The impacts of equal access to land and farmer-herder conflicts on household food insecurity and production decisions in Nigeria

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Amaka Precious Nnaji

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Declaration

This work was completed under the supervision of Assoc. Prof. Nazmun N. Ratna, Professor Alan Renwick and Assoc. Prof. Wanglin Ma at Lincoln University, New Zealand. Four analytical chapters of this work have been published in Agricultural Resource and Economics Review, International Journal of Social Economics and European Review of Agricultural Economics. To the best of my knowledge, the thesis is original and contains no materials previously written or published by any other persons except as acknowledged in the text.

Amaka Precious Nnaji

Abstract of a thesis submitted in partial fulfilment of the
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Food insecurity remains a key challenge in most developing countries, especially in Sub-Saharan Africa. Among others, the threats to food security include unequal access to productive resources like land and increasing resource-use conflicts over scarce land resources. Several studies attempted to understand how access to productive resources affects the food security of rural households and what this implies for female-headed households. Studies have highlighted the main causes of the increasing farmer-herder conflicts over land resources. However, few empirical studies have sought to understand the mediating effect of access to land on the influence of gender on food insecurity. There is also a lack of knowledge regarding the immediate and long-term influence of farmer-herder conflicts on the livelihoods and food security of rural households. This thesis, therefore, contributes to these strands of literature by investigating (1) the impact of gendered access to land on food insecurity; (2) the direct and indirect implications of farmer-herder conflicts on rural households' production decisions and food security; and (3) the factors that influence the risk perception of farmer-herder conflicts.

This thesis includes seven chapters. Chapter 1 provides a general introduction. Chapter 2 presents an overview of the data and empirical strategies adopted to address the research questions. Chapter 3 examines the mediating effect of land access on the effect of gender of the household head on household food insecurity using a logistic regression model and secondary data from the Nigeria General Household Survey. Chapter 4 determines the influence of the incidence and severity of farmer-herder conflicts on the food insecurity of rural households' using primary data from 401 rural households in Nigeria and employs a two-staged predictor substitution instrumental variable analysis. Chapter 5 investigates the effect of the risk perception of farmer-herder conflicts on rural households' production decisions using simultaneous equation regression analysis. Chapter 6 explores the factors influencing the risk perception of farmer-herder conflicts using ordinary least squares and seemingly

unrelated regression analysis. Finally, the last chapter provides a general conclusion and discusses policy implications.

The empirical results show that even though female-headed households are more food insecure than male-headed households, with extra access to one acre of farmland, they are 16% less likely to be food insecure compared to male-headed households. Results also reveal that both the incidence and severity of farmer-herder conflicts increase the food insecurity status of rural households; although, the severity of farmer-herder conflict has a larger impact than its incidence. Regarding rural households' risk perception of farmer-herder conflicts and household production decisions, results indicate that the risk perception of farmer-herder conflicts exerts negative effects on the likelihood of adopting fertilisers, investment in fertilisers, and the degree of participation in the land rental market. In addition, rural households' risk perception of farmer-herder conflicts exerts a positive and statistically significant impact on their time allocation for farm work. The results also indicate that farming experience of household head, farm size, crop and livestock diversity, migration status, number of languages spoken, ownership of formal title to farmland, settlement density, and household location are primary factors influencing the risk perception of farmer-herder conflicts.

The findings of this thesis call for the development of policies that tackle unequal gendered access to land. Initiatives that facilitate procurement and enforcement of formal land titles to improve tenure security can reduce the perceived risk of farmer-herder conflicts. Finally, all results highlight the importance of dealing with the root cause of farmer-herder conflicts by facilitating policies that promote more sustainable herding practices to curb the likelihood of these types of conflicts.

Keywords: Land access; gender; farmer-herder conflict; food security; production decisions; households; Nigeria.

