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Livestock diversification mitigates the impact of farmer-herder conflicts on animal-source foods consumption in Nigeria

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ABSTRACT

The escalation of farmer-herder conflicts poses a threat to agricultural production and livelihood outcomes in Nigeria. However, households with adaptive capacity may mitigate the negative impact of these conflicts on nutritious food consumption. In this study, we examine the impact of farmer-herder conflicts on animal-source foods (ASF) consumption and investigate the extent to which livestock diversification can serve as a mitigating factor. Using panel household data from Nigeria with a global georeferenced conflict dataset, we employ fixed-effects regression models to understand a causal relationship. Our findings reveal that exposure to farmer-herder conflicts reduces the quantity of ASF consumed and increases the number of days households exclude ASF from their diets. Additionally, we establish the role livestock diversification plays in mitigating the impacts of farmer-herder conflicts on ASF consumption. This evidence provides policymakers and practitioners with potential strategies for building nutrition resilience in locations that are exposed to farmer-herder conflicts. Promoting conflict-sensitive livestock production systems, such as cattle ranching, can be a strategy for sustaining nutrition and peacebuilding in Nigeria and countries in similar conflict situations.

1. Introduction

The global nutrition landscape has shown gradual improvement, largely due to the commitments outlined in the Sustainable Development Goals 2030 (FAO et al., 2019). However, the developing world faces a significant decline in food consumption and nutrition quality, with climate change, the recent Covid-19 pandemic, and conflicts acting as contributing factors. These challenges have particularly affected countries with limited resilience capacity (Brück et al., 2019a). Of concern is the fact that conflict-affected nations are home to approximately 75 % of the world's malnourished children, with a notable concentration in Africa (Reyes et al., 2021; FAO et al., 2019). The region has experienced a stagnation in improving nutrition indicators, especially concerning child stunting and anemia in women of reproductive age, since 2015 (Micha et al., 2020). This concerning regression in nutrition indicators underscores the adverse effects of escalating conflict situations in Africa (Raleigh, 2019).

In recent years, the escalation in conflicts between settled farmers and nomadic herders in sub-Saharan Africa, primarily driven by competition for limited land and water resources, has gained considerable attention (Brottem, 2021). The emerging body of literature highlights the damaging effects of farmer-herder conflicts on agricultural and food systems. Some empirical studies have also begun to investigate the impact of these conflicts on agricultural production (George et al., 2021), food security (Nnaji et al., 2022), and overall household well-being (Kaila and Azad, 2019). The findings from these studies are important in quantifying the negative consequences of farmer-herder conflicts on food security and nutrition. However, it is important to note that these studies have limited scope in informing policy decisions regarding the nutritional needs of affected households, a research gap that is also evident in studies examining conflicts perpetrated by other actors (Baliki et al., 2018; George et al., 2020).

In a broader view of armed conflicts, only a few studies have analysed conflict impacts on such indicators as dietary diversity, which is a valuable measure of household food security and nutrition (see Baliki et al., 2018; Brück et al. 2019a; Dabalen and Paul, 2014; George et al., 2020; Tranchant et al., 2021). However, it may be more relevant to assess the effect of conflict on nutrition indicators like animal-source foods (ASF) consumption for nutrition-focused interventions, particularly in the context of farmer-herder conflicts. Also relevant in this

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context is the nutritional importance of small-scale livestock production in improving household ASF consumption in many countries in Africa (Kumar et al., 2015).

ASF contains the best micronutrients needed by women of reproductive age and for the child's optimal growth from conception to second year birthday (FAO, 2023). Limited intakes of micronutrients have long-term negative consequences for the child's cognitive development (Black, 2003). Hence, evidence from this study will throw light on the depth of nutritional deprivation for women and children in conflict situations and accentuate ASF as an essential pathway linking conflict to poor child health outcomes (Bageant et al., 2016; Kim, 2019; Le & Nguyen, 2020; Acharya et al., 2020).

Furthermore, the existing literature on the connection between conflict and food security is limited in terms of providing evidence-based strategies for mitigating the impact of conflict on food security and nutrition. More importantly, there is a lack of understanding regarding the role of livestock diversification, an adaptive strategy, in this context. It is crucial to develop this evidence in order to enhance policy for conflict mitigation, food security, and nutrition resilience. Considering these identified research gaps, our study focuses on Nigeria, a country with the highest number of fatalities resulting from farmer-herder conflicts globally (Brottem, 2021), and facing significant challenges related to nutrition among women and children (FAO et al., 2019; Micha et al., 2020). Our study aims to examine the influence of farmer-herder conflicts on ASF consumption, while also exploring the mitigating impact of livestock diversification.

Understanding the relationship under investigation in this study holds significant importance for several reasons. Firstly, conflict actors are driven differently, and their impact on various well-being indicators, including food security and nutrition, may vary by the perpetrators (Kaila and Azad, 2019). Secondly, the rise in farmer-herder conflicts can disproportionately affect livestock-holding households (see Fadare et al., 2022; George et al., 2021) and disrupt the animal-source food systems. Consequently, this may increase the number of days households exclude ASF from their food basket. Lastly, evidence from around the developing world has shown that livestock diversification can enhance food security and nutrition resilience (Khonje et al., 2022; Kray et al., 2018), and it is crucial to examine this evidence within conflict contexts. This study aims to provide evidence to further support the existing studies that have suggested livestock diversification as an adaptive strategy in conflict situations (see Fadare et al., 2022).

Empirically investigating the impact of conflicts on food security and nutrition poses significant methodological challenges in establishing causal effects (Brück et al., 2019b). More importantly, when cross-sectional data are employed for analysis (e.g., Dabalen and Paul, 2014; Nnaji et al., 2022). Such analysis has limitations in adequately accounting for household-level heterogeneity, which complicates policy recommendations (Martin-Shields and Stojetz, 2019). Our study addresses these challenges through several approaches. To begin, we utilise a nationally representative household panel dataset that incorporates global georeferenced conflict data, covering the period from 2010 to 2016. The data were collected seasonally, allowing us to explore the seasonality dimension in our analysis. Then, we adopted a quasi-experimental research design, fixed-effects, difference-in-differences (DiD), and event study estimators, to understand the causal relationship between farmer-herder conflicts and ASF consumption, and to assess the mitigating effect of livestock diversification.

Our study establishes a causal relationship between farmer-herder conflicts and ASF consumption, as measured by the amount of ASF consumed and the number of days households exclude ASF from their diets (i.e., the number of days households rely on less-preferred foods and limit the variety of food eaten) as coping strategies. Specifically, our findings reveal that with each additional conflict event, there is a decrease of 1.9 g per day per adult equivalent (g/day/aeq) in ASF consumption. While for an average household affected by farmer-herder conflicts, this reduction can reach as high as 14.8 g/day/aeq. Moreover, households increase the number of days they exclude ASF from their food basket as coping strategies by up to 0.28. Additionally, the findings demonstrate that livestock diversification significantly mitigates the impact of farmer-herder conflicts on ASF consumption, increasing it by 27 g/day/aeq. Seasonality plays a moderating role in this relationship, with post-harvest season intensifying the adverse effect of the conflicts. Hence, these results indicate that conflict-exposed households with limited livestock diversification are likely to face year-round risks of chronic undernutrition and micronutrient deficiencies. This is attributed to a diminished food supply during the post-planting season and escalated conflict in the post-harvest season, which disrupts expected harvests.

This study holds significant implications for food and nutrition policy, conflict prevention, and peacebuilding. It deviates from previous studies by providing evidence of the nutritional consequences of farmer-herder conflicts and emphasises the importance of livestock diversification in mitigating such effects. The findings can inform strategic humanitarian response and policies for enhancing food and nutrition resilience in conflict-prone locations. The study emphasises the necessity for the government to address climate-induced factors leading to farmer-herder conflicts by promoting conflict-sensitive agricultural and livestock practices, such as irrigation and cattle ranching. Finally, the study emphasises livestock diversification as a critical pathway to building nutritional resilience in Nigeria and countries in similar conflict situations.

2. Background

2.1. Livestock diversification and household nutrition in shock situations

Agricultural production is increasingly vulnerable to covariate shocks such as conflict (Adelaja and George, 2019; Kaila and Azad, 2019) and extreme weather events (Sewando et al., 2016). However, empirical evidence indicates that agricultural households in developing countries often adapt to these shocks by diversifying their agricultural production (Arslan et al., 2018) as a risk mitigation strategy to stabilise income and ensure food consumption and nutrition security (Ngigi et al., 2021). In such circumstances, households may opt for various forms of diversification, including crop-livestock diversification (Mortimore and Adams, 2001), crop diversification (Paul et al., 2015), or diversification of livestock species production (Fadare et al., 2022). While conflict-affected households may be inclined to diversify their livestock towards less vulnerable species, crop diversification can present challenges due to the increased risk of attacks, as demonstrated in the study by Paul et al. (2015), which highlights the risks associated with crop diversification in a militia-controlled land context in Cote d'Ivoire.

Studies conducted in African countries have shown that agricultural diversification can have a positive impact on children's nutritional status through the consumption of diverse diets (e.g., Kumar et al., 2015). Most research linking agricultural diversification to food security and nutrition focuses on climate shock mitigation or does not specify a particular context (Kumar et al., 2015). Nonetheless, these studies provide valuable insights into the effects of agricultural diversification on household food security and nutrition within specific settings. While there is consistent evidence supporting the positive impact of livestock diversification or crop-livestock diversification on food security and nutrition, the evidence regarding crop diversification is inconclusive. The study by Kray et al. (2018) suggests that the impact of crop diversification on nutrition lacks conclusive evidence, unless it is integrated with livestock diversification.

In a recent study conducted by Habtemariam et al. (2021) in Tanzania, only crop-livestock diversification demonstrated a significant relationship with dietary diversity, while crop diversification alone did not. Similar findings were observed in a study by Paul et al. (2015), where no statistically significant relationship between crop diversification and dietary diversity was found in a conflict-affected situation. In

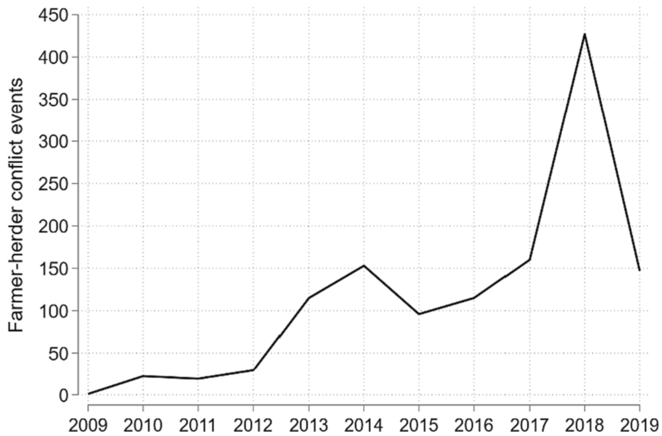

Fig. 1. The trend in farmer-herder conflict events in Nigeria from 2009 to 2019 **Source:** Authors' analysis from ACLED (2009–2019). Data available at www.acleddata.com.

the context of seasonality in Afghanistan, Zanello et al. (2019) found that market access improved dietary diversity during the lean season. However, livestock diversification increased dietary diversity in both the lean and regular seasons, while crop diversification only enhanced dietary diversity during the regular season. Likewise, Ayenew et al. (2018) in Nigeria revealed that crop-livestock diversification only increased dietary diversity during the post-harvest season and not the post-planting season. These findings collectively suggest that seasonal shocks have significant effects on food security and nutrition.

