Rainfall shocks and intra-annual food insecurity in Uganda: insights from a high-frequency phone survey

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1. Introduction

There has been an increase in the frequency and intensity of climate change induced weather shocks with severe negative consequences for household food security across many countries in Africa including Uganda (Kubik and May, 2018, World Meteorological Organization, 2020). Moreover, in the case of Uganda, studies have shown significant changes in the starting month and length of rain seasons in recent years, and these are projected to increase in the next decades (Mubiru et al., 2018, Nsubuga and Rautenbach, 2018). This in turn has added more volatility to agricultural production thereby directly affecting food security from an availability angle. Yet most studies that have tried to shed light on the impact of these shocks on household food security have been conducted on an annual level, exploring year-to-year changes on account of using traditional annual household surveys. This inevitably means that they fail to show the intra-annual or within-season impacts of these shocks. Thus, a month-to-month data is more appropriate to understand the changes in household food security in the context of rainfall shocks.

While several prior studies exploited high frequency phone surveys to analyze food security, these mostly provided insights into household food security in the context of shocks such as COVID-19 (Gourlay et al., 2021, Agamile, 2022, Dasgupta and Robinson, 2022, Semakula et al. 2024) and conflict (Bauer et al., 2013, Enenkel et al., 2015, Morrow et al., 2016). Relatedly, high frequency phone survey data has also been exploited to study household resilience in the horn of Africa (Knippenberg et al., 2019, Jones and Ballon et al., 2020). Despite the increasing frequency and intensity of climate change induced weather shocks, having almost year-round impacts on communities similar to disease epidemics or conflict shocks, high frequency phone surveys have not been exploited to understand their intra-annual impacts. We address this gap by using the Uganda HFPS to analyze the impact of rainfall shocks on household food security and within this lies our main contribution to the literature on food security.

Specifically, using the Uganda High Frequency Phone Survey data which captures household food insecurity experience in the previous month, across the calendar year, we estimate the impact of rainfall shocks on intra-seasonal household food security using a two-way fixed effects

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methodology with fixed effects at the household and month levels. Our results show that experiencing a flood (in the month of the survey) increases the probability of experiencing severe food insecurity (in the last 30 days) by 3.5 percentage points and moderate food insecurity by 4.4 percentage points, but experiencing a drought is not significantly correlated with severe or moderate food insecurity. Moreover, we observe not only a change in the start and length of rainy and dry seasons, but that 1.5% of households experienced a drought during the traditional rainy season (while 11.4% experienced a drought during the dry season) and 7.8% of households experienced a flood during the traditional dry season (while 9.5% experienced a flood during the rainy season). When we take into account the occurrence of a flood or a drought during the season when they are expected, we find that it is negatively correlated with both moderate and food insecurity. We interpret these results as adaptation to climate change. In other words, when floods or droughts occur during the months when they are expected, households can mitigate their negative impacts, but when they happen during other times of the year households have a harder time to prepare for them, affecting more their food security.

The rest of the paper is organized as follows. Section 2 presents a brief review of the existing literature on temporal variation of food insecurity in Sub Saharan Africa. Section 3 describes both the household and rainfall data we use including the key variables and their definitions. Section 4 describes the estimation strategy. Section 5 presents both the descriptive and regression results. Section 6 concludes the paper.

2. Existing literature

The temporal examination of food insecurity has been the subject of intense study in the food security literature. While there is a lot of heterogeneity in the time scales examined, most of these studies have examined variation in food insecurity incidences either at an annual or inter-seasonal level, i.e., variation between lean season and when harvests come in. For example, in a study focused on rural Ethiopia, Sibhatu and Qaim, (2017) document the seasonal variation in household food security from an access point of view highlighting the changing importance of households' subsistence and market sources in different seasons. In another study, focused on rural Ethiopia, Roba et al. (2019) show that seasonal variation in food availability and access negatively affected household food security and dietary diversity with maternal and child nutrition suffering the most. Mezgebe et al. (2024) reported similar results indicating a pattern of seasonal variation in incidences of food insecurity in rural Ethiopia with particularly negative impacts on women. These negative inter-seasonal variations in food insecurity incidences have not only been reported in Ethiopia. Several studies (Devereux, 2009, Kaminski et al., 2014) have argued that the problem of seasonal food insecurity is widespread across Africa. Much of the longer time scales analyzed in the prior studies could be attributed to data limitations, i.e., their use of traditional household survey data that tend to be conducted on an annual basis, and in a given period of the year.

