adopted by farmers, and Panel B highlights the average production sales of farmers adopting each strategy.

Saving is most commonly reported strategy, followed by *Other types of strategies* and *Support from relatives*. *Other strategies* include farmers coping with the Covid shock by themselves (endogenous strategies) with for instance borrowing money or selling crops at a lower price. The Covid-19 pandemic also led to changes in consumption, with some farms describing reduced or changed consumption as a coping strategy. We can see that additional sales activities (sales of crops or livestock) were not widely used. This is not surprising insofar as the Covid-19 pandemic disrupted entire value chains and the policy-induced lockdown reduced not only access to markets but also demand for many goods. From Panel B, we can see the average value of production sales for each resilience strategy. *Crop sales* has the highest production sale on average (more than 17 million

FCFA), though the sample of households adopting this strategy is very small. The second-highest average production sales are among those using *Support from relatives* as a strategy, followed by those using *Saving* and *Other strategies* to face the health shock.

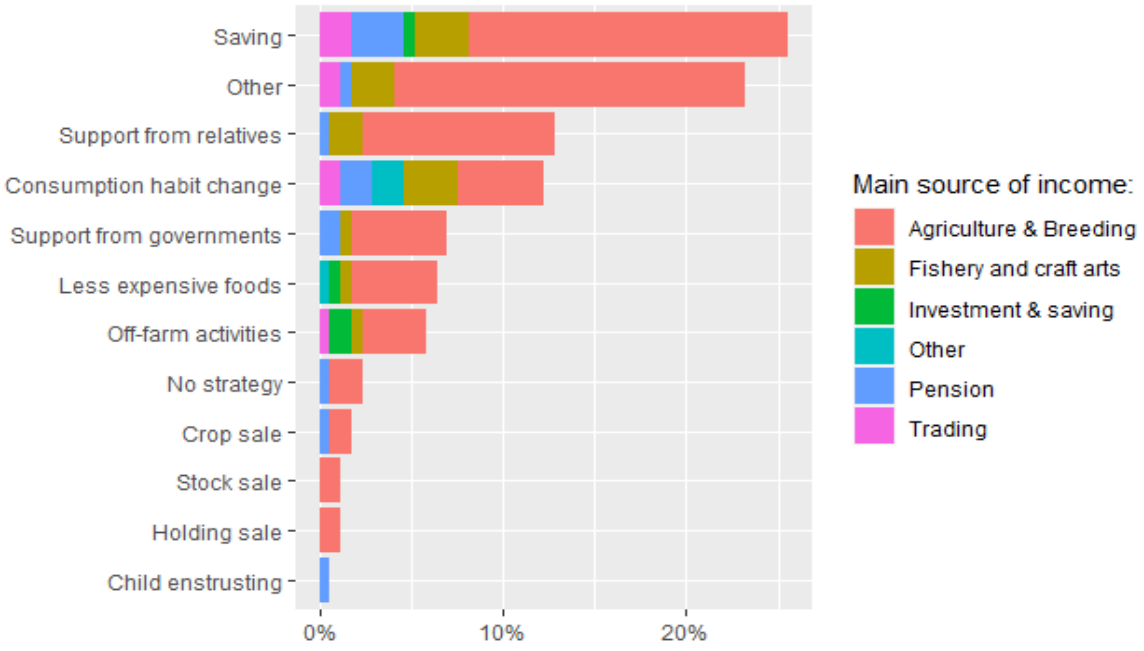
Figure 3. Production sales of resilience strategies during the Covid-19.



Source: Authors' calculations.

An examination of demographic characteristics associated with adoption of adaptation strategies suggests the income and accordingly the source of income of the household strongly relates to strategy choice. Figure 4 presents the different sources of income of households for each strategy.

Figure 4. Main source of income by resilience strategies during the Covid-19.



Source: Authors' calculations.

Households deriving their main source of income from agriculture and breeding use a wide range of strategies. When fishery and crafts arts is the main source of income, households are more likely to use *saving* and *consumption habit change* as resilience strategies. Households with wages as the main source of income (six of them) did not use any strategy – which may suggest that the Covid-19 pandemic did not affect their primary jobs, allowing them to sustain their standard of living during the shock. Finally, for households depending only on pension retirement, they also use *saving* as and *consumption changes* , and also rely on *Support from government* and *Support from NGO*. These households might be the most vulnerable, especially with the low levels of pension in Senegal, and therefore have very little margin for coping with the Covid-19 outside of exogenous support.