2.2. Farmer-herder conflicts development in sub-Saharan Africa

Conflicts between farmers and herders have long troubled various parts of Africa, as extensively documented in studies like those by Brottem (2021), and Penu and Paalo (2021). These conflicts are primarily driven by demographic and environmental changes, exacerbating tensions between nomadic herders and settled farmers as they vie for access and utilisation of land, pastures, and water resources (Brottem, 2016). Encroachment on traditional rangelands and trespassing incidents frequently serve as catalysts for these disputes, resulting in severe consequences for all involved parties (Krätli and Toulmin, 2020). In recent years, the complexity and intensity of farmer-herder conflicts have notably increased, resulting in a distressing upsurge in violence, numerous fatalities, and significant population displacement (ICG, 2018).

A recent study by Brottem (2021) highlighted several factors that contribute to heightened tensions between farmers and herders in West and Central Africa, including population growth, climate change, and the proliferation of small arms. Desertification and other environmental factors have led to the degradation of grazing lands, scarcity of land and water resources in the Sahel, compelling herders to migrate southwards in search of pastureland (IOM, 2021; Toulmin, 2020). In addition, ethnic and religious differences have been argued to play a significant role in fuelling these conflicts (Shettima and Tar, 2008; Nwankwo, 2021). The lack of effective government policies, weak institutions, and corruption also contribute to the crisis (Krätli and Toulmin, 2020). Consequently, farmer-herder conflicts in Africa have transformed from a simple competition for resources to a complex crisis driven by a range of factors.

In Nigeria, the intricacies of farmer-herder conflicts are amplified by a mix of demographic, environmental, ethnoreligious, and political

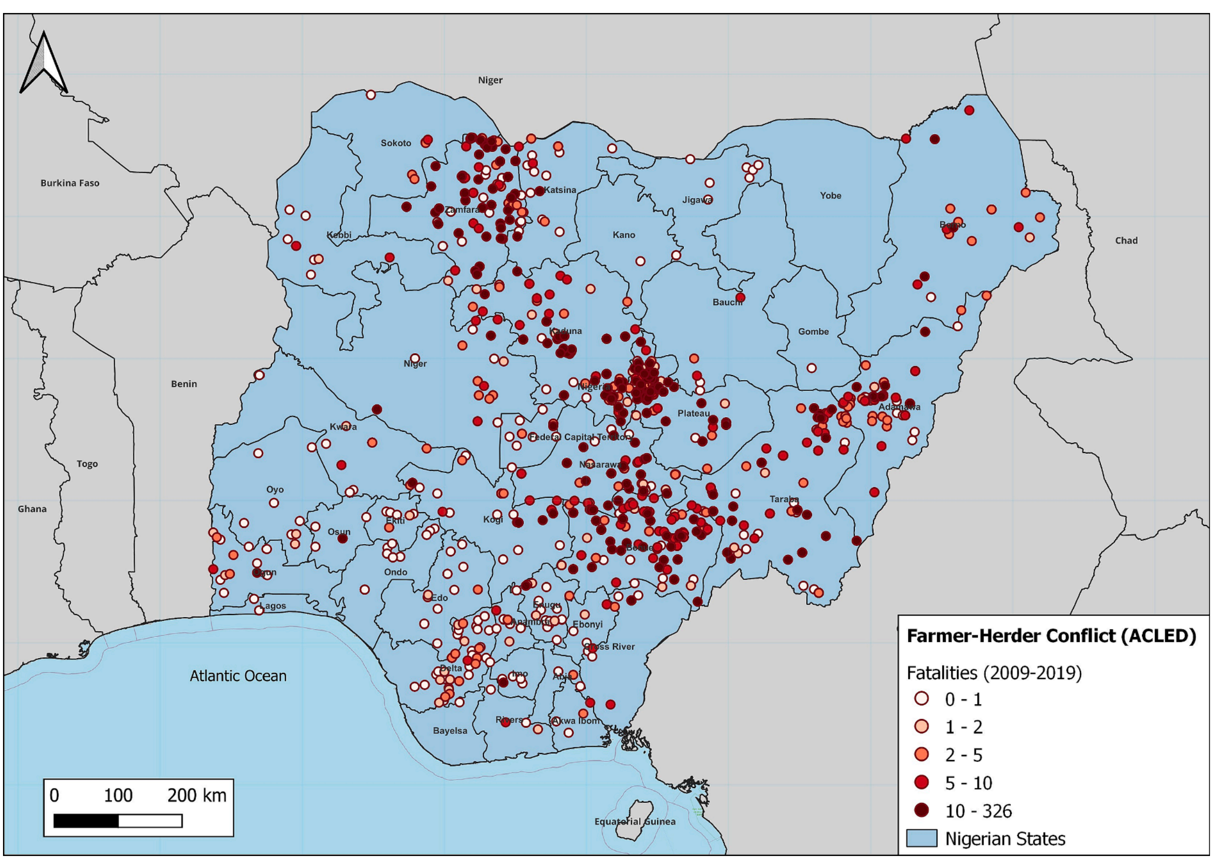

Fig. 2. Farmer-herder conflict events spots and fatalities across Nigerian States from 2009 to 2019. **Source:** Authors' analysis from ACLED (2009–2019). Data available at www.acleddata.com.

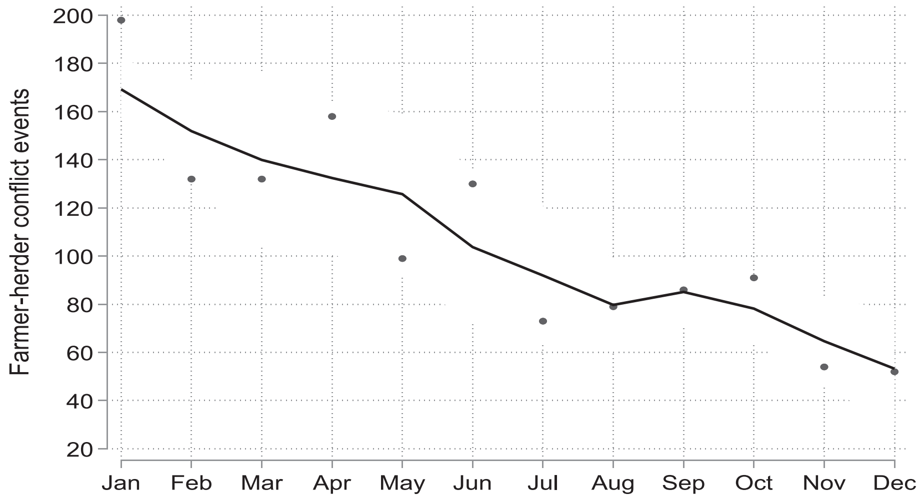

Fig. 3. Farmer-herder conflict events in Nigeria by months. The grey region represents 95% confident intervals. **Source:** Authors' analysis from ACLED (January 2009 to December 2019). Data available at www.acleddata.com.

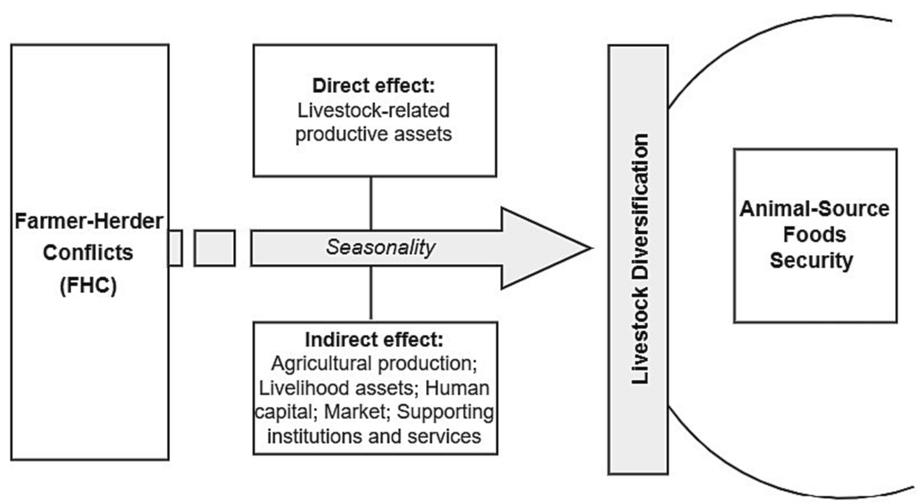

Fig. 4. Conceptual framework linking farmer-herder conflicts, livestock diversification, and animal-source foods security.***Source***: Authors' depiction.

elements. The migrant herders are mostly of the Fulani ethnicity and practice Islam, contrasting with the largely Hausa Muslim farmers in the North and the ethnically diverse, predominantly Christian farmers in the South and Middle-belt regions (Ajala, 2020). Challenges such as the ongoing insurgency in the North-East, heightened banditry in the North-West, and extreme climatic conditions have driven herders southward (United Nations, 2021). Groups like Boko Haram further aggravate these conflicts, amplifying the negative effects of droughts, natural disasters, and heightened temperatures on herding (George et al., 2022). Furthermore, climate change has been pushing herders to the South due to worsening environmental conditions in the North (Madu and Nwankwo, 2021).

The frequency of farmer-herder conflicts in Nigeria has shown a significant increase over the years, peaking at more than 425 incidents in 2018 alone (Fig. 1), leading to over 2,700 deaths (Brottem, 2021). This death toll surpassed the casualties from Boko Haram attacks in the same year. From 2009 to 2018, the total deaths from such conflicts exceeded 10,000 (Pinaud, 2019). Notably, farmer-herder conflicts events, although relatively fewer, are associated with higher fatalities than recent Boko Haram attacks (Chiluwa and Chiluwa, 2022). These conflicts span the North-Western and Southern regions but are particularly dense in the North-Central region, characterised by its majority Christian population and diverse ethnicities (see Fig. 2).

Furthermore, the escalation of farmer-herder conflicts in Nigeria can be partly attributed to the government's failure to review land policies and strengthen land institutions to develop climate-sensitive land tenure policies (Ugwueze et al., 2022; Apeh et al., 2021). Also, attempts to reduce farmer-herder conflicts seemed not to be informed by evidence-based conflict analysis and strategic planning. For instance, the introduction of anti-open grazing laws in some Nigerian states in 2017–18 aimed to alleviate the conflict but instead led to an increase in conflicts in 2018 as herding activities shifted to neighbouring southern states (ICG, 2018). Even though some states suspended these laws, violence continued to surge as other southern governments enacted laws against open grazing (ICG, 2018).