While prior studies offer interesting insights on the temporal dimension of food insecurity, the focus on annual or inter-seasonal variation is increasingly becoming insufficient given the rapidly changing patterns of seasons across many countries in sub–Saharan Africa. For example, Kotir (2011) in a review showed that there are already significant changes in seasonal rainfall amounts and patterns across Africa. In other studies, focused on southern African countries, intra-seasonal changes in the frequency of rainy days have also been reported (Tadross et al. 2009, Thomas et al. 2011). Relatedly Boansi et al., (2019), Tore et al., (2021) and Adimassu et al., (2023) in their respective studies also document intra-seasonal changes especially in rainfall patterns in West Africa. This volatility in seasons needs an examination of food insecurity at much shorter time intervals and this is where the major contribution of this study lies.

3. Data

3.1 Household Data and key variables

We use 17 rounds of the Uganda High Frequency Phone Survey (HFPS) data collected between June 2020 and February 2024. The HFPS is part of the high frequency phone surveys conducted by the World Bank's Living Standards Measurement Study (LSMS) across six countries in Africa including Uganda. The households in the sample were selected from among the households in the 2019/202 wave of the Uganda National Panel Survey (UNPS) that reported an active phone number. The UNPS is an annual survey and is also part of the World Bank's LSMS - Integrated Survey on Agriculture. Both the HFPS and the UNPS data are collected by the Uganda Bureau of Statistics (UBOS). The monthly intervals of data collection of the Uganda HFPS make it a unique dataset for our analysis that seeks to examine intra-annual variation in food insecurity.

The HFPS collects information on multiple modules, which have been changing according to different interests the countries had after the beginning of the COVID-19 pandemic. One of the modules the HFPS has collected in all rounds, for Uganda, is the Food Insecurity Experience Scale (FIES) module, which asks the eight binary questions[3] suggested by the Food and Agriculture Organization (FAO) to assess the level of food insecurity at household or individual level. This is

[3] The questions were framed as follows in the instrument. During the last 30 days, was there a time when: 1. You or others in your household were worried about not having enough food to eat because of lack of money or other resources? 2. You, or others in your household, were unable to eat healthy and nutritious/preferred foods because of a lack of money or other resources? 3. You, or others in your household, ate only a few kinds of foods because of a lack of money or other resources? 4. You, or others in your household, had to skip a meal because there was not enough money or other resources to get food? 5. You, or others in your household, ate less than you thought you should because of a lack of money or other resources? 6. You or others in your household ran out of food because of a lack of money or other resources? 7. You, or others in your household, were hungry but did not eat because there was not enough money or other resources for food? 8. You, or others in your household, went without eating for a whole day because of a lack of money or other resources?

the main variable we use in our analysis. Based on the frequency of the different food insecurity experiences on the FIES reported by households, we define two dummy household food insecurity variables: moderate and severe food insecurity for our analysis. In addition to the moderate and severe food insecurity variables, we also use house demographic and geographic characteristics.

3.2 Rainfall Data and shock definition

To construct the rainfall shock (drought and flood) variables, we use 0.05°resolution monthly rainfall data from the Climate Hazards Group InfraRed Precipitation with Station data (CHIRPS) (Funk et al. 2014) merged with the HFPS at the sub-county level and interview month, i.e., we average rainfall data at the sub-county level weighting by sub-county area. Thus, we construct drought and flood variables at the sub-county level. Specifically, we construct the rainfall z-score, with respect to the long-run rainfall mean and standard deviation, for each sub-county and each month of the survey. We define drought and flood as dummy variables which take the value of one if rainfall z-score is below -1.5 and above 1.5 respectively and zero otherwise.

4. Estimation strategy

To approach the relationship between the occurrence of rainfall shocks (droughts and floods) and food insecurity (severe and moderate), we use a two-way fixed effects (TWFE) model, with time (month-year) fixed effects and household fixed effects, for an unbalanced panel of 2,475 households, observed over 25 different months between June 2020 and December 2023, amounting to a total of 24,215 observations. Thus, we estimate the following equation:

$$Y_{it} = \alpha + \beta_l Rainfall\ Shock_{st} + \beta_l X_i + \gamma_i + \theta_t + \varepsilon_{it}$$

where Y_{it} denotes the experience of severe or moderate food insecurity in the last 30 days by household i in month-year (of the survey) t; $Rainfall\ Shock_{st}$ denotes the occurrence of a drought or a flood in sub-county s in month-year t; X_i is a vector of covariates that indicates whether the household is in a rural area and the region where the household is located (Central, Eastern, and Western); γ_i represented the household fixed effects; θ_t are the month-year fixed effects; and ε_{it} is the remaining error.