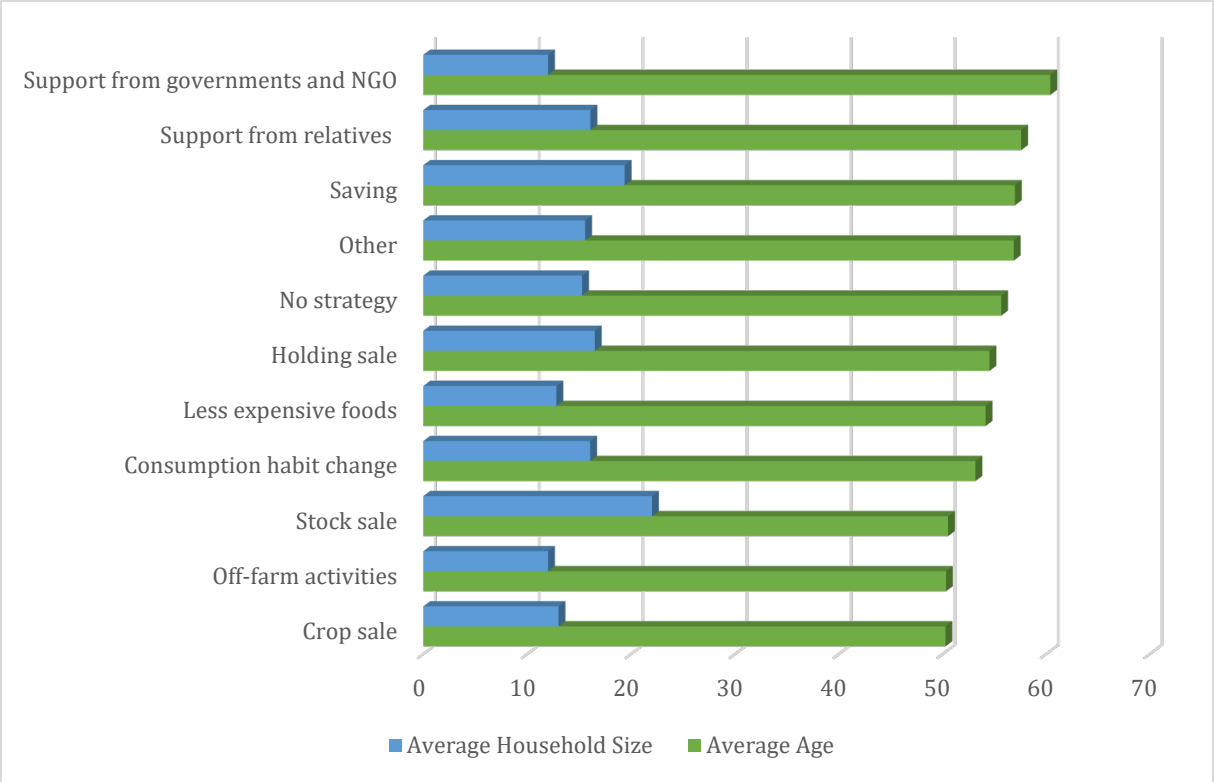
Figure 5 depicts the different adaptation strategies of households depending on their spatial location in the Niayes area's 4 regions: Dakar, the capital city, Saint-Louis, Thies and Louga.

Figure 5. Resilience strategies by region during the Covid-19.

Household located in Dakar and Saint-Louis adopted only a few strategies in response to Covid-19, which mainly include saving and either *support from family* or changes in food purchases to *less expensive foods* (mainly in Saint Louis). These two regions count only 22% and 9% of total households in the sample, however. Among the much larger samples in Thies and Louga, *savings* was still an important strategy used during the pandemic, as well as *support from relatives* and *changes in consumption habits*. In Thies, there is also a large *"Other"* category, reflecting strategies such as selling at lower price or just managing themselves with their own resources. Finally, household from Louga were the only one to use *crop sales* strategy. This might indicate that local markets in the region were not as strongly affected by government measures to stem the Covid-19 progression.

Finally, Figure 6 presents the average age of the household head age and average household size for each strategy. Older households appear to depend more on exogenous strategies to cope with the health shock (*Government and NGO support* and *Support from relatives*). The households relying on *Government and NGO support* are also smaller, on average, than households adopting other strategies (though with 12 members, these farm households are still larger than the overall average across Senegal (Appendix A.1).

Figure 6. Average production sales by strategies for each region during the Covid-19.



This descriptive analysis shows us how resilience strategy was influenced by revenue but also spatial location and socio-demographic characteristics. Household with the head older and depending only on pension retirement were the most vulnerable. Some households, mainly located to Louga, seem to be most resilient to the Covid-19 pandemic as they had access to multiple adaptation strategies and have, on average, the highest production sale (Appendix D).

5 Conclusions

Agriculture employs the poorest populations in developing countries and must ensure food security in a continent marked by a high prevalence of famine. However, it is one of the most vulnerable sectors to shocks. This article studies the behaviour of farmers in the face of drought and Covid-19. More precisely, we are trying to (a) understand the effectiveness of endogenous resilience strategies (off-farm activities and sale of farm assets) and an exogenous resilience strategy (government/NGO support) applied by farmers who have suffered drought during the 2017-2018 agricultural campaign, and (b) examine the resilience strategies put in place by food system actors in the Niayes area to cope with the negative effects of Covid-19 and associated restrictive policy measures.

The results of PSM analyses using nationally representative AAS survey data suggest that endogenous resilience strategies were less effective at supporting high production sales (a key resilience indicator) among farmers in Senegal than exogenous strategies such as support from government or NGOs in response to a drought shock. Off-farm activities meanwhile may be effective when applied as a secondary resilience strategy, complementing another resilience method. The sale of farm assets is not associated with value of production sales - likely because this strategy reduces the production capacity of farmers and can cause a decline in farm income.

When it comes to the Covid-19 shock, our preliminary analyses of households from the Niayes area suggest the resilience strategies adopted were very diverse, depending on the main source of income but also on the spatial location and other socio-demographic characteristics of households. Households located in Louga had the highest average production sales, which may indicate that markets in Louga were relatively less disrupted, allowing farmers to sell their crop (Louga is the only region where increased crop sales was cited as an adaptation strategy to the pandemic). We also find farmers with older heads of household tend to rely more on exogenous support (from government and NGOs), but also support from relatives. This might indicate a heightened level of vulnerability of these households, which have difficulties implementing resilience strategies on their own. It might also highlight the devastating effects of Covid-19 on some households: the health shock has worsened living conditions among the already vulnerable, and increased their dependence on external supports.

Combined, these results suggest government and NGO support has been crucial for enabling farmers in Senegal to adapt to climate shocks. Moreover, these same supports helped farmers during the Covid-19 pandemic, especially the most vulnerable ones.