3. Conceptual framework

The interplay between extreme climate events and conflict can significantly exacerbate the vulnerability of food consumption for agricultural households. Unlike other violent conflict events, farmer-herder conflicts exhibit a distinct seasonality, which aligns closely

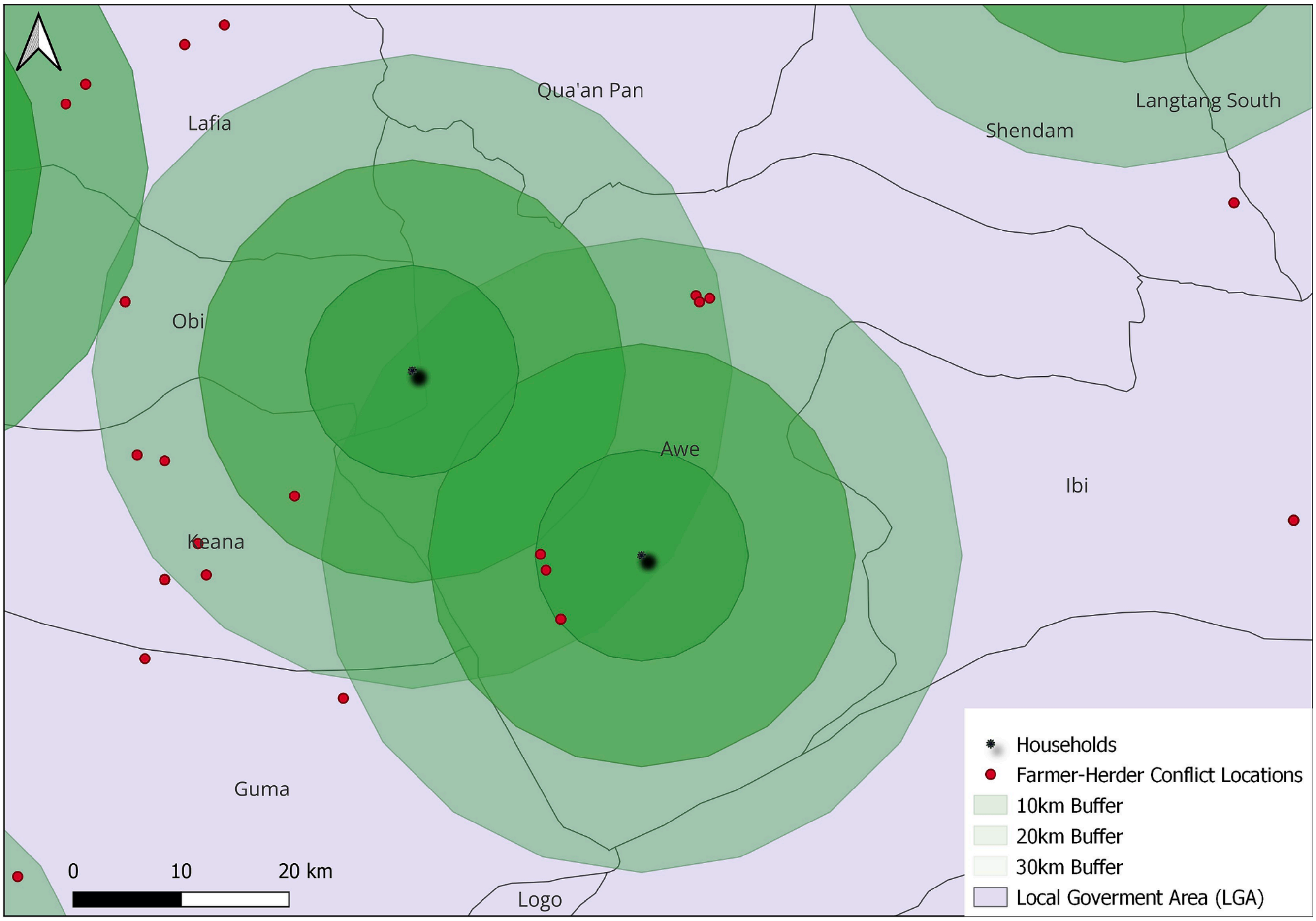

Fig. 5. Farmer-herder conflicts exposure measurement using buffer zones. **Source:** Authors' depiction from LSMS-ISA and ACLED datasets for Nigeria (2009–2016). Data available www.worldbank.org/en/programs/lsms/initiatives/lsms-ISA and www.acleddata.com.

with climate events such as drought (Brottem, 2021). We develop a conceptual framework for understanding the relationship between seasonally patterned farmer-herder conflicts, food consumption, and the role livestock diversification plays in mitigating the conflicts impacts, taking insights from the study by FAO and Tufts University (2019). This earlier study highlighted the connection between contemporary conflicts in Africa, seasonal farming and herding patterns, and child malnutrition in Chad, South Sudan, and Sudan.

According to the Nigerian agricultural calendar (FEWS NET, 2013), the dry season begins in October in the North and between November and December in the South. It peaks from January to February in the South and extends until April in the North. Fig. 3 shows that farmer-herder conflicts follow these seasonal patterns, peaking during the height of the dry season and declining with the onset of the dry season. This may allow farmers to anticipate periods of high conflict intensity, thus reavealing a seasonal pattern in the effects of these conflicts.

Fig. 4 depicts the mechanisms through which farmer-herder conflicts can influence ASF consumption, and the mitigating role of livestock diversification. Directly, these conflicts can decrease ASF availability, as livestock assets may be lost due to theft, attacks, or forced sales. Their indirect impacts manifest through a range of vulnerability pathways. Conflicts disrupt agricultural activities, diminishing crop yields that are crucial for livestock sustenance. Essential assets like barns or pastures may be destroyed, posing challenges to livestock production. Additionally, conflicts can cause human fatalities or migrations, leading to a shortage in farming labour. Trust in key local ASF-related institutions may weaken, disrupting supply chains. Especially, markets vital for ASF trade might suffer interruptions. Lastly, supporting services, like veterinary care and animal feed supply chains could be compromised. The relationship between farmer-herder conflicts and ASF consumption is thus complex, with effects being both immediate and progressively manifesting through various indirect channels.

More importantly, the framework suggests that seasonality plays a moderating role in influencing the connection between farmer-herder conflicts and ASF consumption, as well as their consumption coping strategies. However, recognising the recurring pattern of these conflicts, households might adjust livelihood assets, such as engaging in livestock portfolio diversification. This involves shifting livestock production from large species to smaller ones that are less susceptible to conflict attacks (Arias et al., 2019; Fadare et al., 2022). Such an ex-ante (asset smoothing) strategy is adaptive in nature, as it involves planning and is driven by the sustainability of livelihood assets. In contrast, ex-post (consumption smoothing) coping strategies are reactive in nature, being implemented after a shock has occurred to mitigate the adverse effects of shocks on household food security. The study by Ansah et al. (2021) discusses further the relationship between shocks, coping strategies, and household food security.

Our conceptual framework suggests that households with adaptive capacity might adopt assets smoothing strategies in conflict situations, which may result in ASF consumption smoothing. Based on this framework, we test three hypotheses. Hypothesis 1: Farmer-herder conflicts have a negative effect on ASF consumption; that is, they reduce the quantity consumed and increase the number of days households forego their consumption. Hypothesis 2: Seasonality moderates the relationship between farmer-herder conflicts and ASF consumption, with the post-harvest season exacerbating the negative impacts. Hypothesis 3:

Livestock diversification reduces the negative impact of farmer-herder conflicts on ASF consumption.

4. Data and descriptive statistics

In this section, we present a description of the datasets used for analysis, which are obtained from two sources. Initially, we obtained a panel household dataset from the Living Standards Measurement Study – Integrated Surveys on Agriculture (LSMS-ISA) for Nigeria (NBS, 2016). Subsequently, we merged this dataset with a corresponding global georeferenced conflict dataset obtained from the Armed Conflict Location & Event Data project (ACLED) (Raleigh et al., 2023). The ACLED data were accessed in January 2020 and are publicly available at www.acleddata.com.

4.1. Data

The LSMS-ISA initiative for Nigeria, a collaboration between the World Bank and the Nigeria National Bureau of Statistics (NBS), surveys 5,000 households that are representative of Nigeria's six geopolitical regions as well as urban and rural areas. The household surveys were conducted in waves, consisting of two visits or rounds, starting from the post-planting season, which corresponds to the onset of the dry season (September/October), and then post-harvest season, corresponding to the peak of the dry season (February/March), with no two rounds completed in the same year. Our analysis is centred on agricultural households, which constitute approximately 60 % of the sample, and spans six survey rounds, capturing the years 2010 to 2016. The sample size used for analysis is 18,842 panel observations, drawn from 3,256 (2010), 3,314 (2011), 3,160 (2012), 3,087 (2013), 3,015 (2015), and 3,010 (2016) survey responses. Information was sought on household socioeconomic status, livelihoods, and food consumption, among others.

ACLED presents an up-to-date resource for analysing global political violence and protests (Raleigh et al., 2023). It provides comprehensive information on various aspects of conflict events, including death tolls, event types, event time, locations with coordinates, and involved actors, along with detailed event notes. In our research, we focused on conflict events associated with Farmers, Pastoralists, the Fulani Ethnic Group, and the Fulani Ethnic Militia. In addition, we examined the event notes to verify that the identified events are those involving conflicts between farmers and herders.

While ACLED primarily relies on media and public sources for information gathering, the emergence of modern communication technology has enhanced data quality by enabling direct conflict events data collection from eyewitnesses, reducing reliance on government and public press sources (Croicu and Kreutz, 2017). However, caution should be exercised when using this data to inform policy, given the potential limitations associated with ACLED's methodology. These may include underreporting of conflict events in areas with limited media coverage, internet, and mobile phone penetration, as well as the potential for biased and non-independent reporting sources, which may affect the accuracy of the data.

Despite these limitations, ACLED is widely used as a global georeferenced dataset for measuring conflicts. Researchers (e.g., Dabalen and Paul, 2014; Adelaja and George, 2019) can merge this data with other survey data by employing unique identifiers such as administrative unit codes or event location coordinates, and event year and time. In particular, to identify households that are exposed to farmer-herder conflicts in our research, we merge the household-level data from LSMS-ISA with the conflict data from ACLED using the coordinates (longitudes and latitudes) from both datasets and the corresponding years. More insight is provided on the merging method in the next section.

4.1.1. Farmer-herder conflicts exposure measurement

We depict in Fig. 5 the precision of our measurement by employing two hypothetical households in the Awe and Obi Local Government Areas (LGAs) of Nasarawa State, Nigeria. The household in Obi experienced a higher number of conflict events within a 30 km radius and more outside neighbouring LGAs (Awe and Keana) than within Obi itself. As such, we measured our farmer-herder conflict events by counting the number of conflicts that occurred within radii of 30 km, 20 km, and 10 km from the households. This measurement approach enables each household to have a distinct conflict exposure experience.

This assessment spanned a period of 12 months before the start of the first round of the LSMS-ISA survey in 2010 and continued until the beginning of the 2016 survey for the same households. The time frame, starting from 2009, was characterised by minimal or no conflict events, as shown in Fig. 1. Thus, enabling us to capture the cumulative impact of the conflict on the ASF consumption measure variables. In our analysis, we use the number of farmer-herder conflict events within buffer zones of 30 km, 20 km, and 10 km radius around the households as continuous variable to measure conflict intensity. This helps in understanding how incremental changes in the number of conflict events affect the outcomes. Additionally, we generated a binary indicator of farmer-herder conflict exposure, which assigns one (1) to households that experienced at least one fatality within our predefined radius and time frame, and zero (0) to non-exposed households. Using this indicator helps us assess the influence of occurrence of famer-herder conflicts in a location, rather than their magnitude, and for testing our research hypotheses. Conflict events without fatalities were excluded to ensure only violent conflicts are captured.

4.1.2. Animal-source foods consumption measures

We employ three primary metrics to assess household ASF consumption. Firstly, we consider the overall quantity of ASF consumption, which is further categorised into four specific measures: meats, milk, poultry, and fish consumption. From the survey, an adult household member responsible for food preparations or purchases within the household was asked to recall the quantity of each ASF item consumed during the preceding seven days. We standardised ASF items[1] reported in non-standard units in some instances and quantified them as grams per day per adult-equivalent unit (g/day/aeq). The concept of an adult-equivalent unit takes into account variations in household composition and individual consumption requirements by adjusting for factors such as household size, age, and sex. In this study, we employed the adult-equivalent conversion factor as used by Desiere et al. (2018). It is worth noting that less than 10 % of the households did not consume any ASF in the seven days leading up to the survey. Consequently, these observations were excluded from the analysis, along with a few unrealistic outliers representing less than 1 % of the data. To address extreme values, the distribution of the outcomes was winsorised at 1 % and 99 %.

The other two indicators of ASF consumption are derived from the tools employed to evaluate household food consumption coping strategies, as outlined in the LSMS-ISA questionnaire. These indicators are based on two specific questions posed to an adult female household member who possesses knowledge about household food consumption. The first question assesses the number of days in the past week when any member of the household had to rely on less preferred foods. The second question pertains to the number of days in the past week when the household had to limit the variety of foods consumed. These two indicators demonstrate a stronger negative correlation with ASF consumption compared to other coping strategies for food consumption, while exhibiting a positive correlation with fruit and vegetable consumption (see Table A1 in the Appendix). Consequently, these indicators can serve as proxies for ASF consumption within the housheolds, as they assess the extent to which households can compromise on nutritious and

[1] ASF captured in the LSMS-ISA are categorised into four groups: i) meat (all meat, except poultry products), ii) milk (all milk and dairy products), iii) poultry (all poultry products), and iv) fish (all fish and seafood).