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Chapter 1

General Introduction

1.1 Motivation and Problem Setting

In developing countries, where the majority of the population is primarily involved in agricultural production, land is a vital economic resource. Since most rural dwellers are largely engaged in agricultural activities, access to land is important for their livelihoods and subsequent well-being. While studies have shown that improved access to land increases the food security prospects for agrarian households (Jayne et al., 2003; Muraoka, Jin, & Jayne, 2018; Rammohan & Pritchard, 2014), there is evidence that households headed by women have less access to land than men (Adekola et al., 2013; Ankrah, Freeman, & Afful, 2020; Lambrecht, 2016; Moyo, 2017; Pindiriri, 2021; Tripta & Mehta, 2009; Twum et al., 2020; Wineman & Liverpool-Tasie, 2017). In addition, existing studies show that male-headed households are more food secure than female-headed households (Akadiri, Nwaka, & Jenkins, 2018; Choithani, 2020; Gebre et al., 2021; Joshi & Joshi, 2017; Kassie, Ndiritu, & Stage, 2014; Larson, Castellanos, & Jensen, 2019; Ma et al., 2021; Shin, 2020; Tibesigwa & Visser, 2016).

Also, increased timely access to arable land by female-headed households has been found to improve their poverty status, especially if it targets landless households and those with less than three acres of land (Pindiriri, 2021). However, a gap still exists in the literature in understanding how and to what extent increased access to land resources influences the food security status of female-headed households. There is a lack of empirical evidence illustrating the mediating effect of land access on the impact of gender on household food security.

Gendered access to land, however, is no longer the immediate problem for developing countries prone to conflict, especially those involving farmer-herder (FH) conflicts. The problem becomes greater than a gender issue. Although FH conflicts have always existed, studies show that the cause of the recent

increase in FH conflicts is the recurrent drought[1] and consequent increased competition for land resources by herders and crop farmers. Extant literature also shows that there are other causes of FH conflicts, including the blockage of cattle grazing routes by crop farmers, destruction of crops by cattle, scarcity, and competing use of freshwater (Audu, 2013; Dary, James, & Mohammed, 2017; Umar, 2002; Usman, Bakari, & Abdullahi, 2017). All these have detrimental consequences for the livelihoods of both parties, for example through the loss of yield and income by both farmers and herders (Usman et al., 2017). There is a dearth of empirical studies investigating the impact of the occurrence and severity of FH conflicts on rural households' food security. Hence, there is a need to empirically determine the influence of FH conflicts on the food security of rural households.

In addition, the literature shows that farm households react to uncertainty in a conflict situation even without having physically experienced conflict (Arias, Ibáñez, & Zambrano, 2019). Likewise, Rockmore (2020) found that the risk of conflict affects crop and livestock portfolios negatively. However, a gap exists in the knowledge of how farming households react to the threats of FH conflicts. The impact of the risk perception of FH conflicts will become one of the biggest issues in countries with higher climate vulnerability. Therefore, there is a need to empirically investigate the impact of the risk perception of FH conflicts on rural households' production decisions and behaviour.

Furthermore, determining the socioeconomic and demographic factors that influence how the risk of FH conflicts is perceived becomes essential to aid understanding of the behavioural process of farmers in a conflict. In addition, an awareness of what attributes impact farmers' perception of the threat of FH conflicts will aid policymakers and other stakeholders in the agricultural sector in facilitating strategies that will be effective in promoting agricultural production and improving the welfare of rural dwellers.

This thesis contributes to the gendered land access and FH conflict literature by filling these research gaps indicated above. Using both secondary data from the 2015/2016 Nigerian general household

[1] Moderate to severe historical droughts occurred in Nigeria between 1914, 1924, 1935, 1943, 1951-1954, 1972-1973 and 1991-1995 (Federal Ministry of Environment, 2018)

survey and primary data from rural households in Nigeria's North Central and South-East geopolitical zones. Nigeria is selected in this thesis as the study area for several reasons. First, it is the most populous country in Africa, with an annual population growth rate of about 2.6%, and the bulk of its population is primarily involved in agricultural activities (NBS, 2021a). Second, there has been a recent increase in the occurrence and frequency of FH conflicts in Nigeria (Madu & Nwankwo, 2020). The detrimental effects of these conflicts have been exacerbated by the rapid population increase, rising temperatures, and the resultant increase in drought and desertification in the Sahelian region (Day & Caus, 2020b). These make the choice of Nigeria appropriate for examining the dynamics of FH conflicts, land access, and how these influence rural households' food security and livelihoods.