However, given the sudden nature of shocks, the limited climate forecasting capacities in many low-income countries (Ziervogel & Downing, 2004) and the lower effectiveness of current endogenous strategies, there may also be risks associated with government and NGO support. Indeed, one the criticisms of emergency food aid to vulnerable households is dependency. Jackson (2020) finds that emergency food aid has reduced the use of endogenous resilience strategies by food system actors in the Bedamuni tribe of Western Province, Papua New Guinea region. While the latter were effective and allowed them to cope with shocks. Minviel & Latruffe, (2017) found that 54% of the study on public subsidies is negative and significant, show a reduction of the managerial effort from farmers. Indeed, in the medium to long-term reliance on external aid (government, NGOs, others) may increase vulnerability, especially where aid may not be sustainable over time. Furthermore, in the event of a sudden shock, governments may act with delay, or may make ineffective targeting, which may further increase the vulnerability of aid-

dependent farm households. A recent IPAR survey during Covid-19 with the monitoring committees, distribution committee, and beneficiaries of the state emergency food aid program showed some failures related to targeting and storage, but also the delay in distribution in certain areas (Tounkara et al., 2021). Alternative sources of exogenous and endogenous support, such as the creation of a business environment favourable to investment, access to credit, investments in infrastructure, and human capital investments such as education might make for more effective endogenous resilience strategies against shocks. This will promote endogenous resilience strategies and allow households to better fight against shocks in the medium and long term.

Therefore, to support farm household resilience to shocks, the results of this study suggest governments should apply policies that can make endogenous resilience strategies, such as non-farm activities, more effective, while also maintaining and possibly expanding social safety net programs that help protect the most vulnerable.

This study suffers from drawbacks and some caveats need to be made. The survey for the period after Covid-19 did not allow us to develop extensively the causal effect of the shock and the effectiveness of the strategies used. Therefore, the results after the outbreak should be taken with caution. Indeed, they should be considered as mainly descriptive and a foundation for future studies. We believe that future research on adaptation strategies during Covid-19 but also before Covid-19, with panel data for instance, could help better understand the resilience features of farmers.

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Appendix A. Data analysis

Table A.1. Descriptive Statistics

Variable	Observations	Moyenne	Écart-type	Minimum	Maximum
Value of production sales	5358	169652.8	571796.26	0	20250000
Education	5107	1.321	.708	1	4
Age of household head	5249	52.172	10.843	19	65
Gender of household head	5292	1.071	.257	1	2
Household size	5292	8.596	4.554	1	20
Association of operators	5357	1.908	.289	1	2
Commercial cooperative	5357	1.953	.212	1	2
Production cooperative	5357	1.925	.264	1	2
Borrowed land rate	5358	4.986	19.317	0	100
Rented land rate	5358	.954	7.707	0	100
Land owned rate	5358	94.06	20.724	0	100
Number of plots	5358	3.208	2.145	1	19
Total area	5313	27311.251	25292.494	86.71	232465.68
Area used	203	3.217	1.267	1	5
Work factor (days)	5292	198.272	246.913	0	3600
Labour expenses	5067	8367.21	58465.742	0	2000000
Total expenses	3791	80715.657	131158.09	0	1548300
Culture expenses	4284	53753.488	100217.1	0	1530800
Livestock expenditure	4369	27248.179	96111.746	0	4753000
Number of animals	5292	134.505	119.45	0	883
Material expenses	5092	3263.757	23734.518	0	1225500
NPK (quantities)	404	363.686	482.235	0	3700
Urea (quantities)	169	134.799	91.412	1	500
Fertilizers (quantities)	4782	124.094	138.735	0	1299.879
Shock 1 Drought	5358	.243	.429	0	1
Shock 1 Flood	5358	.011	.105	0	1
Shock 1 Slips	5358	.01	.098	0	1
Shock 1 Pests	5358	.038	.191	0	1
Shock 1 Livestock disease	5358	.01	.097	0	1
Shock 1 Lower selling price	5358	.01	.102	0	1
Shock 1 Decrease in the price of inputs	5358	.019	.137	0	1
Shock 1 Theft of agricultural property	5358	.011	.104	0	1
Shock 1 Animal theft	5358	.021	.145	0	1
Shock 1 Fires	5358	.008	.089	0	1
Shock 1 Others	5358	.038	.191	0	1
Shock 2 Drought	5358	.02	.14	0	1
Shock 2 Flood	5358	.01	.101	0	1
Shock 2 Slips	5358	.005	.073	0	1
Shock 2 Pests	5358	.054	.227	0	1
Shock 2 Livestock disease	5358	.024	.153	0	1
Shock 2 Lower selling price	5358	.038	.19	0	1
Shock 2 Decrease in the price of inputs	5358	.048	.215	0	1