Table 1
Summary statistics of variables used for analysis.

	N	Mean	Std. dev.	Min	Max
ASF consumption (g/day/aeq)	16,970	74.203	79.407	0.930	1076.605
Meat consumption (g/day/aeq)	9,794	34.455	25.384	0.016	139.752
Milk consumption (g/day/aeq)	2,206	53.157	31.683	1.027	113.379
Poultry consumption (g/day/aeq)	2,655	28.572	25.781	0.121	108.225
Fish consumption (g/day/aeq)	11,769	35.394	29.814	0.019	144.928
Number of days HH rely on less-preferred foods	18,842	1.126	1.737	0	7
Number of days HH limit the variety of foods eaten	18,838	0.961	1.579	0	7
Livestock diversification (Binary)	12,827	0.353	0.478	0	1
Own livestock (Binary)	18,842	0.679	0.467	0	1
Value of crop produced (Naira *x* 10,000)	18,842	12.902	15.416	0	85.938
Average years of HH education	18,842	9.984	5.660	0	18
HH size (Number)	18,842	6.273	3.262	1	31
Wealth index	18,842	−0.003	2.344	−3.535	6.124
Distance to market (km)	18,842	71.543	39.880	0.28	214.36
Distance to the nearest population centre with + 20,000	18,842	24.883	19.251	0.06	130.5
Annual average rainfall (mm)	18,842	1258.777	458.388	378	2574
Annual average temperature (multiplied by 10 °C)	18,842	263.665	9.751	210	288
Number of FHC incidents (10 km radius)	18,842	0.060	0.550	0	12
Number of FHC incidents (20 km radius)	18,842	0.203	1.465	0	29
Number of FHC incidents (30 km radius)	18,842	0.343	1.963	0	33
FHC exposed (30 km radius) (binary)	18,842	0.084	0.278	0	1

Note: FHC means Farmer-herder conflicts; HH means Households.
Source: Authors' estimates derived from LSMS-ISA and ACLED datasets for Nigeria (2010 to 2016).

diverse food options. Furthermore, these variables also capture short-term deprivation of ASF consumption, as they are sensitive to temporary changes such as seasonality or the impact of conflict shocks (Maxwell et al., 2003).

4.1.3. Livestock diversification measurement

The Livestock Diversification Index (LDI) is constructed based on the Herfindahl Index (HI) methodology. The calculation of LDI is as follows: $S_k = \frac{R_k}{\sum_{k=1}^{n} R_k}$, where S_k is the share for the k^{th} value of livestock species in the total for all value of livestock owned by household, R_k represents the value for the k^{th} livestock for a sample household, and $\sum_{k=1}^{n} R_k$ is the total value from livestock $k = 1, 2, \dots, n$ represents the number of species own. Given the HI to be $HI_L = \sum_{k=1}^{n} S_k^2$, our LDI $= 1 - HI_L$. The LDI is a metric that ranges from 0 to 1, with lower values indicating a higher degree of species specialization and higher values indicating greater diversification. In this study, households with an average LDI equal to or greater than the sample mean are categorised as having a higher inclination towards adopting livestock diversification strategies and are assigned a code of 1. On the other hand, households with an LDI below the sample mean are associated with relatively less diverse livestock production practices and are assigned a code of 0, representing our livestock diversification variable.

4.1.4. Control variables

We incorporate some control variables in our analysis to account for various factors. These control variables include a binary variable livestock ownership status, the monetary value of crop production by households within a year in Naira, the average educational attainment of the household, household size, and a wealth index computed based on durable household assets, excluding livestock assets. Additionally, we control for distance to market (in kilometres), distance to population centres (in kilometres), and annual mean rainfall (in millimetres) and annual mean temperature multiplied by 10 °C (degree Celsius). These variables were directly obtained from the LSMS-ISA dataset and were collected at the household level using georeferenced household locations along with geospatial climate data.

4.2. Descriptive statistics

Table 1 presents the summary statistics of variables used for analysis and shows that the mean aggregated ASF consumption was 74.2 g/day/aeq, meat consumption was 34.5 g/day/aeq, milk consumption was 53.2 g/day/aeq, poultry consumption was 28.6 g/day/aeq, and fish consumption was 35.4 g/day/aeq. On average, households experienced at least one day of relying on ASF consumption coping strategies. About 3 % of households engaged in livestock diversification strategy, coming from 68 % of livestock-holding households in our sample. Average monetary value of crops produced by households was 129,020 Naira. Households have an average of 10 years of education and 6 members. The mean farmer-herder conflict events were 0.06, 0.20, and 0.34 at buffer zones of 10 km, 20 km, and 30 km respectively, while about 8 % of households experienced at least one fatality event within 30 km radius.

Table 2 shows a significant reduction in ASF consumption, except for poultry, among the exposed households. The reduction was more pronounced during the post-harvest season, particularly regarding fish consumption. Moreover, the results indicate that the exposed group had significantly fewer days of relying on ASF consumption coping strategies compared to the non-exposed group across both seasons. The exposed group were more engaged in livestock diversification strategy than the non-exposed group, and significantly more in post-harvest season. The consumption patterns observed in this data indicate that ASF consumption, which was already low during the post-planting season, further declined during the post-harvest season for the exposed group. Consequently, households exposed to farmer-herder conflicts may be trapped in a state of severe micronutrient malnutrition.

5. Empirical strategy

Violent conflicts are reasonably argued as endogenous in the model estimating the relationship between conflict and food security or nutrition. The primary sources of endogeneity are unobserved confounders, reverse causality or simultaneity (Martin-Shields and Stojetz, 2019). In the case of farmer-herder conflicts, it is correlated with extreme climate events (Brottem, 2016; Eberle et al., 2020; Moritz et al., 2019). Therefore, it is difficult to isolate conflicts' impacts on food security and nutrition from that of extreme weather events. More importantly, we cannot rule out the possibility of endogeneity arising from omitted variables bias and selection bias. Eberle et al. (2020) highlight that farmer-herder conflicts predominantly occur in agropastoral communities, particularly in areas vulnerable to climate shocks. Consequently, the occurrence of conflicts is not randomly determined within a

Table 2
A mean comparison of animal-source foods and adaptive strategy between groups.

	Post-planting				Post-harvest			
	N	Non-exposed	Conflict exposed	Difference	*N*	Non–exposed	Conflict exposed	Difference
Number of FHC incidents (30 km radius)	9,358	0.026	3.521	3.495***	9,484	0.024	3.977	3.953***
ASF consumption (quantity)								
ASF consumption	8,549	74.065	64.335	−9.730***	8,421	76.599	60.242	−16.357***
Meat consumption	4,801	34.179	32.512	−1.667	4,993	35.038	32.633	−2.405*
Milk consumption	1,248	54.473	54.511	0.038	958	51.735	48.945	−2.791
Poultry consumption	1,249	26.659	31.923	5.264*	1,406	29.649	32.833	3.183
Fish consumption	5,857	35.157	31.277	−3.880***	5,912	36.266	33.007	−3.259**
ASF consumption (coping strategies)								
Number of days HH rely on less-preferred foods	9,358	1.173	0.980	−0.193***	9,484	1.098	1.048	−0.051
Number of days HH limit the variety of foods eaten	9,357	1.051	0.781	−0.270***	9,481	0.897	0.837	−0.060
Adaptive strategy								
Livestock diversification	6,408	0.352	0.371	0.019	6,419	0.346	0.418	0.072***

Note: FHC and HH are respectively farmer-herder conflict, and households. Significance levels: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. 'Conflict exposed' are households that experienced at least one fatality within 30 km radius, and 'Non-exposed' are households who did not.
Source: Authors' estimates derived from LSMS-ISA and ACLED datasets (2010 to 2016).

population, posing a potential challenge for establishing causality.

Previous studies have employed several approaches in dealing with selection bias in empirical studies of this nature, including the matching method, instrumental variables, and difference-in-differences (Dabalen and Paul, 2014; Nnaji et al., 2022; Paul et al., 2015; Tranchant et al., 2021). Another approach is to control for climate shocks or seasonal shocks variables and to account for the likely correlation between conflict and extreme weather events while controlling for household fixed effects, as demonstrated by Tranchant et al. (2021). In our study, we employed a set of fixed-effects models to address endogeneity issues. We accounted for spatial and temporal autocorrelation using the arbitrary correlation regression (*acreg*) approach, a modification of Conley (1999), implemented in the Stata statistical software by Colella et al. (2023). Using the *acreg* approach helps to fit models that incorporate high-dimensional fixed effects. Specifically, it allows for the effective control of unobserved heterogeneity across various time, geographic locations, and households.

In the first instance, we specify a fixed-effects model that accounts for the influence of unobserved household and geographical location characteristics that may affect both ASF consumption and farmer-herder conflict incidents simultaneously. Thus, in addition to incorporating important covariates, the model accounts for the temporal shocks that might have influenced household-level food security during each time period by including time fixed effects. We also incorporate geographic coordinates into the model, enabling the adjustment of spatial trends and patterns that affect the dependent variable and are not addressed by other variables. The specific equation of the fixed-effects regression model, which examines the relationship between farmer-herder conflicts and ASF consumption, is as follows:

$$y_{hlt} = \alpha + \beta_1 I_{hlt} + \beta_2 S_t + \rho \boldsymbol{X}_{hlt} + \gamma_t + \tau_l + \vartheta_h + \delta_1 Lat_l + \delta_2 Lon_l + \varepsilon_{hlt} \quad (1)$$

In the specified equation, y_{hlt} represents ASF aggregated consumption and coping strategies for household h in LGA l in time period t. The intercept term is denoted by α, while I_{hlt}, in three separate models, represents the number of farmer-herder conflict incidents within 30 km, 20 km and 10 km radii from the households h during time period t, and S_t is a binary indicator for seasonality. The coefficients are β_1 for conflicts effect and β_2 for seasonality, while ρ is for the vector X_{hlt}, which includes variables such as livestock ownership, value of crop produced, average education of household, household size, wealth index, distance to market, distance to population, temperature, and rainfall variables. The time fixed effects and the LGA fixed effects are denoted by γ_t and τ_{lt}, respectively, while ϑ_h represents the household fixed effects capturing unobserved household-specific characteristics. δ_1 and δ_2 represent the coefficient for latitude, $\delta_1 Lat_l$, and longitude, $\delta_1 Lon_l$, variables, while the idiosyncratic error term, ε_{hlt} captures other unobserved factors that may impact ASF consumption within the households and across time and space. We also estimated an alternative model without location and time fixed effects.

In another instance, and in accordance with the conceptual framework of this study, we employ the two-way fixed-effects model (DiD model), as we detailed in equation (2). In the DiD framework, model using OLS regression would assume exogenous treatment. However, if the treatment is endogenous, the DiD's parallel trends assumption is violated. In such cases, OLS will estimate an effect size using the slope of the control group as the counterfactual, regardless of the correctness of the slope (Goodman-Bacon, 2021; Kahn-Lang and Lang, 2020). To ensure the internal validity of our approach, certain assumptions are met. Firstly, we focus our analysis on agricultural households that share some degree of similar characteristics. Secondly, the DiD strategy assumes that both the treatment and control groups follow a similar parallel trend of the outcome variable during the pre-treatment period for an exogenous treatment (Wing et al., 2018). To evaluate the validity of the parallel trends assumption, a test was conducted using local nonparametric regression to assess ASF consumption in relation to seasonal year trends for both conflict-exposed and non-exposed groups.