1.2 Background

Food insecurity persists despite numerous efforts to curtail it. According to the Food and Agricultural Organisation (FAO), just under nine per cent of the world's population are undernourished, while 26 per cent lack regular access to sufficient nourishing food in 2019 (FAO et al., 2020). The agricultural sector plays a vital role in improving food availability and subsequent food security, especially in developing countries. Prior evidence has shown that adoption of improved farm technologies, extension services, and improving value-added food systems help increase the productivity of smallholder farmers, contributing to food security at both national and global levels (Brander, Bernauer, & Huss, 2021; Gebru, Brhane, & Gebremedhin, 2021; Huss et al., 2021; Otsuka, 2013; Pawlak & Kołodziejczak, 2020).

The share of agriculture in the global gross domestic product (GDP) has been stable at about four per cent since 2000 (FAO, 2020). In Africa, the share of agriculture in GDP increased one and a half per cent over the 2000-2018 period. For most developing countries, especially in the sub-Saharan Africa (SSA) region, the share of the agricultural sector in total GDP is increasing (FAO, 2020). In Nigeria, for example, it increased from 17.2 per cent in 2000 to 22.4 per cent by 2018 and now employs about 19.5 million people (FAO, 2020). Although the share of employment in agriculture has declined globally,

agriculture remains the second-highest employer of labour after the services sector (FAO, 2020). Africa has the highest share of employment in agriculture (around 49 per cent of the total population), implying that for most countries in Africa, agricultural production is the mainstay of their economy. Therefore, advancement in agriculture can establish the foundation for the progress and growth of developing countries, especially in SSA. Improved agricultural production will offer stable and improved access to safe and nutritious food leading to increased food security (FAO et al., 2020; OECD/FAO, 2016; Otsuka, 2013).

Despite the significant role of agriculture in ensuring economic growth and food security in developing countries, several factors are challenging the sustainability of agricultural sectors. These include climate change and the resulting adverse weather events, freshwater scarcity, limited access to arable land, soil fertility deterioration, limited market access, and the subsequent post-harvest losses (Jellason, Robinson, Chapman, et al., 2021; Jellason, Robinson, & Ogbaga, 2021; Shuaibu & Nchake, 2021). In SSA, perhaps the greatest challenge of the agricultural sector is poor infrastructure including irrigation systems, transportation networks, access to power, as well as storage facilities (Jellason, Robinson, & Ogbaga, 2021; OECD/FAO, 2016). These challenges have contributed to the dwindling productivity of the agricultural sector.

In SSA, one of the major obstacles to enhanced agricultural production is insufficient access to arable land (OECD/FAO, 2016). For instance, even though most of the land in rural SSA is under-utilised, the majority of its rural population are smallholder farmers in densely populated areas facing land shortages (Chamberlin, Jayne, & Headey, 2014; Jayne, Chamberlin, & Headey, 2014). Because a shortage of land negatively affects food security and rural household welfare, finding ways to increase access to land for smallholder farmers is a crucial developmental concern (Jayne et al., 2014).

Subsumed in the challenge of limited land access in developing countries, is the issue of inadequate access to land resources for women. Historically, women have been disadvantaged in terms of access to productive resources like land, in most cases having use rights rather than ownership (Agarwal, 1994, 2003; Dokken, 2015; Odeny, 2013). Even when women have access to land, they may have

insecure tenure and consequently cannot use the land as collateral to access credit to improve agricultural investment and productivity (Dokken, 2015; Doss, Summerfield, & Tsikata, 2014; Khalid, Nyborg, & Khattak, 2015). This is a noteworthy problem considering women contribute significantly towards global food availability by their direct participation in agricultural production (Doss et al., 2018; Fonjong & Gyapong, 2021). Studies have shown that increased availability of land resources can increase household welfare and make the difference between a food secure and food-insecure household (Goli, Rammohan, & Reddy, 2021; Muraoka et al., 2018; Rammohan & Pritchard, 2014). Thus, since women contribute significantly to their households' welfare and food security (Agarwal, 2003), the unequal access to land resources for agrarian households headed by women may inadvertently lead to a decline in the welfare of such households. Empirical evidence of this impact is key to informing policies that encourage more equitable access to arable land.