Shock 2 Theft of agricultural property	5358	.025	.155	0	1
Shock 2 Animal theft	5358	.03	.17	0	1
Shock 2 Fires	5358	.008	.089	0	1
Shock 2 Others	5358	.045	.208	0	1
Shock 3 Drought	5358	.01	.102	0	1
Shock 3 Flood	5358	.004	.061	0	1
Shock 3 Slips	5358	.003	.056	0	1
Shock 3 Pests	5358	.01	.102	0	1
Shock 3 Livestock disease	5358	.011	.104	0	1
Shock 3 Lower selling price	5358	.034	.181	0	1
Shock 3 Decrease in the price of inputs	5358	.04	.195	0	1
Shock 3 Theft of agricultural property	5358	.023	.151	0	1
Shock 3 Animal theft	5358	.031	.174	0	1
Shock 3 Fires	5358	.005	.073	0	1
Shock 3 Others	5358	.053	.223	0	1
Stra1 shock 1 Land sale	5358	.024	.152	0	1
Stra1 shock 1 Harvest sale	5358	.05	.218	0	1
Stra1 shock 1 Animal sale	5358	.135	.342	0	1
Stra1 shock1 Sale of goods	5358	.01	.1	0	1
Stra1 shock1 Off farm activities	5358	.098	.297	0	1
Stra1 shock1 Support from government	5358	.022	.148	0	1
Stra1 shock1 Support from relatives	5358	.041	.199	0	1
Stra1 shock1 Support from NGO	5358	.004	.059	0	1
Stra1 shock1 Decrease in operating expenses	5358	.004	.059	0	1
Stra1 shock1 Decrease in household expenses	5358	.004	.059	0	1
Stra1 shock1 No strategy	5358	.033	.178	0	1
Stra2 shock1 Land sale	5358	.003	.058	0	1
Stra2 shock1 Harvest sale	5358	.028	.166	0	1
Stra2 shock1 Animal sale	5358	.059	.236	0	1
Stra2 shock1 Sale of goods	5358	.017	.129	0	1
Stra2 shock1 Off farm activities	5358	.059	.236	0	1
Stra2 shock1 Support from government	5358	.026	.158	0	1
Stra2 shock1 Support from relatives	5358	.052	.223	0	1
Stra2 shock1 Support from NGO	5358	.009	.095	0	1
Stra2 shock1 Lower operating expenses	5358	.013	.114	0	1
Stra2 shock1 Decrease in household expenses	5358	.009	.096	0	1
Stra2 shock1 No strategy	5358	.008	.089	0	1
Stra3 shock1 Land sale	5358	.002	.047	0	1
Stra3 shock1 Harvest sale	5358	.008	.089	0	1
Stra3 shock1 Animal sale	5358	.018	.135	0	1
Stra3 shock1 Sale of goods	5358	.008	.09	0	1
Stra3 shock1 Off farm activities	5358	.023	.149	0	1
Stra3 shock1 Support from government	5358	.02	.14	0	1
Stra3 shock1 Support from relatives	5358	.056	.23	0	1
Stra3 shock1 Support from NGO	5358	.01	.098	0	1

Stra3 shock1 Decrease in operating expenses	5358	.019	.137	0	1
Stra3 shock1 Decrease in household expenses	5358	.018	.134	0	1
Stra3 shock1 No strategy	5358	.04	.196	0	1

Table A.2. Pairwise correlations

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)
(1) Value of production sales	1.000																		
(2) Education	-0.006	1.000																	
(3) Age of household head	-0.004	-0.134*	1.000																
(4) Gender of household head	-0.035*	-0.086*	-0.014	1.000															
(5) Total area	0.048*	-0.056*	-0.042*	-0.023	1.000														
(6) Used area	-0.026	-0.003	0.198*	0.159*	-0.077	1.000													
(7) Labour factor (days)	0.023	0.143*	0.079*	-0.039*	-0.014	-0.048	1.000												
(8) Labour expenses	-0.012	0.003	0.014	0.007	0.095*	0.035	0.029*	1.000											
(9) Total expenses	0.276*	0.022	-0.031	-0.035*	0.064*	0.140	0.030	-0.012	1.000										
(10) Culture expenses	0.321*	0.043*	-0.017	-0.036*	0.061*	0.092	0.020	-0.002	0.869*	1.000									
(11) Livestock expenses	0.028	-0.010	-0.014	-0.015	0.015	0.152	0.039*	-0.013	0.623*	0.154*	1.000								
(12) Number of animals	-0.002	0.135*	0.140*	-0.007	-0.032*	-0.075	0.627*	0.037*	0.019	-0.006	0.053*	1.000							
(13) Material expenses	-0.014	0.010	-0.017	-0.012	0.074*	0.015	-0.005	0.260*	-0.018	-0.010	-0.014	-0.007	1.000						
(14) NPK (quantities)	0.173*	-0.006	-0.068	0.014	0.805*	-0.200	-0.077	0.246*	0.083	0.076	0.040	-0.023	0.063	1.000					
(15) Urea (quantities)	-0.169*	-0.193*	-0.066	0.037	0.465*	-0.522*	-0.213*	0.311*	0.049	0.063	-0.039	-0.050	0.579*	0.383*	1.000				
(16) Fertilizers (quantities)	0.036*	-0.044*	-0.039*	-0.012	0.818*	-0.100	0.001	0.136*	0.035*	0.044*	-0.005	-0.008	0.088*	0.771*	0.557*	1.000			
(17) Association of operators	0.002	-0.013	-0.005	0.007	-0.005	-0.068	0.049*	-0.017	-0.060*	-0.075*	0.005	0.016	-0.011	0.108*	-0.222*	-0.011	1.000		
(18) Commercial cooperative	-0.024	-0.010	-0.007	-0.006	-0.025	-0.087	0.028*	-0.032*	-0.058*	-0.062*	-0.003	0.020	-0.016	-0.046	-0.044	-0.010	0.164*	1.000	
(19) Production cooperative	0.004	-0.012	0.019	0.002	-0.003	-0.100	0.037*	-0.018	-0.089*	-0.087*	-0.010	0.010	-0.006	0.092	-0.249*	0.010	0.228*	0.201*	1.000