Subsequently, the specified model in Equation (1) is modified by incorporating a binary conflict-exposed indicator, C_{lt}, which assigns one (1) to households that experienced at least one fatality within 30 km, 20 km, or 10 km radius, and zero (0) if no fatalities occurred within these distances, and employed in three separate models. This is interacted with a binary variable that indicates the season of exposure, S_t. The equation for the DiD model is written as follows:

$$y_{hlt} = \alpha + \beta_1 C_{hlt} + \beta_2 S_t + \beta_3 (C_{hlt}.S_t) + \rho \boldsymbol{X}_{hlt} + \gamma_t + \tau_l + \vartheta_h + \delta_1 Lat_l + \delta_2 Lon_l + \varepsilon_{hlt} \quad (2)$$

Equation (2) assesses the impact of farmer-herder conflicts on ASF consumption and represents the Average Treatment Effect on the Treated (ATT), with β_3 being the coefficient. Additionally, we adopt the event study estimator in modelling the impact of farmer-herder conflicts on all indicators of ASF consumption employed, which serves as a sensitivity check to increase the robustness of our estimations. The model specification and results of the event study analysis are presented in the Appendix (Additional analysis section). More importantly, and central to our research objective, is to examine the extent to which the impact of farmer-herder conflicts on ASF consumption is mitigated by livestock diversification. Thus, we modify Equation (2) as three-way fixed-effects model (triple differences) and specified it as follows:

Table 3
The impacts of farmer-herder conflicts on animal-source foods (ASF) consumption (fixed-effects results).

	Animal-source foods consumed (grams per day per adult-equivalent unit)		Animal-source foods consumption coping strategies			
			Number of days households had to rely on less-preferred foods		Number of days households had to limit the variety of foods eaten	
Panel A: 30 km radius	(1)	(2)	(1)	(2)	(1)	(2)
FHC incidents	−0.636**	−0.674	0.027**	0.028*	0.017*	0.017
	(0.291)	(0.458)	(0.010)	(0.016)	(0.010)	(0.015)
PH season	1.416*	1.396	−0.070***	−0.070	−0.145***	−0.145***
	(0.826)	(2.388)	(0.019)	(0.046)	(0.017)	(0.042)
R-squared	0.014	0.018	0.007	0.007	0.010	0.010
***Panel B:** 20 km radius*	(1)	(2)	(1)	(2)	(1)	(2)
FHC incidents	−1.033***	−1.061*	0.022	0.023	0.004	0.004
	(0.396)	(0.632)	(0.015)	(0.014)	(0.015)	(0.013)
PH season	1.372*	1.350	−0.067***	−0.067*	−0.143***	−0.143***
	(0.825)	(1.845)	(0.019)	(0.039)	(0.017)	(0.035)
R-squared	0.014	0.018	0.007	0.007	0.010	0.010
***Panel C:** 10 km radius*	(1)	(2)	(1)	(2)	(1)	(2)
FHC incidents	−1.920**	−1.910*	0.067*	0.069*	0.030	0.032
	(0.811)	(1.116)	(0.038)	(0.040)	(0.031)	(0.037)
PH season	1.347	1.323	−0.067***	−0.067**	−0.143***	−0.143***
	(0.825)	(1.376)	(0.019)	(0.034)	(0.017)	(0.029)
R-squared	0.014	0.018	0.007	0.007	0.010	0.010
Household fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Location and time fixed effects	No	Yes	No	Yes	No	Yes
Number of observations	16,970	16,970	18,842	18,842	18,838	18,838
Number of households	3,671		3,708		3,708	

Note: FHC and PH are respectively farmer-herder conflicts and post-harvest. Significance levels: *** p < 0.01, ** p < 0.05, * p < 0.1; Robust standard errors in parentheses. Full results are in Table A3 in the Appendix.Table A4.
Source: Authors' estimates derived from LSMS-ISA and ACLED datasets (2010 to 2016). Table A5.

Table 4
The impacts of farmer-herder conflicts on animal-sorce foods (ASF) consumption (two-way fixed-effects results).

	Animal-source foods consumed (grams per day per adult-equivalent unit)		Animal-source foods consumption coping strategies			
			Number of days households had to rely on less-preferred foods		Number of days households had to limit the variety of foods eaten	
Panel A: 30 km radius	(1)	(2)	(1)	(2)	(1)	(2)
FHC exposure	1.619	2.725	−0.025	−0.038	−0.136**	−0.148*
	(2.696)	(3.730)	(0.069)	(0.087)	(0.063)	(0.076)
PH season	2.606***	2.650	−0.082***	−0.083*	−0.166***	−0.167***
	(0.894)	(2.604)	(0.020)	(0.049)	(0.018)	(0.044)
FHC exposure x PH season	−13.815***	−14.841***	0.166**	0.181	0.273***	0.287**
	(3.166)	(5.096)	(0.082)	(0.122)	(0.073)	(0.112)
R-squared	0.016	0.019	0.007	0.007	0.011	0.011
***Panel B:** 20 km radius*	(1)	(2)	(1)	(2)	(1)	(2)
FHC exposure	0.191	1.310	−0.013	−0.021	−0.136*	−0.140
	(3.162)	(4.162)	(0.084)	(0.097)	(0.075)	(0.090)
PH season	1.977**	2.009	−0.076***	−0.076*	−0.157***	−0.158***
	(0.867)	(1.954)	(0.019)	(0.041)	(0.018)	(0.036)
FHC exposure x PH season	−10.495***	−11.666**	0.147	0.159	0.262***	0.270**
	(3.731)	(5.169)	(0.096)	(0.127)	(0.086)	(0.117)
R-squared	0.001	0.018	0.001	0.007	0.004	0.010
***Panel C:** 10 km radius*	(1)	(2)	(1)	(2)	(1)	(2)
FHC exposure	2.782	4.129	−0.057	−0.066	−0.229**	−0.234*
	(4.207)	(5.721)	(0.145)	(0.135)	(0.111)	(0.123)
PH season	1.578*	1.575	−0.067***	−0.067**	−0.144***	−0.144***
	(0.846)	(1.411)	(0.019)	(0.034)	(0.017)	(0.030)
FHC exposure x PH season	−10.119**	−11.302*	0.057	0.072	0.133	0.146
	(4.871)	(6.277)	(0.159)	(0.161)	(0.120)	(0.138)
R-squared	0.014	0.018	0.006	0.007	0.010	0.010
Household fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Location and time fixed effects	No	Yes	No	Yes	No	Yes
Number of observations	16,970	16,970	18,842	18,842	18,838	18,838
Number of households	3,671		3,708		3,708	

Note: FHC and PH are respectively farmer-herder conflicts and post-harvest. Significance levels: *** p < 0.01, ** p < 0.05, * p < 0.1; Robust standard errors in parentheses. Full results are in Table A4 in the Appendix.
Source: Authors' estimates derived from LSMS-ISA and ACLED datasets (2010 to 2016).

Table 5
The impacts of livestock diversification on animal-source foods (ASF) consumption (three-way fixed-effects results).

	Animal-source foods consumed (in grams per day per adult-equivalent unit.		Animal-source foods consumption coping strategies			
			Number of days households had to rely on less-preferred foods		Number of days households had to limit the variety of foods eaten	
Panel A: 30 km radius	*(1)*	*(2)*	*(1)*	*(2)*	*(1)*	*(2)*
FHC exposure	3.639	4.456	0.055	0.044	0.016	−0.001
	(3.911)	(4.122)	(0.107)	(0.107)	(0.096)	(0.089)
PH season	7.680***	7.726***	−0.173***	−0.174***	−0.207***	−0.209***
	(1.260)	(2.368)	(0.030)	(0.055)	(0.026)	(0.047)
FHC exposure x PH season	−16.410***	−17.308***	0.190	0.209	0.182	0.206
	(5.132)	(5.950)	(0.130)	(0.156)	(0.113)	(0.148)
LD	−5.314***	−4.680**	0.113**	0.109*	0.196***	0.189***
	(1.973)	(2.016)	(0.048)	(0.063)	(0.044)	(0.055)
FHC exposure x LD	3.965	4.455	−0.182	−0.189	−0.242*	−0.250*
	(5.885)	(5.026)	(0.153)	(0.148)	(0.145)	(0.135)
PH season x LD	−15.360***	−15.303***	0.275***	0.275***	0.146***	0.146**
	(1.865)	(2.854)	(0.051)	(0.078)	(0.046)	(0.065)
FHC exposure x PH season x LD	8.488	8.063	−0.144	−0.144	−0.029	−0.026
	(7.515)	(7.461)	(0.188)	(0.210)	(0.175)	(0.203)
R-squared	0.027	0.030	0.014	0.014	0.020	0.021
Panel B: 20 km radius	*(1)*	*(2)*	*(1)*	*(2)*	*(1)*	*(2)*
FHC exposure	5.054	5.947	−0.024	−0.030	−0.043	−0.051
	(5.004)	(5.232)	(0.124)	(0.135)	(0.108)	(0.102)
PH season	7.218***	7.253***	−0.169***	−0.169***	−0.200***	−0.201***
	(1.214)	(1.969)	(0.030)	(0.049)	(0.026)	(0.042)
FHC exposure x PH season	−17.150***	−18.172***	0.249*	0.263	0.165	0.184
	(6.375)	(6.836)	(0.149)	(0.168)	(0.132)	(0.144)
LD	−4.993**	−4.327**	0.107**	0.102*	0.190***	0.182***
	(1.963)	(1.949)	(0.048)	(0.057)	(0.043)	(0.050)
FHC exposure x LD	−1.652	−1.576	−0.090	−0.089	−0.179	−0.174
	(7.136)	(5.857)	(0.184)	(0.178)	(0.179)	(0.157)
PH season x LD	−15.628***	−15.584***	0.273***	0.273***	0.142***	0.143**
	(1.830)	(2.566)	(0.050)	(0.071)	(0.045)	(0.058)
FHC exposure x PH season x LD	17.470*	17.247**	−0.229	−0.233	−0.028	−0.034
	(9.066)	(8.606)	(0.231)	(0.236)	(0.214)	(0.212)
R-squared	0.027	0.029	0.014	0.014	0.019	0.020
Panel C: 10 km radius	*(1)*	*(2)*	*(1)*	*(2)*	*(1)*	*(2)*
FHC exposure	14.424**	15.117**	−0.292	−0.292	−0.293*	−0.295**
	(7.051)	(7.095)	(0.214)	(0.189)	(0.163)	(0.139)
PH season	6.877***	6.888***	−0.159***	−0.160***	−0.191***	−0.191***
	(1.198)	(1.620)	(0.029)	(0.043)	(0.026)	(0.037)
FHC exposure x PH season	−24.871***	−26.113***	0.219	0.242	0.020	0.047
	(8.416)	(9.299)	(0.227)	(0.219)	(0.162)	(0.170)
LD	−4.851**	−4.182**	0.101**	0.096*	0.184***	0.176***
	(1.924)	(1.683)	(0.047)	(0.053)	(0.043)	(0.045)
FHC exposure x LD	−10.946	−10.042	0.122	0.111	−0.143	−0.158
	(11.572)	(9.157)	(0.278)	(0.254)	(0.226)	(0.195)
PH season x LD	−15.326***	−15.303***	0.263***	0.263***	0.138***	0.138***
	(1.790)	(2.219)	(0.049)	(0.065)	(0.044)	(0.053)
FHC exposure x PH season x LD	28.054**	27.493**	−0.164	−0.166	0.229	0.231
	(13.096)	(11.667)	(0.336)	(0.288)	(0.281)	(0.238)
R-squared	0.027	0.029	0.013	0.014	0.020	0.020
Household fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Location and time fixed effects	No	Yes	No	Yes	No	Yes
Number of observations	11,373	11,373	12,827	12,827	12,827	12,827
Number of households	2,917		2,960		2,960	

Note: FHC, PH, and LD are respectively farmer-herder conflicts, post-harvest, and livestock diversification. Significance levels: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$; Robust standard errors in parentheses. Full results are in Table A5 in the Appendix.
Source: Authors' estimates derived from LSMS-ISA and ACLED datasets (2010 to 2016).

$$y_{hlt} = \alpha + \beta_1 C_{hlt} + \beta_2 S_t + \beta_3 (C_{hlt}.S_t) + \beta_4 L_{hlt} + \beta_5 (C_{hlt}.L_{hlt}) + \beta_6 (S_t.L_{hlt}) + \beta_7 (C_{hlt}.S_t.L_{hlt}) + \rho X_{hlt} + \gamma_t + \tau_l + \vartheta_h + \delta_1 Lat_l + \delta_2 Lon_l + \varepsilon_{hlt} \quad (3)$$

Equation (3) introduces the inclusion of the interaction term between livestock diversification indicator, L_{hlt}, the conflict-exposed indicator, C_{hlt}, and the season of exposure, S_t. The coefficient, β_5, represents the effect of livestock diversification on ASF consumption in non-exposed season, while β_7 captures the mitigating effect of livestock diversification, the ATT.