5. Results

5.1 Descriptive statistics

Panel A in Table 1 shows the experience of food insecurity for each one of the eight FIES questions and it also summarizes them into moderate and severe food insecurity, in the last 30 days. Severe food insecurity experience is measured as answering “yes” to “was hungry but did not eat” or to “went without eating for a whole day”. Moderate food insecurity is measured as answering “yes” to “their household ran out of food”, to “ate less than they thought they should”, to “had to skip a meal”, to “was hungry but did not eat” or to “went without eating for a whole day”. According to the HFPS, in the last 30 days, on average, 53.5% of Ugandans declared to be unable to eat healthy and nutritious food, and 53.7% declared to have eaten only a few kinds of foods. Furthermore, 41.7% of Ugandans experienced moderate food insecurity and 20.8% experienced severe food insecurity, in the last 30 days, on average between 2020 and 2023 (see Panel A in Table 1) but these averages show very different levels per month and not a clear seasonal pattern (see Figure 1 and Figure 2).

Panel C in Table 1 shows that 54.7% of the households in our sample were interviewed during the traditional rainy season months (according to FEWS-NET), 75.1% live in rural areas, and that the interviewed households are very evenly divided between the Northern, Central, Eastern, and Western regions.

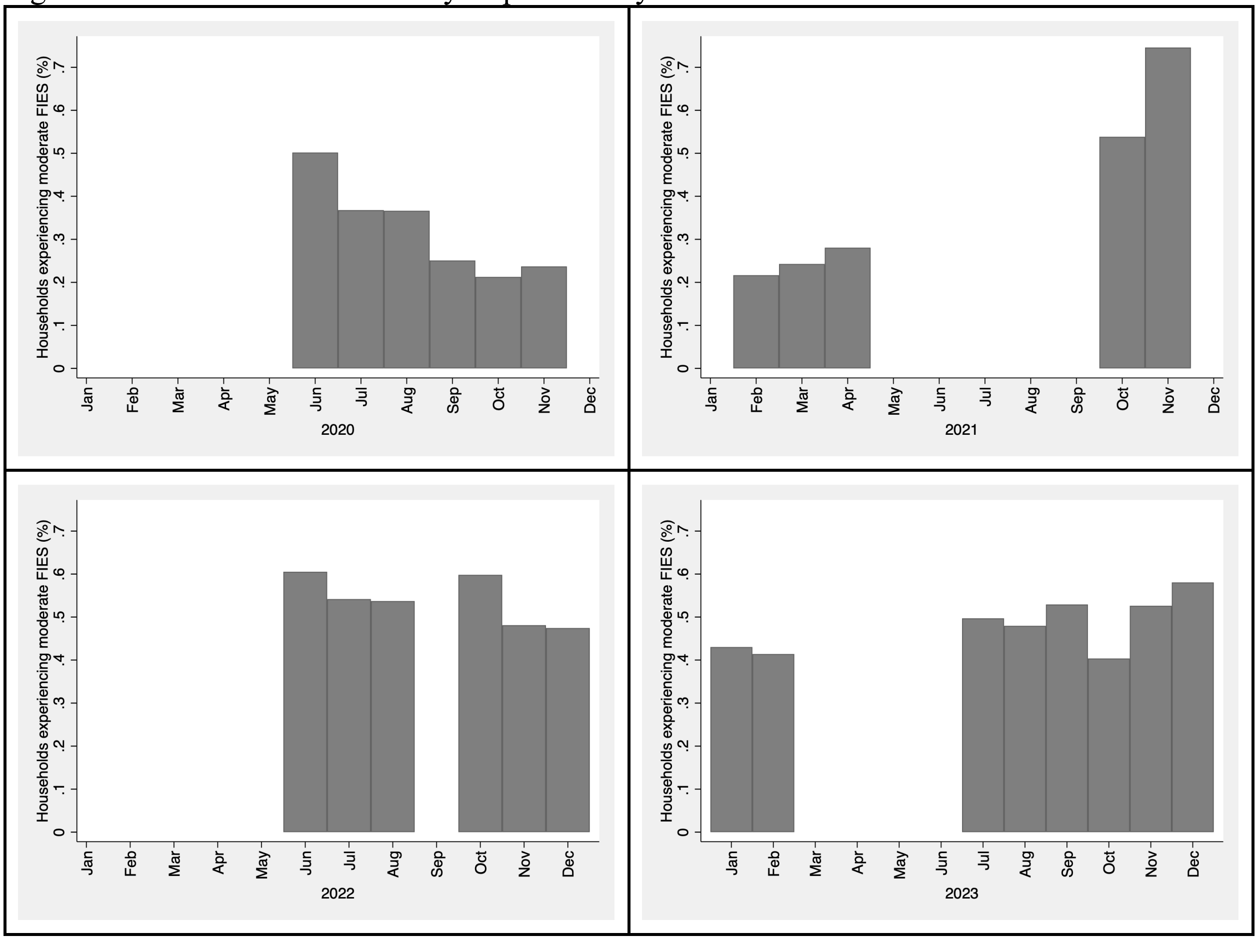
Table 1. Descriptive Statistics

	(1)	(2)
Variables	Mean	Std. Dev
Panel A. Food Insecurity		
In the last 30 days, was worried they would not have enough food to eat (=1)	0.490	0.500
In the last 30 days, was unable to eat healthy and nutritious food (=1)	0.535	0.499