Table A.3. **Pairwise correlations**

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
(1) Value of production sales	1.000											
(2) Shock 1 Drought	0.006	1.000										
(3) Shock 1 Flood	0.046*	-0.060*	1.000									
(4) Shock 1 Slips	-0.012	-0.056*	-0.011	1.000								
(5) Shock 1 Pests	-0.006	-0.112*	-0.021	-0.020	1.000							
(6) Shock 1 Livestock disease	0.027*	-0.055*	-0.010	-0.010	-0.019	1.000						
(7) Shock 1 Lower selling price	0.034*	-0.058*	-0.011	-0.010	-0.020	-0.010	1.000					
(8) Shock 1 Decrease in the price of inputs	0.022	-0.079*	-0.015	-0.014	-0.028*	-0.014	-0.014	1.000				
(9) Shock 1 Theft of agricultural property	0.040*	-0.060*	-0.011	-0.010	-0.021	-0.010	-0.011	-0.015	1.000			
(10) Shock 1 Animal theft	0.083*	-0.084*	-0.016	-0.015	-0.029*	-0.015	-0.015	-0.021	-0.016	1.000		
(11) Shock 1 Fires	-0.002	-0.051*	-0.010	-0.009	-0.018	-0.009	-0.009	-0.013	-0.009	-0.013	1.000	
(12) Shock 1 Others	-0.010	-0.113*	-0.021	-0.020	-0.039*	-0.020	-0.020	-0.028*	-0.021	-0.029*	-0.018	1.000

**** p<0.01, ** p<0.05, * p<0.1*

Table A.4. Pairwise correlations

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
(1) Value of production sales	1.000											
(2) Shock 2 Drought	-0.014	1.000										
(3) Shock 2 Flood	0.002	-0.015	1.000									
(4) Shock 2 Slips	-0.015	-0.011	-0.008	1.000								
(5) Shock 2 Pests	-0.028*	-0.034*	-0.024	-0.018	1.000							
(6) Shock 2 Livestock disease	0.009	-0.022	-0.016	-0.012	-0.038*	1.000						
(7) Shock 2 Lower selling price	0.001	-0.028*	-0.020	-0.015	-0.047*	-0.031*	1.000					
(8) Shock 2 Decrease in the price of inputs	0.008	-0.032*	-0.023	-0.017	-0.054*	-0.035*	-0.044*	1.000				
(9) Shock 2 Theft of agricultural property	0.062*	-0.023	-0.016	-0.012	-0.038*	-0.025	-0.031*	-0.036*	1.000			
(10) Shock 2 Animal theft	0.031*	-0.025	-0.018	-0.013	-0.042*	-0.027*	-0.035*	-0.040*	-0.028*	1.000		
(11) Shock 2 Fires	0.008	-0.013	-0.009	-0.007	-0.022	-0.014	-0.018	-0.020	-0.014	-0.016	1.000	
(12) Shock 2 Others	0.029*	-0.031*	-0.022	-0.016	-0.052*	-0.034*	-0.043*	-0.049*	-0.035*	-0.038*	-0.020	1.000

**** p<0.01, ** p<0.05, * p<0.1*

Table A.5. Pairwise correlations

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
(1) Value of production sales	1.000											
(2) Shock 3 Drought	0.035*	1.000										
(3) Shock 3 Flood	0.002	-0.006	1.000									
(4) Shock 3 Slips	-0.006	-0.006	-0.003	1.000								
(5) Shock 3 Pests	-0.010	-0.011	-0.006	-0.006	1.000							
(6) Shock 3 Livestock disease	0.003	-0.011	-0.006	-0.006	-0.011	1.000						
(7) Shock 3 Lower selling price	0.005	-0.019	-0.011	-0.011	-0.019	-0.020	1.000					
(8) Shock 3 Decrease in the price of inputs	0.014	-0.021	-0.012	-0.011	-0.021	-0.021	-0.038*	1.000				
(9) Shock 3 Theft of agricultural property	0.025	-0.016	-0.009	-0.009	-0.016	-0.016	-0.029*	-0.031*	1.000			
(10) Shock 3 Animal theft	0.018	-0.018	-0.011	-0.010	-0.018	-0.019	-0.034*	-0.037*	-0.028*	1.000		
(11) Shock 3 Fires	0.020	-0.008	-0.005	-0.004	-0.008	-0.008	-0.014	-0.015	-0.011	-0.013	1.000	
(12) Shock 3 Others	-0.003	-0.024	-0.014	-0.013	-0.024	-0.025	-0.044*	-0.048*	-0.036*	-0.042*	-0.017	1.000

**** p<0.01, ** p<0.05, * p<0.1*

Table A.6. **Pairwise correlations**

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
(1) Stra1 shock 1 Land sale	1.000											
(2) Stra1 shock 1 Harvest sale	-0.022	1.000										
(3) Stra1 shock 1 Animal sale	0.038*	-0.036*	1.000									
(4) Stra1 shock1 Sale of goods	0.084*	-0.062*	-0.091*	1.000								
(5) Stra1 shock1 Off farm (6) activities	-0.012	-0.016	-0.023	-0.040*	1.000							
(6) Stra1 shock1 Support from government	-0.007	-0.051*	-0.076*	-0.130*	-0.033*	1.000						
(7) Stra1 shock1 Support from relatives	0.022	-0.024	-0.035*	-0.060*	-0.015	-0.050*	1.000					
(8) Stra1 shock1 Support from NGO	-0.036*	-0.032*	-0.048*	-0.082*	-0.021	-0.068*	-0.031*	1.000				
(9) Stra1 shock1 Decrease in operating expenses	0.000	-0.009	-0.014	-0.024	-0.006	-0.020	-0.009	-0.012	1.000			
(10) Stra1 shock1 Decrease in household expenses	-0.004	-0.009	-0.014	-0.024	-0.006	-0.020	-0.009	-0.012	-0.004	1.000		
(11) Stra1 shock1 No strategy	0.040*	-0.009	-0.014	-0.024	-0.006	-0.020	-0.009	-0.012	-0.004	-0.004	1.000	
(12) Stra1 shock 1 Land sale	0.000	-0.029*	-0.042*	-0.073*	-0.019	-0.061*	-0.028*	-0.038*	-0.011	-0.011	-0.011	1.000