6. Results and discussion

This section provides the results of our estimations for the model specifications presented in Equations (1) to (3), along with a discussion of the findings. To examine the impact of farmer-herder conflicts on ASF consumption (quantity of ASF consumed, and the two ASF consumption coping strategies), we present the results of the fixed-effects regression model from Equation (1) in Table 3, and the two-way fixed-effects model specification from Equation (2) in Table 4. Next, we present the results of the three-way fixed-effects model specification from Equation (3) in Table 5, which examines the mitigating impact of livestock diversification on ASF consumption.

Table A1
Correlation between nutrients-dense foods consumption and food consumption coping strategies.

	Animal-source foods consumption as aggregated and disaggregated into food items (grams per day per adult-equivalent units)						
	ASF	Meat	Milk	Poultry	Fish	Vegetable	Fruits
ASF consumption indicators							
ASF consumption	1.000						
Meat consumption	0.615*	1.000					
Milk consumption	0.622*	0.228*	1.000				
Poultry consumption	0.427*	0.258*	0.094	1.000			
Fish consumption	0.659*	0.354*	0.197*	0.069*	1.000		
Vegetable consumption	0.012	−0.026*	−0.094*	−0.067*	0.0123	1.000	
Fruits consumption	0.104*	−0.032*	−0.034	−0.139*	0.076*	0.124*	1.000
Coping strategies							
Days rely on less-preferred foods	**−0.097***	**−0.124***	**0.062***	**−0.196***	**−0.014**	**0.067***	**0.143***
Days limit the variety of foods eaten	**−0.094***	**−0.133***	**−0.020**	**−0.214***	**−0.001**	**0.063***	**0.151***
Days limit portion size at mealtime	−0.075*	−0.113*	−0.034	−0.198*	0.002	0.051*	0.128*
Days reduce meals eaten in a day	−0.072*	−0.114*	−0.067*	−0.180*	0.013	0.043*	0.129*
Days restrict consumption for children to eat	−0.081*	−0.089*	−0.024	−0.109*	−0.041*	0.018*	0.055*
Days borrow food or rely on help from a friend	−0.024*	−0.021*	−0.021	−0.087*	0.003	−0.006	0.028*
Days have no food in your household	−0.021*	−0.037*	−0.001	−0.056*	0.005	−0.014*	0.053*
Days households have to go to sleep hungry	−0.036*	−0.061*	−0.016	−0.042*	0.006	−0.011	0.052*
Days have to go a whole day and night not eaten	−0.027*	−0.018	0.019	0.005	−0.002	−0.036*	−0.003

Note: *Significant correlation at $p < 0.05$. Indicators in bold are those employed in the analysis.
Source: Authors' estimates derived from LSMS-ISA datasets for Nigeria (2010 to 2016).

Table A2
Event study results of the impacts of farmer-herder conflicts on animal-source foods consumption.

	ASF consumption	Meat consumption	Milk consumption	Poultry consumption	Fish consumption	Days rely on less-preferred foods	Days limit the variety of foods eaten
	(1)	*(2)*	*(3)*	*(4)*	*(5)*	*(6)*	*(7)*
Conflict exposure time							
−5	28.560***	1.000	0.901	6.669*	2.011	−1.273***	−1.033***
	(10.622)	(2.920)	(1.954)	(3.983)	(2.349)	(0.207)	(0.189)
−4	35.682***	0.749	−4.916	8.718**	7.370***	−0.655***	−0.823***
	(8.259)	(2.093)	(9.789)	(4.421)	(2.301)	(0.136)	(0.128)
−2	20.365***	2.171**	0.588	2.246	2.814***	−0.378***	−0.576***
	(3.934)	(0.935)	(1.451)	(1.717)	(1.075)	(0.079)	(0.077)
−2	16.755***	4.197***	1.718	7.141*	4.091***	−0.197***	−0.382***
	(3.450)	(1.462)	(5.880)	(3.989)	(1.452)	(0.069)	(0.060)
−1 (base)							
0	−5.609**	−0.996	−6.244	−1.874	−1.627	0.010	−0.058
	(2.540)	(1.173)	(4.744)	(3.200)	(1.263)	(0.063)	(0.056)
1	−1.346	−0.268	−3.104	0.476	−0.837	−0.000	0.081
	(2.911)	(1.478)	(4.708)	(3.527)	(1.326)	(0.072)	(0.065)
2	−10.137***	−3.960**	−2.993	−0.829	−2.071	0.099	0.121
	(3.085)	(1.543)	(5.513)	(3.524)	(1.451)	(0.079)	(0.074)
3	−13.761***	−4.103**	−1.501	−13.402*	−2.426	0.186*	0.270**
	(4.308)	(2.010)	(9.744)	(7.431)	(2.031)	(0.109)	(0.105)
4	−11.873*	−5.710**	7.175	−2.239	−3.706	−0.225*	−0.047
	(6.908)	(2.524)	(10.409)	(10.063)	(3.043)	(0.134)	(0.124)
5	−23.966***	−4.275	−26.731**	−29.576**	−5.896*	−0.288*	−0.010
	(6.630)	(3.261)	(11.967)	(13.863)	(3.230)	(0.160)	(0.160)
Constant	−244.667	101.041*	452.107***	−18.268	−14.004	0.434	−4.118
	(203.627)	(60.690)	(100.939)	(297.566)	(52.271)	(3.276)	(4.165)
Number of observations	16,970	9,794	2,206	2,655	11,769	18,842	18,838
Number of households	3,671	3,105	922	1,511	3,227	3,708	3,708
R-squared	0.029	0.010	0.022	0.044	0.008	0.013	0.019
Additional controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Note: PH and HH are respectively post-harvest, and households. Robust standard errors in parentheses. Significance levels: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. Estimates graphically depicted in Fig. A1.
Source: Authors' estimates derived from LSMS-ISA and ACLED datasets (2010 to 2016).

6.1. Farmer-herder conflicts and cofounding determinants of ASF consumption

Table 3 reports the results in Panels A, B, and C, representing farmer-herder conflict buffer zones of 30 km, 20 km, and 10 km around the households, and compares their results. We report Model 2, which corresponds to the specification outlined in Equation (1). Alternative Model 1 did not account for location and time effects. Our analysis shows a negative effect of farmer-herder conflicts on ASF consumption. Households closer to conflict locations, within a 10 km to 20 km radius, reduce ASF consumption at 10 % level of statistical significance. Specifically, it shows that an increase in farmer-herder conflicts by one event results in up to a 1.9 g/day/aeq reduction in ASF consumption. The conflicts also significantly increase the number of days households

Table A3
The impacts of farmer-herder conflicts on ASF consumption (fixed-effects results).

	Animal-source foods consumed (grams per day per adult-equivalent unit)		Animal-source foods consumption coping strategies			
			Number of days households had to rely on less-preferred foods		Number of days households had to limit the variety of foods eaten	
FHC exposure at 30 km radius	−0.636**	−0.674	0.027**	0.028*	0.017*	0.017
	(0.291)	(0.458)	(0.010)	(0.016)	(0.010)	(0.015)
PH season	1.416*	1.396	−0.070***	−0.070	−0.145***	−0.145***
	(0.826)	(2.388)	(0.019)	(0.046)	(0.017)	(0.042)
Own livestock	3.308	3.237*	0.106**	0.107***	0.052	0.052
	(2.235)	(1.742)	(0.044)	(0.034)	(0.043)	(0.033)
Log of value of crop produced	0.110	0.130	0.008	0.007	0.006	0.006
	(0.242)	(0.249)	(0.005)	(0.006)	(0.005)	(0.005)
Average years of HH education	−0.072	−0.047	−0.007	−0.007	0.001	0.001
	(0.272)	(0.209)	(0.005)	(0.005)	(0.005)	(0.004)
HH size	−2.120***	−2.171***	0.039***	0.041***	0.044***	0.045***
	(0.455)	(0.348)	(0.012)	(0.011)	(0.010)	(0.009)
Wealth index	4.310***	4.313***	−0.077***	−0.075***	−0.075***	−0.073***
	(0.896)	(0.705)	(0.016)	(0.014)	(0.015)	(0.013)
Distance to market	−0.606*	−0.321	0.007	0.005	0.004	−0.001
	(0.352)	(0.289)	(0.006)	(0.006)	(0.006)	(0.006)
Distance to population	0.147**	0.171**	0.000	0.000	0.002	0.002
	(0.065)	(0.077)	(0.001)	(0.002)	(0.001)	(0.002)
Annual mean rainfall	0.228***	0.301***	−0.003***	−0.003***	−0.002***	−0.003***
	(0.037)	(0.048)	(0.001)	(0.001)	(0.001)	(0.001)
Annual mean temperature	1.034	0.665	0.002	−0.008	0.017	−0.002
	(0.891)	(0.650)	(0.012)	(0.011)	(0.014)	(0.010)
Constant	−443.032*	−0.000	3.424	0.000	−0.889	0.000
	(245.751)	(1.137)	(3.286)	(0.023)	(3.942)	(0.021)
R-squared	0.014	0.018	0.007	0.007	0.010	0.010
Household fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Location and time fixed effects	No	Yes	No	Yes	No	Yes
Number of observations	16,970	16,970	18,842	18,842	18,838	18,838
Number of households	3,671		3,708		3,708	

Note: FHC, PH, and HH are respectively farmer-herder conflicts, post-harvest, and household. Significance levels: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$; Robust standard errors in parentheses.
Source: Authors' estimates derived from LSMS-ISA and ACLED datasets (2010 to 2016).

sacrificed ASF consumption. Also, there is a positive, non-statistically significant association between increased consumption of ASF and the post-harvest season. However, this season is significantly associated with households increasing the number of days they consume a variety of food items. This result suggests that the post-harvest season favours ASF consumption more than the post-planting season, evidence supported by Ayenew et al. (2018).

Furthermore, examining other determinants (Table A3 in the Appendix shows the full results), the results reveal a positive and statistically significant association between ASF consumption and factors such as livestock ownership, household wealth, distance to the nearest population centre, and rainfall. The positive association between livestock assets and consumption of ASF is consistent with previous studies (Azzarri et al., 2015; Fadare et al., 2019). Similarly, higher household socioeconomic status is expected to increase ASF consumption, as most studies suggest (Bukachi et al., 2022; Eini-Zinab et al., 2021). Households farther away from population centres, that is, those in rural areas, are more likely to own livestock and consume their products. Although proximity to population centres may suggest access to ASF markets, evidence shows that many agricultural households consume from their own production (Nandi and Nedumaran, 2022), and may not be able to economically afford ASF in the market.