However, in a conflict situation, the problem becomes much worse. Conflicts may occur because of terrorism (e.g., Boko Haram insurgency in Nigeria or Al-Shabab insurgence in Somalia) or the resource-use conflict between herders and farmers. In this study, the focus is on conflicts resulting from resource-use problems between farmers and herders. Historically, there have been ongoing conflicts between herders and crop farmers over scarce land resources (Mbih, 2020). However, in recent times, these resource-use clashes have been on the increase due to rising temperatures, and erratic rainfall initiating recurrent droughts and floods in the Sahel (Ahmed & Kuusaana, 2021; Benjaminsen et al., 2012; Day & Caus, 2020a). In most SSA countries, this had led to conflicts between farming communities and pastoralists because of unresolved cases of encroachment into grazing routes by farmers or crop damage by herders (Benjaminsen & Ba, 2019; Jones-Casey & Knox, 2011; Shettima & Tar, 2008).

In Nigeria, farmer-herder (FH) conflicts have been increasing in both number and severity and now cause more fatalities than conflicts from armed groups like the "Boko Haram" insurgents (ICG, 2018). Between 2016 and 2018 alone, FH conflicts led to the death of around 1,500 people and the displacement of about 300,000 (ICG, 2018). Being the most populous country in Africa, FH conflicts in

Nigeria are more prevalent because of the large populace and the resulting intensification of agricultural production to meet the rising food demand. Women and girls are also more vulnerable during FH conflicts. In patriarchal societies like Nigeria, the loss of male breadwinners during FH conflicts frequently leave women vulnerable and unable to support themselves and their families. Women suffer the most in conflict-prone areas with unequal access to productive resources and economic opportunities (Day & Caus, 2020a; Pindiriri, 2021). Understanding how these conflicts influence rural livelihoods and food security is therefore essential to help guide and inform policy aimed at tackling the problem.

1.2.1 Economic Conditions in Nigeria

With a population of about 206.1 million people and a gross domestic product (GDP) of US$440.9 billion, Nigeria is a lower-middle-income country (World Bank, 2021). According to the World Bank, Nigeria is ranked the 27th largest economy in the world and 24th with respect to purchasing power parity. Nigeria has the largest economy in Africa, with a debt-to-GDP ratio of 18.82 per cent as of 2020 and a Gini inequality index of 35.1 in 2018 (World Bank, 2021). In 2020, Nigeria had a GDP per capita of US$2139.1 with an annual decrease of 0.7 per cent, 0.4 per cent, and 4.2 per cent from 2017, 2018 and 2019, respectively. The real GDP growth in Nigeria increased 1.9 per cent in 2018 and 2.2 per cent in 2019, but reduced by three per cent in 2020 (AfDB, 2021; Nam, 2020). The statistics above show that even though the Nigerian economy is growing, as shown by the increasing GDP, there is a sustained decline in per capita income which is reflected in the increased poverty rate and high Gini index. Currently, Nigeria's economy is in a recession due to the COVID-19 economic lockdown measures, as well as the decline in crude oil prices (World Bank, 2021).

Formerly a large exporter of agricultural produce, Nigeria currently imports some of its food products to meet domestic demand. Its agricultural sector has not grown to keep pace with its rapid population growth (NBS, 2021a; World Bank, 2021). Other reasons for the declining levels of national food sufficiency are smallholder agricultural cultivation, market constraints, overreliance on rain-fed agriculture, poor access to productive inputs like fertilisers, and a poor agricultural extension system.