*** *p<0.01, ** p<0.05, * p<0.1*

Table A.7. Pairwise correlations

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
(1) Stra2 shock 1 Land sale	1.000											
(2) Stra2 shock 1 Harvest sale	-0.007	1.000										
(3) Stra2 shock 1 Animal sale	0.019	-0.010	1.000									
(4) Stra2 shock1 Sale of goods	0.025	-0.015	-0.043*	1.000								
(5) Stra2 shock1 Off farm (6) activities	0.004	-0.008	-0.022	-0.033*	1.000							
(6) Stra2 shock1 Support from government	-0.002	-0.015	-0.043*	-0.063*	-0.033*	1.000						
(7) Stra2 shock1 Support from relatives	0.018	-0.009	-0.028*	-0.041*	-0.021	-0.041*	1.000					
(8) Stra2 shock1 Support from NGO	0.003	-0.014	-0.040*	-0.059*	-0.031*	-0.059*	-0.038*	1.000				
(9) Stra2 shock1 Decrease in operating expenses	0.010	-0.006	-0.016	-0.024	-0.013	-0.024	-0.016	-0.023	1.000			
(10) Stra2 shock1 Decrease in household expenses	0.007	-0.007	-0.020	-0.029*	-0.015	-0.029*	-0.019	-0.027*	-0.011	1.000		
(11) Stra2 shock1 No strategy	-0.006	-0.006	-0.017	-0.024	-0.013	-0.024	-0.016	-0.023	-0.009	-0.011	1.000	
(12) Stra2 shock 1 Land sale	-0.005	-0.005	-0.015	-0.023	-0.012	-0.023	-0.015	-0.021	-0.009	-0.010	-0.009	1.000