Conversely, household size is associated with reduced ASF consumption and with an increased use of coping strategies by households. These results align with studies that suggest larger households may face challenges in obtaining and preparing ASF in sufficient quantities for consumption (Daba et al., 2021; Mebrie and Ashagrie, 2023). The negative association between the wealth index and the adoption of coping strategies suggests that households with higher socioeconomic status may safeguard against food insecurity shocks (Kinda and Badolo, 2019). Similarly, the result suggests that low rainfall may exacerbate food insecurity and limit households' ability for food consumption smoothing (Kinda and Badolo, 2019). These findings underscore the influence of various household dynamics, demographic and economic factors, and climate conditions on ASF consumption, and the coping strategies employed.

6.2. Impacts of farmer-herder conflicts on ASF consumption

Table 4 shows the ATT results for the three ASF consumption measures, following the presentation layout in Table 3. Similarly, we report Model 2 being the specification outlined in Equation (2). To enhance the presentation of our findings, we also report results from the event study as shown in Table A2 and Fig. A1 in the Appendix, incorporating individual ASF items. This integration allows for a comprehensive interpretation of the overall results.

Our analysis reveals important insights into the impact of farmer-herder conflicts on ASF consumption. We find that households exposed to farmer-herder conflicts experienced a significant reduction in ASF consumption. The reduction for those exposed within a 10 km radius was 11.3 g/day/aeq, and it was more, 14.8 g/day/aeq, at a 30 km radius. The event study results show that the decline can be up to 24 g/day/aeq for households exposed to the conflict earlier at a 30 km radius, indicating the cumulative impact of farmer-herder conflicts on ASF consumption. The results from the individual ASF items show a significant decrease in consumption across all food items: meat consumption reduces by 6 g/day/aeq, milk consumption by 27 g/day/aeq, poultry consumption by 30 g/day/aeq, and fish consumption by 6 g/day/aeq.

The detrimental effects of farmer-herder conflicts on meat and dairy consumption are not surprising, given that cattle are often prime targets for destruction in such conflict situations. Attacks on cattle and the disruption of the supply chain for meat and milk may have led to the observed negative impacts. Studies conducted in post-conflict Côte d'Ivoire (Dabalen and Paul, 2014), Mali (Tranchant et al., 2021), and

Table A4
The impacts of livestock diversification on ASF consumption (two-way fixed effects results).

	Animal-source foods consumed (grams per day per adult-equivalent unit)		Animal-source foods consumption coping strategies			
			Number of days households had to rely on less-preferred foods		Number of days households had to limit the variety of foods eaten	
FHC exposure at 30 km radius	1.619	2.725	−0.025	−0.038	−0.136**	−0.148*
	(2.696)	(3.730)	(0.069)	(0.087)	(0.063)	(0.076)
PH season	2.606***	2.650	−0.082***	−0.083*	−0.166***	−0.167***
	(0.894)	(2.604)	(0.020)	(0.049)	(0.018)	(0.044)
FHC exposure x PH season	−13.815***	−14.841***	0.166**	0.181	0.273***	0.287**
	(3.166)	(5.096)	(0.082)	(0.122)	(0.073)	(0.112)
Own livestock	3.156	3.093*	0.106**	0.106***	0.052	0.052
	(2.234)	(1.744)	(0.044)	(0.034)	(0.043)	(0.033)
Log of value of crop produced	0.093	0.115	0.008	0.007	0.006	0.006
	(0.241)	(0.246)	(0.005)	(0.006)	(0.005)	(0.005)
Average years of HH education	−0.068	−0.042	−0.007	−0.007	0.001	0.001
	(0.272)	(0.208)	(0.005)	(0.005)	(0.005)	(0.004)
HH size	−2.104***	−2.161***	0.040***	0.041***	0.045***	0.046***
	(0.456)	(0.349)	(0.012)	(0.011)	(0.010)	(0.009)
Wealth index	4.310***	4.312***	−0.076***	−0.075***	−0.075***	−0.073***
	(0.894)	(0.703)	(0.016)	(0.014)	(0.015)	(0.013)
Distance to market	−0.601*	−0.315	0.007	0.005	0.004	−0.001
	(0.352)	(0.289)	(0.006)	(0.006)	(0.006)	(0.006)
Distance to population	0.137**	0.160**	0.000	0.000	0.002	0.002
	(0.065)	(0.076)	(0.001)	(0.002)	(0.001)	(0.002)
Annual rainfall	0.228***	0.302***	−0.003***	−0.003***	−0.003***	−0.003***
	(0.037)	(0.048)	(0.001)	(0.001)	(0.001)	(0.001)
Annual mean temperature	1.068	0.717	0.002	−0.008	0.015	−0.003
	(0.884)	(0.650)	(0.012)	(0.010)	(0.015)	(0.010)
Constant	−452.446*	0.000	3.482	0.000	−0.488	0.000
	(244.078)	(1.132)	(3.333)	(0.023)	(4.034)	(0.021)
R-squared	0.016	0.019	0.007	0.007	0.011	0.011
Household fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Location and time fixed effects	No	Yes	No	Yes	No	Yes
Number of observations	16,970	16,970	18,842	18,842	18,838	18,838
Number of households	3,671		3,708		3,708	

Note: FHC, PH, and HH are respectively farmer-herder conflicts, post-harvest, and household. Significance levels: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$; Robust standard errors in parentheses.
Source: Authors' estimates derived from LSMS-ISA and ACLED datasets (2010 to 2016).

Nepal (Bageant et al., 2016) have reported reductions in household expenditure on meat and milk in conflict contexts. Also, the study by Bageant et al. (2016) in Nepal found a significant negative relationship between conflict and the quantity of milk consumed by livestock-holding households. They attributed the decline in milk consumption to reductions in livestock productivity and increases in milk prices, with noticeable effects on households with smaller herd sizes.

Farmer-herder conflicts negatively affecting fish consumption is also expected. This can be attributed to a decrease in household expenditure on fish, considering that a significant portion (between 23 % and 54 %) of fish consumed in rural Nigeria is imported frozen fish, while the remainder is sourced from farming or capturing (Liverpool-Tasie et al., 2021). Therefore, the disruption caused by farmer-herder conflicts may affect the availability and accessibility of these fish sources, further exacerbating the negative effects on fish consumption. The results further show that livestock-holding households significantly increase their poultry consumption by 4 g/day/aeq. Although the associations with other ASFs remain positive, they are not statistically significant. Our findings align with previous research suggesting that poultry keepers are more inclined to consume poultry products (Azzarri et al., 2015; Fadare et al., 2019). Moreover, in response to conflict risk, households diversify their livestock to include smaller species such as poultry (Arias et al., 2019), suggesting a potential impact pathway.

Furthermore, exposure to farmer-herder conflicts significantly increases ASF consumption coping strategies, increasing the number of days households would limit the variety of foods consumed. These findings highlight the positive association between farmer-herder conflicts and households resulting to food consumption coping strategies, which align with previous research conducted in Nigeria (e.g., George et al., 2020; Nnaji et al., 2022). Importantly, this evidence enhances our understanding of the severity of food insecurity among agricultural households, such negative consumption coping strategies increase in response to shocks.

6.3. Mitigating impacts of livestock diversification on ASF consumption

In Table 5, we present the ATT results for the mitigating impact of livestock diversification on ASF consumption in the same setup as presented in Table 4. We report results in Model 2, following the specifications outlined in Equation (3), and compare results from Panels A, B and C to better understand the mitigating impact of livestock diversification.

Our findings reveal that livestock diversification positively impacts ASF consumption, especially among households within a 10 km to 20 km radius of conflict events. Specifically, adopting livestock diversification strategies increases ASF consumption by up to 27 g/day/aeq, effectively mitigating the impact of farmer-herder conflicts on ASF consumption. Additionally, we found that livestock diversification has no statistically significant association with ASF consumption coping strategies, though it shows a tendency to reduce households' engagement in food consumption coping strategies, as evidenced by the negative sign of the coefficients for the two coping strategy measures.

Previous research on the effects of livestock diversification on ASF consumption in conflict situations is limited. However, there are related studies that highlight the importance of livestock diversification in improving household nutrition in different seasons. For example, Zanello et al. (2019) found that livestock diversification increased dietary diversity throughout the year in Afghanistan, indicating its role in buffering household nutrition during the lean seasons. Similarly, Ayenew et al. (2018) conducted a study in Nigeria and observed that the

Table A5
The impacts of livestock diversification on ASF consumption (three-way fixed effects results).

	Animal-source foods consumed (grams per day per adult-equivalent unit)		Animal-source foods consumption coping strategies			
			Number of days households had to rely on less-preferred foods		Number of days households had to limit the variety of foods eaten	
FHC exposure at 30 km radius	3.639	4.456	0.055	0.044	0.016	−0.001
	(3.911)	(4.122)	(0.107)	(0.107)	(0.096)	(0.089)
PH season	7.680***	7.726***	−0.173***	−0.174***	−0.207***	−0.209***
	(1.260)	(2.368)	(0.030)	(0.055)	(0.026)	(0.047)
FHC exposure x PH season	−16.410***	−17.308***	0.190	0.209	0.182	0.206
	(5.132)	(5.950)	(0.130)	(0.156)	(0.113)	(0.148)
LD	−5.314***	−4.680**	0.113**	0.109*	0.196***	0.189***
	(1.973)	(2.016)	(0.048)	(0.063)	(0.044)	(0.055)
FHC exposure x LD	3.965	4.455	−0.182	−0.189	−0.242*	−0.250*
	(5.885)	(5.026)	(0.153)	(0.148)	(0.145)	(0.135)
PH season x LD	−15.360***	−15.303***	0.275***	0.275***	0.146***	0.146**
	(1.865)	(2.854)	(0.051)	(0.078)	(0.046)	(0.065)
FHC exposure x PH season x LD	8.488	8.063	−0.144	−0.144	−0.029	−0.026
	(7.515)	(7.461)	(0.188)	(0.210)	(0.175)	(0.203)
Log of value of crop produced	0.078	0.057	0.016**	0.017**	0.015**	0.017***
	(0.355)	(0.294)	(0.008)	(0.008)	(0.006)	(0.006)
Average years of HH education	0.336	0.374*	−0.009	−0.009	−0.002	−0.002
	(0.323)	(0.215)	(0.007)	(0.006)	(0.006)	(0.005)
HH size	−1.889***	−1.952***	0.028*	0.027**	0.029**	0.029**
	(0.573)	(0.375)	(0.015)	(0.013)	(0.013)	(0.012)
Wealth index	4.661***	4.721***	−0.077***	−0.078***	−0.078***	−0.078***
	(1.115)	(0.863)	(0.023)	(0.019)	(0.021)	(0.017)
Distance to market	−0.648	−0.272	0.005	−0.004	−0.005	−0.025**
	(0.516)	(0.448)	(0.008)	(0.009)	(0.011)	(0.011)
Distance to population	0.076	0.098	0.003*	0.003	0.004***	0.004**
	(0.067)	(0.066)	(0.001)	(0.002)	(0.001)	(0.002)
Annual rainfall	0.175***	0.252***	−0.002***	−0.003***	−0.002**	−0.003***
	(0.044)	(0.043)	(0.001)	(0.001)	(0.001)	(0.001)
Annual mean temperature	0.462	0.359	0.018	0.003	0.019	−0.004
	(0.790)	(0.592)	(0.015)	(0.012)	(0.017)	(0.012)
Constant	−209.531	0.000	−1.623	−0.000	−1.929	0.000
	(226.892)	(0.793)	(4.262)	(0.022)	(4.872)	(0.019)
R-squared	0.027	0.030	0.014	0.014	0.020	0.021
Household fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Location and time fixed effects	No	Yes	No	Yes	No	Yes
Number of observations	11,373	11,373	12,827	12,827	12,824	12,824
Number of households	2,917		2,960		2,960	

Note: FHC, PH, HH, and LD are respectively farmer-herder conflicts, post-harvest, households, and livestock diversification. Significance levels: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$; Robust standard errors in parentheses.
Source: Authors' estimates derived from LSMS-ISA and ACLED datasets (2010 to 2016).

positive effect of crop-livestock diversification on dietary diversity was only significant during the post-harvest season, not during the post-planting season. This difference could be due to the availability of harvested foods during the post-harvest season in Nigeria, while water and pasture scarcity, as well as conflicts between farmers and herders, could lead to a decline in livestock production during that time. These challenges can undermine livestock production and food consumption for households in conflict-prone regions, especially during critical months and seasons with heightened conflicts.