In the last 30 days, ate only a few kinds of foods (=1)	0.537	0.499
In the last 30 days, had to skip a meal (=1)	0.288	0.453
In the last 30 days, ate less than they thought they should (=1)	0.367	0.482
In the last 30 days, their household ran out of food (=1)	0.199	0.399
In the last 30 days, was hungry but did not eat (=1)	0.202	0.401
In the last 30 days, went without eating for a whole day (=1)	0.089	0.285
Experienced moderate food insecurity in the last 30 days (=1)	0.417	0.493
Experienced severe food insecurity in the last 30 days (=1)	0.208	0.406

Panel B. Rainfall		
Sub-county rainfall z-score in current month	0.070	1.180
Sub-county rainfall z-score in previous month	-0.014	0.980
Sub-county rainfall z-score two months ago	0.139	1.060
Sub-county rainfall z-score three-month-average	0.065	0.768
Sub-county experienced a flood in current month (=1)	0.087	0.282
Sub-county experienced a flood in previous month (=1)	0.055	0.227
Sub-county experienced a flood two months ago (=1)	0.096	0.294
Sub-county experienced a flood in the last three months (=1)	0.219	0.413
Sub-county experienced a drought in current month (=1)	0.060	0.237
Sub-county experienced a drought in previous month (=1)	0.061	0.239
Sub-county experienced a drought two months ago (=1)	0.043	0.202
Sub-county experienced a drought in the last three months (=1)	0.139	0.345
Panel C. Covariates		
Rainy season (=1)	0.547	0.498
Lives in rural area (=1)	0.751	0.432
Northern (=1)	0.246	0.431
Central (=1)	0.274	0.446
Eastern (=1)	0.252	0.434
Western (=1)	0.228	0.420
Households	2,475	
Observations	24,215	

Source: Uganda HFPS (rounds 1-17, 2020-2023) and CHIRPS. Authors' calculations.