1.2.2 Overview of the Agricultural Sector in Nigeria

Agriculture is the major source of livelihood for most Nigerians, with the agricultural sector employing greater than 35 per cent of the labour force, according to the international labour organisation (ILO, 2019). The agricultural sector is dominated by smallholder farmers, accounting for about 90 per cent of agricultural produce. The agricultural sector contributed 23.78 per cent to Nigeria's aggregate real GDP in the second quarter of 2021, decreasing 0.87 per cent from the same quarter in 2020 (NBS, 2021b). For the past decade, the agricultural sector's share in Nigeria's total budget has been less than three per cent, which is substantially lower than 10 per cent, the specified amount in the Maputo Declaration on Agriculture and Food Security (Olowe, 2021).

The food crop subsector in Nigeria, which includes the production of cassava, rice, millet, tomatoes, cocoa, yams, groundnut, etc., remains the main driver of growth in the Nigeria agricultural sector, accounting for 89.13 per cent of the sector's real GDP share in the second quarter of 2020 (NBS, 2020b). On the other hand, the livestock production subsector accounted for about 7.38 per cent of the Nigerian agricultural sector's real GDP share in the second quarter of 2020 (NBS, 2020b).

Despite the importance of the agricultural sector, its contribution to national GDP has declined consistently from 37.5 per cent in 2002 (Urama & Yuni, 2018) to about 22 per cent in 2020 (NBS, 2020b). The Nigerian government introduced several policies and initiatives to boost agricultural productivity and enhance local trade and exports. These policies include the Agricultural Transformation Agenda (ATA) 2011-2015, the Agricultural Promotion Policy (APP) 2016-2020, and the agricultural sector food security and nutrition strategy 2016-2025 (Ecker & Kennedy, 2019). This set of policies aim to improve agricultural production to meet local food demand amidst the rapid population increase, and convert the sector from subsistence to commercial and export-oriented production (Ecker, Hatzenbuehler, & Mahrt, 2018; Ecker & Kennedy, 2019). Notwithstanding these interventions, the agricultural sector remains constrained. The low productivity of both cash and staple crops has contributed to the dwindling performance of agriculture and is due largely to an overreliance on rain-

fed agriculture, market constraints, poor access to credit, and low use of productive inputs such as fertilisers (OECD/FAO, 2016; Urama & Yuni, 2018).

Furthermore, the incidences of conflicts between nomadic herders and farming communities have also increased in recent years, exacerbating crop failure, death of livestock, loss of output and property. Despite the increased frequency of these conflicts with the resulting reported adverse consequences (ICG, 2018), nothing concrete has been done to resolve this problem sustainably. Therefore, these justify the need to empirically examine the consequences of the ongoing FH conflicts and ultimately stimulate policy action towards tackling the problem to ensure the safety of rural dwellers and protect their livelihoods.