7. Policy implications and conclusions

The findings of this study have important policy implications for addressing the impact of farmer-herder conflicts on food security, particularly in relation to ASF consumption. Specifically, our analysis highlights the significant negative effect of farmer-herder conflicts on ASF consumption, with households experiencing a decrease in meat, milk, poultry, and fish consumption. More importantly, livestock diversification emerges as a potential strategy to mitigate the negative impact of conflicts on ASF consumption. These findings underscore the need for proactive measures to mitigate the detrimental effects of conflicts on food security. The study also emphasises the need for a specific focus on ASF in nutrition policy research, as the impact of conflict on ASF consumption can be overlooked when considering broader dietary diversity and child anthropometric indicators.

To improve ASF consumption and mitigate the effects of conflicts on overall food security, some specific policies are recommended. A key insight from our study is the moderating role of seasonality in the relationship between farmer-herder conflicts and ASF consumption. Researchers should therefore control for the influence of seasonality in their analysis to accurately assess the impact of farmer-herder conflicts on food consumption. Interventions and strategies aimed at improving ASF consumption should also consider the seasonal dynamics and adjust accordingly. Failure to account for this factor may lead to a misrepresentation of the relationship, thereby hindering effective policy formulation.

Our findings further highlight the importance of promoting livestock diversification, particularly in conflict-prone areas. Livestock diversification can enhance dietary diversity, thereby improving household food security. Policies that promote livestock diversification through measures such as providing technical assistance, access to credit, and training on livestock management can enhance household nutrition and resilience to conflict shocks, while also effectively enhancing food security in conflict-affected areas. However, emphasis should be placed on smaller species like poultry, which are less cumbersome to manage in conflict situations and have shown positive associations with ASF consumption.

In conflict situations, livestock diversification towards small species, as suggested in some studies (Arias et al., 2019; Fadare et al., 2022), may lead to a reduction in household income as large livestock (cattle) are

Graphical presentation of results of the event study estimation

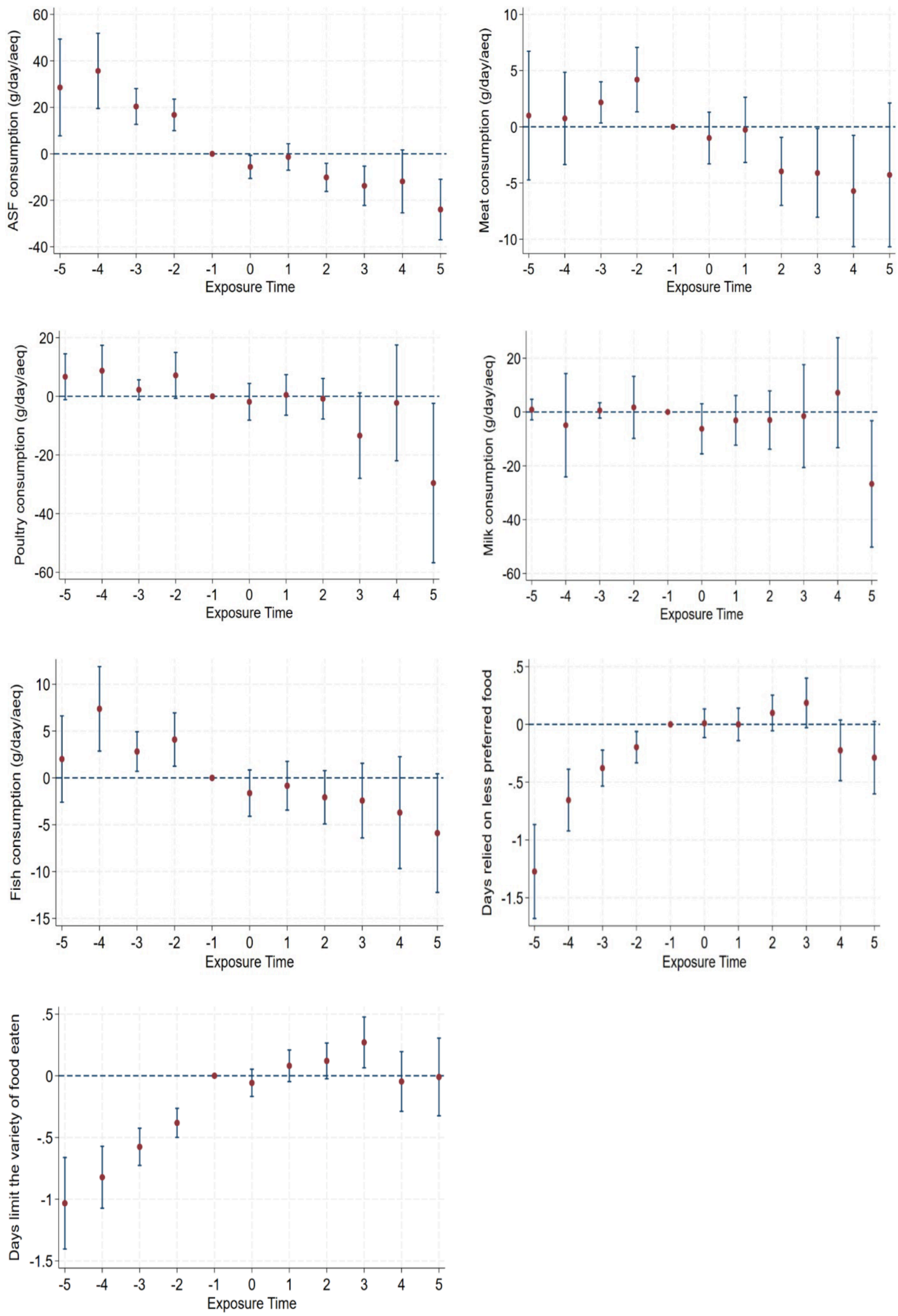

Fig. A1. Event study estimation results with confidence intervals of 95%, show point estimates of each time period before and after the exposure period, the event interval coefficients representing the average mean differences between the exposed and non-exposed groups.

perceived as valuable assets. This income reduction can hinder households' ability to meet non-food but nutrition-sensitive needs such as education, healthcare, and water and sanitation. To address this issue, it is crucial to extend social protection and safety net programs to households enduring protracted conflict, enabling them to access essential non-food needs. By increasing the household budget for nutritious foods, these interventions can contribute to improved nutritional outcomes. Therefore, the government and humanitarian organisations should prioritise food and non-food interventions for vulnerable livestock-holding households affected by conflict shocks, particularly during critical seasons of nutritional vulnerability.

In addition, livestock ownership plays a significant role in ASF consumption, especially poultry consumption. Yet, market access is crucial in meeting household ASF needs and improving market infrastructure and access to ASF markets is a significant step in enhancing consumption. Policies that support livestock production, improve market access for livestock products, reduce transportation costs, improve storage facilities, and facilitate market linkages can help ensure a stable supply of ASF for households. This study also highlights the importance of considering household dynamics, demographic and economic factors, and climate conditions in interventions and strategies aimed at improving ASF consumption. Factors such as household wealth, distance to the population centre, and rainfall all have a positive effect on ASF consumption, while the household size and distance to the market exert a diminishing effect. Policies that target these factors, such as income generation programs, infrastructure development, and climate resilience initiatives, can contribute to improving ASF consumption and overall food security.

The availability of globally georeferenced conflict data and longitudinal household surveys covering pre-conflict periods presents an opportunity to enhance our understanding of the relationship between conflict, food security, and overall well-being. Studies need to expand on the nutrition indicators used to assess the impact of conflict on household nutrition. This will provide more robust evidence for informed policy actions. This research can provide valuable insights for policy development not only in Nigeria but also in other African countries grappling with similar farmer-herder conflicts.

More importantly in Nigeria, efforts should be made to resolve farmer-herder conflicts and promote peaceful coexistence. This includes engaging communities in dialogue, establishing conflict resolution mechanisms, and addressing the underlying causes of conflicts, such as water and land resource scarcity. Specifically, addressing the protracted and seasonal nature of farmer-herder conflicts requires conflict-sensitive livestock policies. These policies should include promoting sedentary cattle ranching systems, developing irrigation systems, adopting climate-smart agricultural production systems, and establishing appropriate land tenure policies. Prioritising climate-smart agriculture and supporting farmers and herders in adapting to changing climate conditions are essential. These measures can contribute to reducing conflicts and ensuring food security in conflict-affected regions. While the Nigerian government has a National Livestock Transformation Plan in place, there is largely a distrust of the led administration by farmers and herders alike (International Crisis Group, 2021), which needs to be addressed.

In conclusion, understanding the channels through which conflict affects food security in general and ASF consumption specifically is crucial for developing effective interventions. Our study highlights the significant negative impact of farmer-herder conflicts on ASF consumption and the potential of livestock diversification to mitigate these effects. The findings underscore the importance of considering seasonal dynamics, household dynamics, and market access in interventions aimed at improving ASF consumption. By implementing targeted policies and interventions that address these factors, policymakers can effectively address the food security challenges posed by farmer-herder conflicts and promote sustainable and resilient food systems.

CRediT authorship contribution statement

Olusegun Fadare: Conceptualization, Data curation, Formal analysis, Funding acquisition, Investigation, Methodology, Project administration, Resources, Software, Validation, Visualization, Writing – original draft, Writing – review & editing. **Chittur Srinivasan:** Conceptualization, Funding acquisition, Resources, Software, Supervision, Validation, Visualization, Writing – review & editing. **Giacomo Zanello:** Conceptualization, Funding acquisition, Resources, Software, Supervision, Validation, Visualization, Writing – review & editing.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix

A.1. Correlation analysis between nutrients-dense foods and consumption coping strategies

(See Tables A1–A5, Fig. A1).

A.2. Additional analysis using event study estimator

a. Model specification

The event study model is a suitable approach for estimating staggered interventions, such as in our case where households were exposed to conflict at different points in time. This model helps assess how relative outcomes evolve over time. It accomplishes this by evaluating the dynamics before the exposure between exposed group and a comparison group with differential timing of exposure. This approach incorporates 'treatment' leads and lags, as demonstrated by Miller et al. (2021). The event study model is specified as follows:

$$Z_{hlt} = \beta C_{lt} + \sum_{s=1}^{S} C_{l,t+s}\varphi_s + \sum_{m}^{M} C_{l,t-m}\lambda_s + \rho \boldsymbol{X}_{hlt} + \gamma_t + \vartheta_h + \varepsilon_{hlt}$$

where Z_{hlt} represents ASF consumption as aggregated and disaggregated into meat, milk, poultry, and fish, and ASF consumption coping strategies for household h in LGA l in time period t. C_{lt} is the exposure indicator as earlier defined. β captures the immediate effect of conflict, while s is the leads or anticipatory effects, and m is the lags or post-exposure effects. Under the strict exogeneity assumption, $\varphi_s = 0$ for $s = 1 \cdots S$. While λ_m measures any additional effects of the conflict that occur in m periods after exposure. If the initial effect of the conflict is positive, then the negative values of λ_m imply that the initial effect of the conflict dissipates over time, and the positive values of λ_m suggest that the conflict has larger effects over time. Vector $\boldsymbol{X}_{hlt}$ includes control variables, while γ_t, ϑ_h and ε_{hlt} are as earlier specified.

b. **Additional results**

Graphical presentation of results of the event study estimation

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