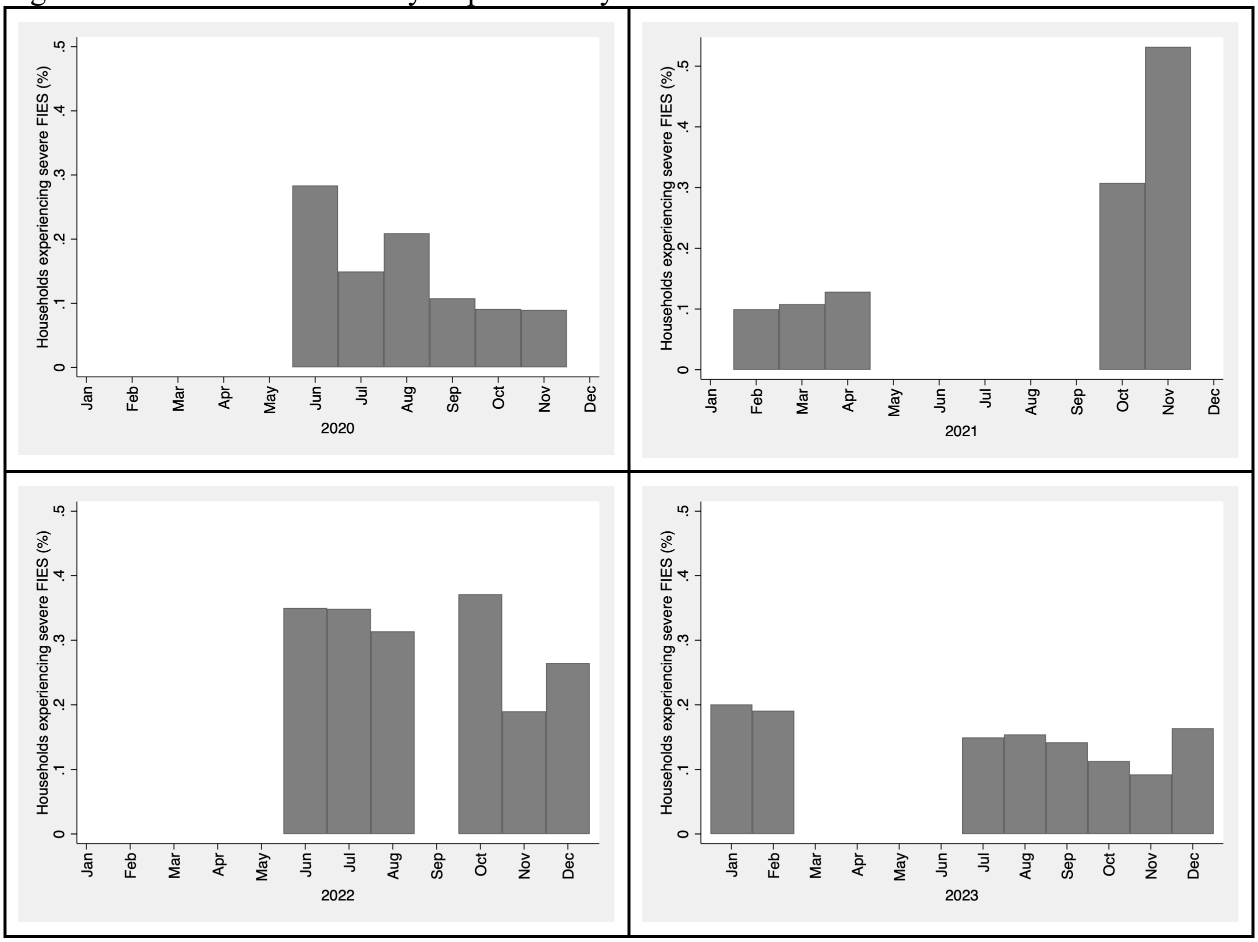
Figure 1. Moderate Food Insecurity Experience by Month and Year



Source: Uganda HFPS (rounds 1-17, 2020-2023). Note: The months where no bars are presented correspond to months with very few or no observations and are not included in the study sample.

Panel B in Table 1 shows that the average rainfall z-score was 0.07, indicating that, in the period of analysis, households in Uganda have experienced more rainfall than the long-run average. Similarly, 8.7% of households were in sub-counties that experienced a flood in the month of the survey. Meanwhile, 6.1% of households were in sub-counties that experienced a drought in the month of the survey. Moreover, we observe that 1.5% of households experienced a drought during the traditional rainy season (while 11.4% experienced a drought during the dry season) and 7.8% of households experienced a flood during the traditional dry season (while 9.5% experienced a flood during the rainy season).

Figure 2. Severe Food Insecurity Experience by Month and Year



Source: Uganda HFPS (rounds 1-17, 2020-2023). Note: The months where no bars are presented correspond to months with very few or no observations and are not included in the study sample.

5.2 Regression results

Table 2 shows the relationship between rainfall shocks and severe food insecurity. Column (1) estimates the relationship between a drought occurrence and severe food insecurity, controlling for being in the traditional dry season. Similarly, column (2) estimates the relationship between a flood occurrence and severe food insecurity, controlling for being in the traditional rainy season. Our results show the relationship between droughts and severe food insecurity is not statistically significant at conventional levels, and that the occurrence of a flood is correlated with an increase of 3.5 percentage points in the probability of experiencing severe food insecurity. Column (3) adds to the specification in column (1) an interaction between a drought occurrence and being in the dry season, i.e., the interaction indicates whether the drought occurred when it was traditionally expected. Similarly, column (4) adds to the specification in column (2) the interaction between a flood occurrence and being in the rainy season. The specification in column (3) shows no significant additional impact of the interaction term. Nonetheless, the results in column (4) show that experiencing a flood during the rainy season decreases the probability of experiencing severe food insecurity, by 8.2 percentage points, while a flood occurrence is positively correlated with severe food insecurity experience.