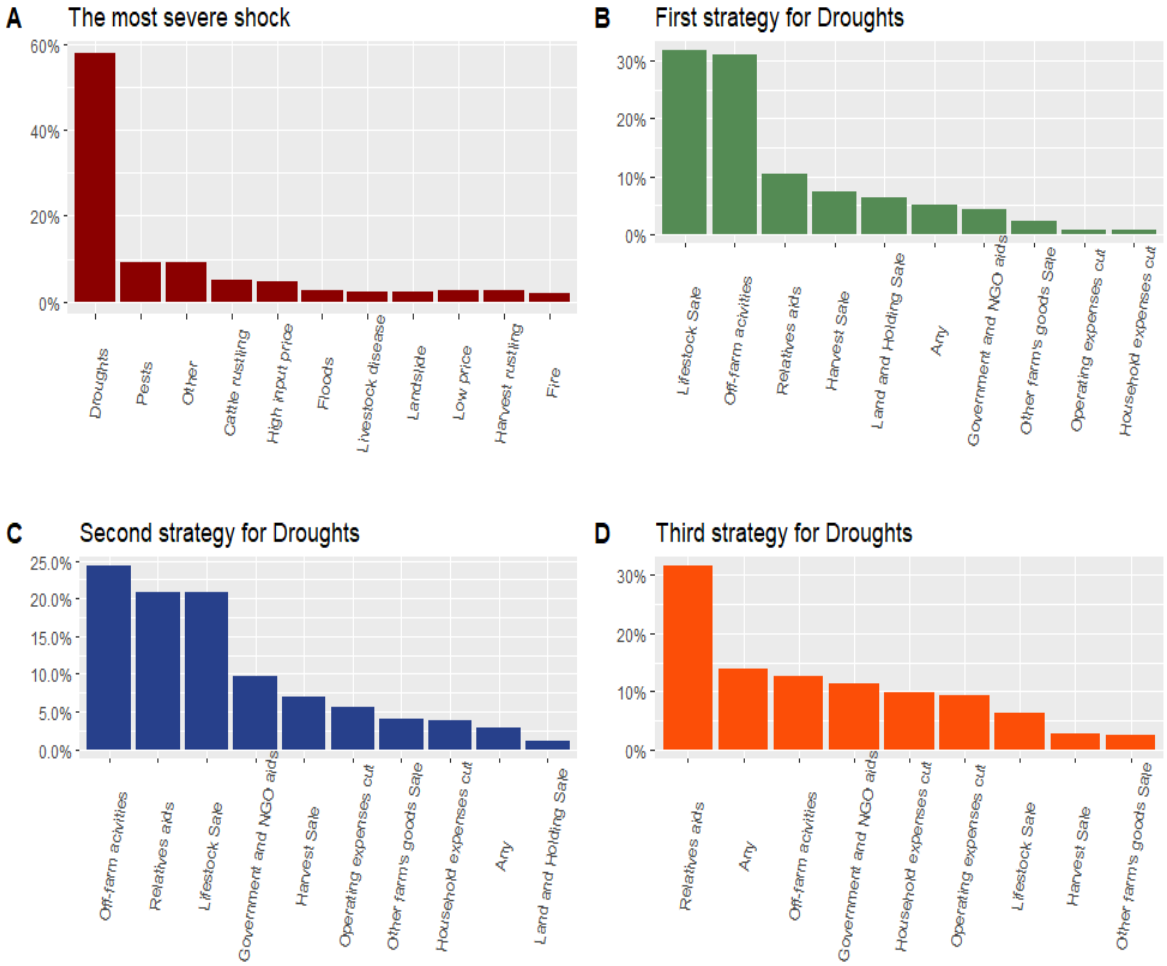
**** p<0.01, ** p<0.05, * p<0.1*

Table A.8. Pairwise correlations

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
(1) Stra3 shock 1 Land sale	1.000											
(2) Stra3 shock 1 Harvest sale	0.019	1.000										
(3) Stra3 shock 1 Animal sale	0.023	-0.004	1.000									
(4) Stra3 shock1 Sale of goods	0.002	-0.007	-0.012	1.000								
(5) Stra3 shock1 Off farm (6) activities	-0.002	-0.004	-0.008	-0.012	1.000							
(6) Stra3 shock1 Support from government	0.006	-0.007	-0.014	-0.021	-0.014	1.000						
(7) Stra3 shock1 Support from relatives	0.024	-0.007	-0.013	-0.020	-0.013	-0.022	1.000					
(8) Stra3 shock1 Support from NGO	0.011	-0.012	-0.022	-0.033*	-0.022	-0.037*	-0.035*	1.000				
(9) Stra3 shock1 Decrease in operating expenses	-0.008	-0.005	-0.009	-0.014	-0.009	-0.015	-0.014	-0.024	1.000			
(10) Stra3 shock1 Decrease in household expenses	-0.001	-0.007	-0.013	-0.019	-0.013	-0.021	-0.020	-0.034*	-0.014	1.000		
(11) Stra3 shock1 No strategy	0.002	-0.006	-0.012	-0.019	-0.012	-0.021	-0.019	-0.033*	-0.014	-0.019	1.000	
(12) Stra3 shock 1 Land sale	0.023	-0.010	-0.018	-0.028*	-0.019	-0.031*	-0.029*	-0.050*	-0.020	-0.029*	-0.028*	1.000

**** p<0.01, ** p<0.05, * p<0.1*

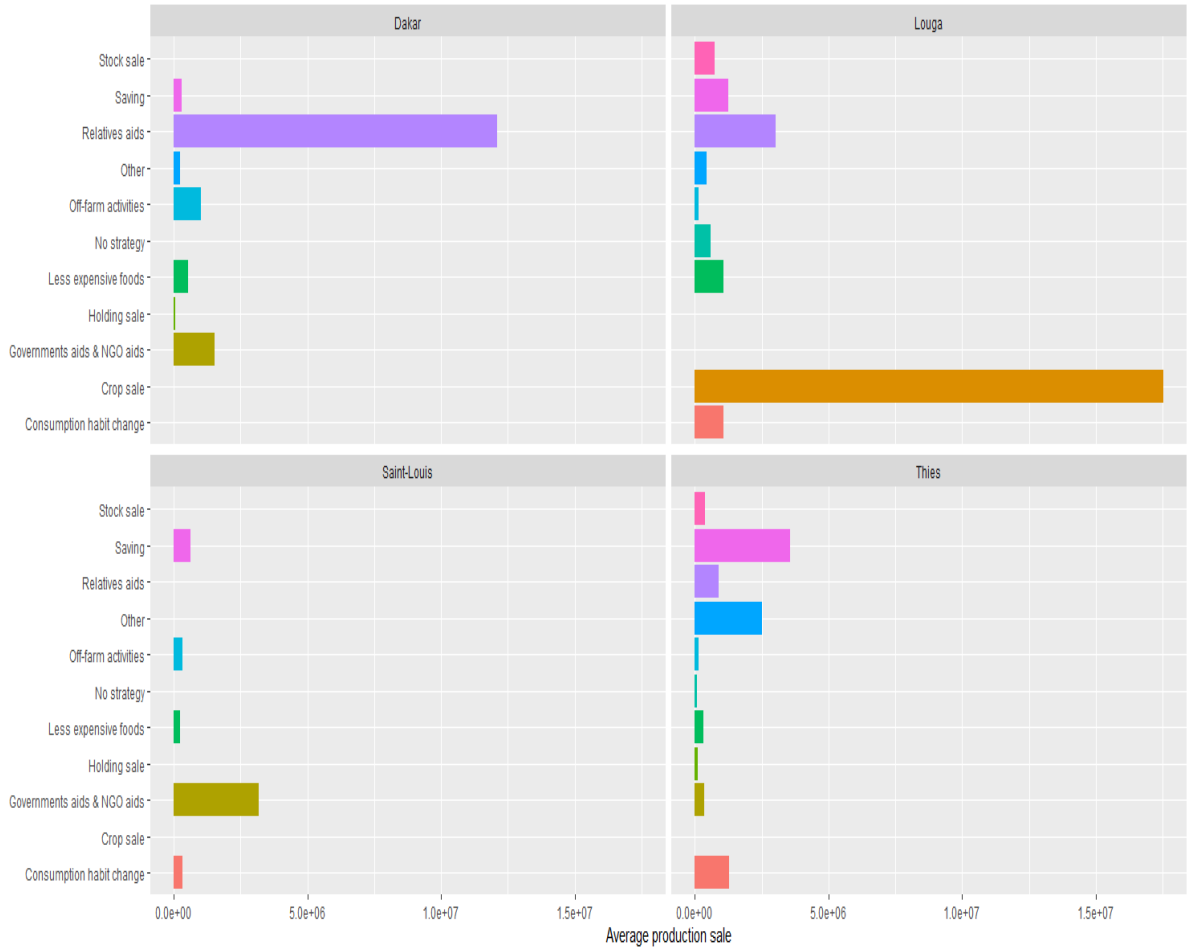
Appendix B. The most severe shocks faced by farmers.