1.2.3 Food Insecurity in Nigeria

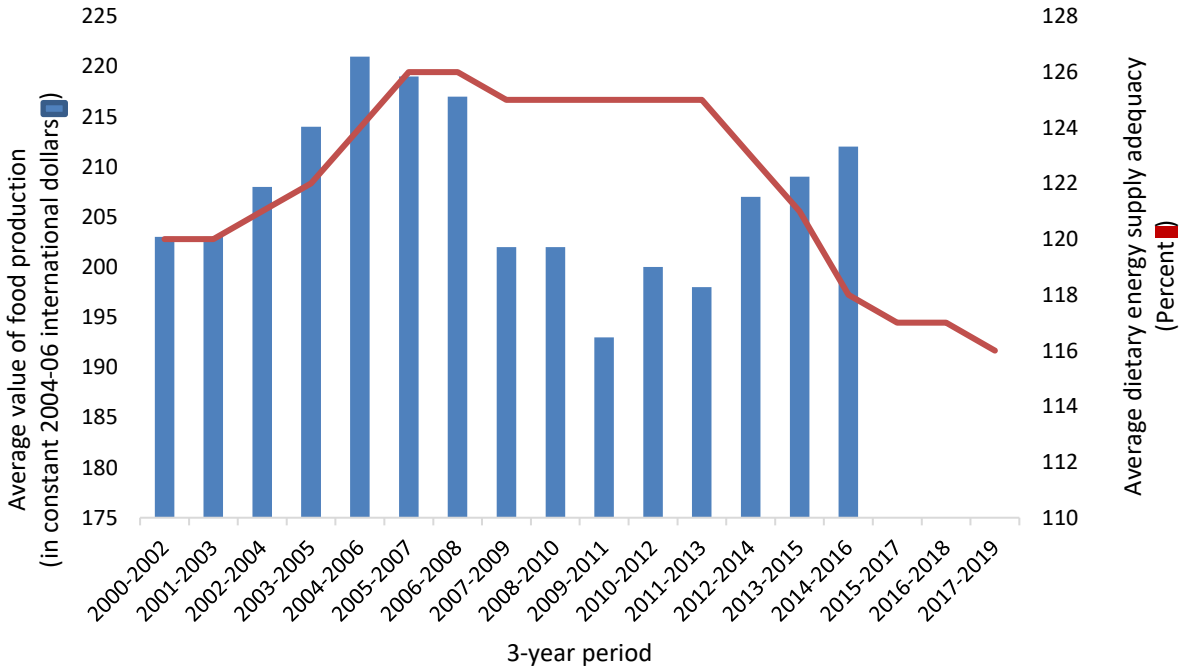
The second sustainable development goal (SDG2) is to achieve zero hunger, attain food and nutrition security, and promote sustainable agriculture. Food security exists when all people have adequate social, physical, and economic access to safe, sufficient, and nutritious food at all times to meet their dietary preferences and needs to facilitate a healthy and active life (FAO, 1996). This multidimensional definition is centred on four pillars, namely: food availability which captures food supply adequacy; food accessibility or affordability; food stability which depicts adequate food supply without seasonal shortages or fluctuations; and food utilization. Indicators for food and nutrition security include domestic production, the percentage of under-five children who are underweight and stunted, and domestic food price volatility.

In Nigeria, food security indicators reveal a food insecurity problem. Figure 1.1 illustrates the average food production and dietary energy supply for 3-year periods.[2] This figure illustrates that even though mean food production was increasing over the last couple of periods, the average dietary energy supply is on the decline. This is because of the rapid disproportionate increase in the national

[2] FAO's approach to estimating energy adequacy has been criticised as not giving enough information on dietary energy consumption of nutritionally vulnerable population within countries. Nonetheless, it is an important indicator of whether a country's food supply is sufficient to meet its aggregate population needs.

population that puts more pressure on food resources. The inability of local agricultural production to meet domestic food requirements in terms of quantity and quality is a consistent problem that has yet to be rectified. Several agricultural initiatives enacted to improve national self-sufficiency in food production by improving the food supply of smallholder farmers in Nigeria have failed (Iwuchukwu & Igbokwe, 2012; Obot et al., 2021).

According to the Food and Agricultural Organisation, in 2020, over 9 million people in Nigeria faced food insecurity due to the negative impacts of COVID-19, armed conflicts, and climate change (WFP & FAO, 2021). This figure is expected to increase to 12.8 million in 2021, with the majority situated in conflict-affected States if nothing is done to prevent it.



Source: FAO (2021)

Figure 1.1 Average food production and dietary energy supply

1.2.4 Farmer-Herder Conflicts in Nigeria

As was described in the background section, conflicts between nomadic herders and farming communities, hereafter called farmer-herder (FH) conflicts, are currently a significant cause of concern in Nigeria. Historically, FH conflicts have always occurred in Nigeria, especially over land resources and

damage to cropland, but recently, their frequency and intensity have increased (Hussein, Sumberg, & Seddon, 1999; Lenshie et al., 2020). This has mostly been attributed to increasing temperatures and recurring drought and desertification in the Sahelian regions of Nigeria, as a result of climate change and the resulting increase in the migration of nomadic herders southwards in search of pasture for their animals (Day & Caus, 2020a; ICG, 2017). This migration leads to disputes with crop farmers over the conflicting use of scarce land resources.