Table 3 shows the same four specifications shown in Table 2 but using moderate food insecure experience as the outcome variable. Specification (1) shows again a statistically insignificant relationship between drought occurrence and the experience of moderate food insecurity. However, when including the interaction term (a drought occurring during the dry season), specification (3) shows a drought is correlated with a 11.4 percentage point increase in the probability of experiencing moderate food insecurity, while experiencing the drought during the dry season decreases the probability of moderate food insecurity by 10.4 percentage points. Similar to Table 2, the results in column (2) show a flood occurrence is correlated with an increase of 4.4. percentage points in the probability of experiencing moderate food insecurity in the last 30 days. Also, the results in column (4) show that experiencing a flood during the rainy season decreases the probability of experiencing moderate food insecurity by 6.5 percentage points.

Table 2. Relationship between Rainfall Shocks and Severe Food Insecurity

Variables	(1)	(2)	(3)	(4)
	Experienced severe food insecurity in the last 30 days (=1)			
Sub-county experienced a drought in current month (=1)	-0.008		0.030	
	(0.013)		(0.035)	
Dry season (=1)	0.042*		0.042*	
	(0.024)		(0.024)	
Sub-county experienced a drought in current month and during the Dry season (=1)			-0.045	
			(0.037)	
Sub-county experienced a flood in current month (=1)		0.035***		0.080***
		(0.010)		(0.017)
Rainy season (=1)		-0.046*		-0.040*
		(0.024)		(0.024)
Sub-county experienced a flood in current month and during the Rainy season (=1)				-0.082***
				(0.020)
Constant	0.213**	0.260***	0.213**	0.256***
	(0.090)	(0.094)	(0.090)	(0.094)
Observations	24,215	24,215	24,215	24,215
R-squared	0.076	0.076	0.076	0.077
Number of households	2,475	2,475	2,475	2,475

Notes: All regressions include month-year fixed effects and control for living in rural areas (=1) and region (Central, Eastern, and Western). Clustered standard errors at the household level in parentheses. *** p<0.01, ** p<0.05, * p<0.1

Table 3. Relationship between Rainfall Shocks and Moderate Food Insecurity

Variables	(1)	(2)	(3)	(4)
	Experienced moderate food insecurity in the last 30 days (=1)			
Sub-county experienced a drought in current month (=1)	0.028*		0.114***	
	(0.015)		(0.037)	
Dry season (=1)	-0.079***		-0.078***	
	(0.018)		(0.018)	
Sub-county experienced a drought in current month and during the Dry season (=1)			-0.104**	
			(0.041)	
Sub-county experienced a flood in current month (=1)		0.044***		0.080***
		(0.011)		(0.018)
Rainy season (=1)		0.069***		0.074***
		(0.018)		(0.018)
Sub-county experienced a flood in current month and during the Rainy season (=1)				-0.065***
				(0.024)
Constant	0.541***	0.473***	0.541***	0.470***
	(0.119)	(0.120)	(0.118)	(0.120)
Observations	24,215	24,215	24,215	24,215
R-squared	0.102	0.103	0.103	0.103
Number of households	2,475	2,475	2,475	2,475

Notes: All regressions include month-year fixed effects and control for living in rural areas (=1) and region (Central, Eastern, and Western). Clustered standard errors at the household level in parentheses. *** p<0.01, ** p<0.05, * p<0.1

6. Conclusion

Food insecurity continues to be an endemic challenge affecting millions of households especially in low-income countries. This has been particularly pronounced in sub-Saharan Africa in rural areas where most households practice small-scale agriculture dependent on natural rains (FAO et al., 2024). With the changing agricultural seasons that have been reported, understanding across the calendar when households likely experience food security is critical to the design of relevant interventions to mitigate it. While several studies have examined the temporal variation of food insecurity before, these have mostly been limited to annual or inter-seasonal time scales. Using a high frequency phone survey data collected at monthly intervals, we examine the impact of rainfall shocks on intra-seasonal variation of household food insecurity in Uganda. Our results suggest that if a rainfall shock occurs when it is expected, i.e., a drought during the dry season, or a flood during the rainy season, households can mitigate their impacts on food security. However, if the rainfall shocks occur outside the expected window, food insecurity seems more affected. Furthermore, our results show households adapt to climate change but the occurrence of rainfall shocks outside the periods when they are expected makes adaptation harder, resulting in worse levels of food security, even more when floods occur, an event that is becoming more common due to global warming. These results provide interesting insights that can be used to inform the design of public policies to mitigate the impacts of rainfall shocks on household food security by targeting interventions when households are least prepared i.e. when the shock is least expected.

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