Appendix C. Distribution of production sales according to resilience strategies (before Covid-19)

Source: Author's calculations

Appendix D. Distribution of average production sale according to resilience strategies by region (during Covid-19)



Appendix E. Propensity score estimation

VARIABLES	Off-farm activities	Sale of goods	Government aid
education	0.425	-0.106	0.147
	(0.273)	(0.434)	(0.640)
age	0.00663	0.278	0.150
	(0.0151)	(0.400)	(0.226)
size	0.359**	1.074**	-0.164
	(0.140)	(0.460)	(0.221)
size_2	-0.0158***	-0.0510**	0.00252
	(0.00608)	(0.0211)	(0.0109)
dummy_region2	1.996***	-3.996***	1.667
	(0.606)	(1.550)	(1.524)
dummy_region4	3.142***		0.627
	(0.673)		(1.686)
dummy_region5	3.663***	-3.254	3.484**
	(1.195)	(2.226)	(1.748)
dummy_region10	3.544***		
	(0.689)		
dummy_region11	1.622**	-2.475*	3.170**
	(0.663)	(1.373)	(1.396)
dummy_region12	2.098***		
	(0.698)		
dummy_region14	4.068***	-0.427	
	(0.778)	(1.275)	
coop_commerciale	0.904		-3.440*
	(0.971)		(2.024)
age_chefmenage_2		-0.00228	-0.00195
		(0.00388)	(0.00238)
genre_chefmenage		3.147*	-0.0295
		(1.645)	(0.974)
dummy_region8		-2.377*	-0.960
		(1.219)	(1.964)
coop_production		-1.620	2.778
		(2.283)	(1.916)
asso_exploitants			-1.701
			(1.237)
Constant	-5.110**	-11.46	0.992
	(2.437)	(10.92)	(5.998)
Observations	402	61	87
Prob>chi2	0.0000	0.0164	0.0002
Pseudo R2	0.1862	0.3094	0.3427

*Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1*

Appendix F. Descriptive statistics for the "during Covid-19" period.

Variable	Obs.	Mean	Std. Dev.	Min	Max
Household size	444	16.207	10.152	0	83
HH sexe	444	.901	.299	0	1
HH age	444	55.568	12.945	21	90
Region					
_Dakar	444	.099	.299	0	1
_Louga	444	.227	.42	0	1
_Saint-Louis	444	.099	.299	0	1
_Thies	444	.574	.495	0	1
Education					
_No education	444	.203	.402	0	1
_Literate in the national language	444	.056	.231	0	1
_French school	444	.216	.412	0	1
_Koranic school	444	.498	.501	0	1
_Franco-Arab school	444	.027	.162	0	1
Main activity					
_Agriculture	444	.664	.473	0	1
_Art and craft	444	.014	.116	0	1
_Trade	444	.054	.226	0	1
_Breeding	444	.036	.187	0	1
_Public official	444	.018	.133	0	1
_Inactive/unemployed	444	.029	.169	0	1
_Fishering	444	.086	.28	0	1
_Retirement	444	.032	.175	0	1
_Transport	444	.014	.116	0	1
_Other	444	.054	.226	0	1
Main source of income					
_Retirement pensions	444	.07	.255	0	1
_Agricultural income	444	.583	.494	0	1
_Breeding income	444	.043	.203	0	1
_Fishing income	444	.128	.335	0	1
_Property income, investment, and savings	444	.02	.141	0	1
_Trade income	444	.063	.243	0	1
_Non farm income	444	.034	.181	0	1
_Salaries	444	.014	.116	0	1
_Money transfers from abroad	444	.002	.047	0	1
_Money transfers from senegal	444	.009	.095	0	1
_Other	444	.034	.181	0	1
Food expenditure per day	444	5077.815	2857.626	1000	25000
Food expenditure per day per member	443	374.168	211.11	33.333	1400
Migrant transfers	444	.1959459	.397	0	1
Migrant transfers (Montant)	87	244137.93	415188.53	10000	2400000
Shock outside Covid-19	444	.547	.498	0	1

_Land grabbing	243	.012	.111	0	1
_Stop sending money by a family member	243	.041	.199	0	1
_Early stop of rainfall	243	.016	.128	0	1
_Increase in the price of inputs / materials	243	.16	.368	0	1
_Other shocks	243	.173	.379	0	1
_Reduction / fall in the price of products sold by the household	243	.14	.348	0	1
_Death of an asset	243	.045	.208	0	1
_Death of an active	243	.025	.156	0	1
_Animal damage	243	.016	.128	0	1
_Higher food prices	243	.049	.217	0	1
_ Floods	243	.008	.091	0	1
_Insecurity	243	.008	.091	0	1
_Insect invasion. Pests / seed-eating birds	243	.004	.064	0	1
_Sickness / accident of a member of the household	243	.07	.256	0	1
_Disease / death of animals (large livestock)	243	.012	.111	0	1
_Disease / death of animals (small livestock)	243	.008	.091	0	1
_Loss of employment or unemployment of a member of the household	243	.066	.249	0	1
_Loss of harvest due to animal disease / insect invasion	243	.025	.156	0	1
_Pluies out of season	243	.029	.168	0	1
_Insufficient fluids	243	.004	.064	0	1
_Rain prolongation beyond the normal period	243	.008	.091	0	1
_Rarefaction of fishery resources	243	.074	.262	0	1
_Theft of property or animals	243	.004	.064	0	1