Ethnic and religious divisions have also been found to worsen these FH conflicts. In Nigeria, about 90% of nomadic herders comprise Fulani's and are predominantly Muslim (ICG, 2018). On the other hand, most farming communities of varying ethnicities are predominantly Christian. The rise in the tribal militia in both communities combined with the ineffective government response has increased violence between both parties. According to the International Crisis Group, the escalation of violence and insecurity due to FH conflicts led to the displacement of over 300,000 people from their homes and the death of about 1,500 in 2018 alone (ICG, 2018).

The Nigerian government responded to the surge in incidences of FH conflicts by proposing several initiatives like establishing Cattle colonies and creating Rural Grazing Areas (RUGA) (ICG, 2021). These policies were vehemently resisted by groups in the southern part of the country, stating the lack of multi-stakeholder consultation in their establishment. Also, the policies were perceived as a ruse by the government to enforce herding routes across agricultural land and a land-grab for herders (ICG, 2021). In response, some State governments instituted laws that outrightly prohibited open grazing leading to dramatic increases in FH conflicts within those states (Day & Caus, 2020b). The Cattle colonies and RUGA establishment policies were eventually suspended.

Finally, the National Livestock Transformation Plan was initiated to tackle this increased tension between nomadic herders and sedentary crop farmers in 2019 (Day & Caus, 2020b). It involved establishing new ranches and restoring grazing reserves to ease competition between herders and farmers over land and water resources (ICG, 2021). To be implemented in stages, the Livestock Reform Plan has met with several political and administrative challenges. Amid all these, rural households from

both sides who are dependent on these resources for their livelihoods are suffering the adverse effects of these FH conflicts.

1.3 Research Questions and Objectives

This thesis is therefore undertaken to examine the impacts of gendered land access on household food insecurity and to investigate the implications of FH conflicts on rural food security and livelihoods in Nigeria. Specifically, the thesis is aimed at answering the following questions:

1. What is the moderating effect of land access on the influence of gender of household head on household food insecurity status?
2. What are the direct and indirect impacts of FH conflicts on rural households' livelihoods and food security?
3. What factors influence how rural households perceive the risk of FH conflicts?

Using the above questions to guide the research, the research objectives are defined as follows:

1. Determine the joint effect of gender of household head and land access on household food insecurity;
2. Examine the differential impacts of the incidence and severity of FH conflicts on rural household food insecurity;
3. Investigate the impact of the risk perception of FH conflicts on rural household production decisions;
4. Evaluate the socioeconomic and demographic determinants of rural households' risk perception of FH conflicts.

Figure 1.2 outlines the analytical framework of this thesis.

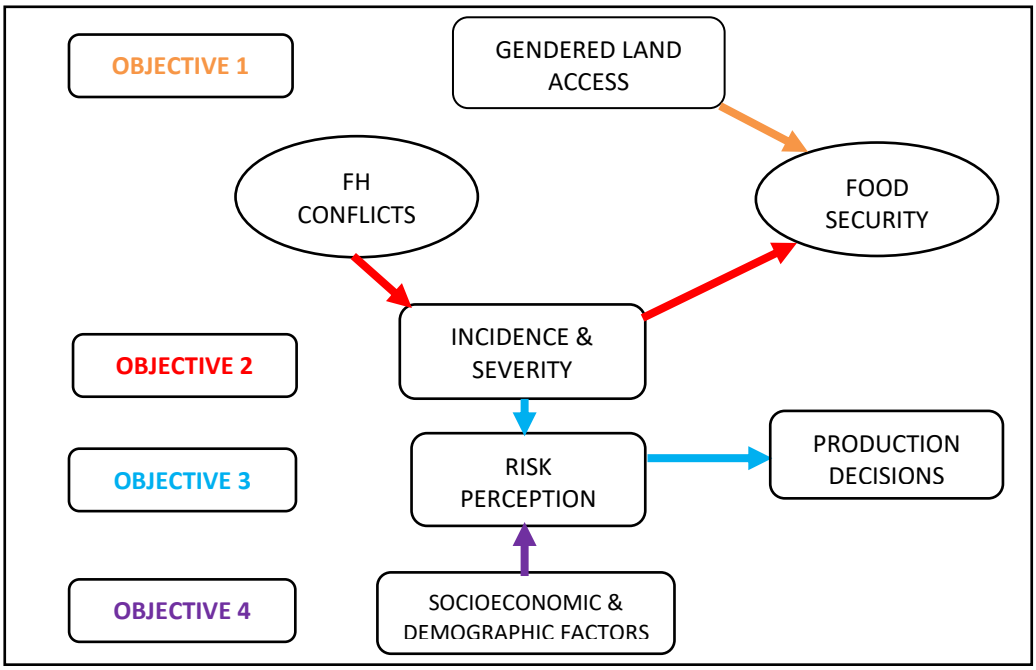


Figure 1.2 Analytical framework

This thesis adopts different empirical strategies to achieve the above objectives. An overview of the different empirical strategies is discussed in the next chapter. Secondary data is used to achieve objective 1. Output from objective 1 informs the primary data collection for objectives 2, 3, and 4. Figure 1.3 summarizes the methods used to examine each research objective empirically and outputs.

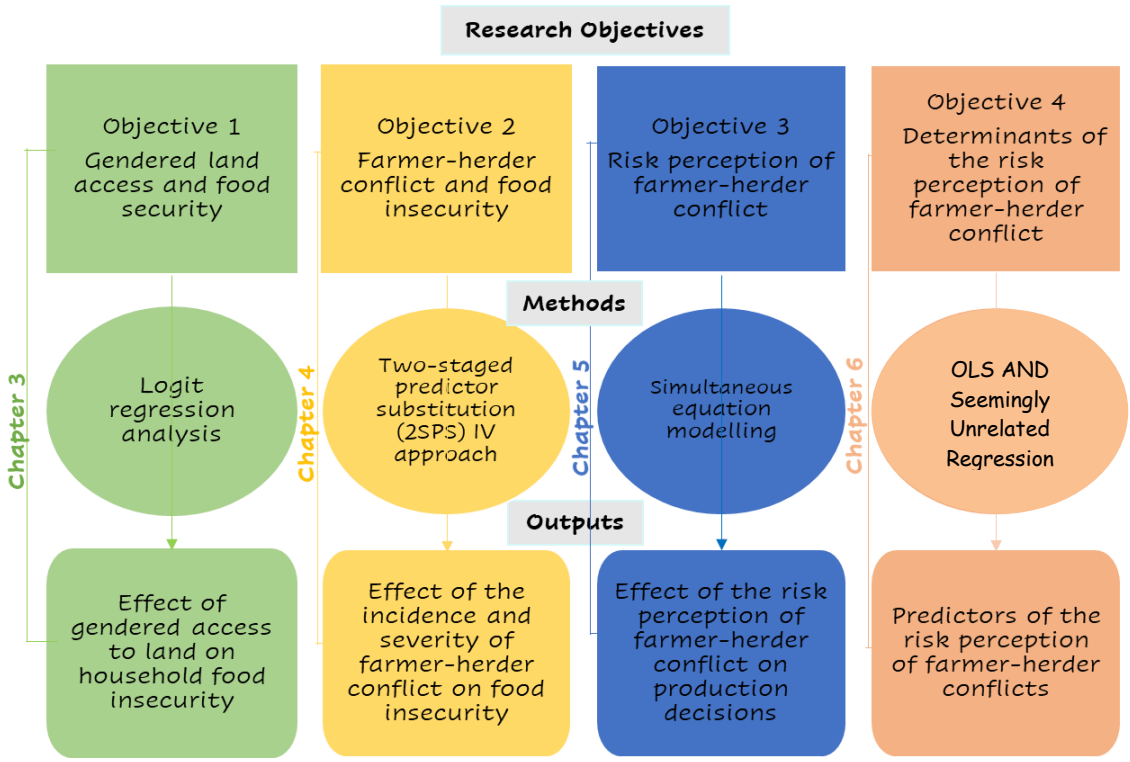


Figure 1.3 Methods and outputs: A summary

1.4 Significance of the Study

Since this study is the first to provide a comprehensive understanding of the impact of gendered access to land on food security as well as the empirical impact of FH conflicts on rural household welfare and livelihoods in Nigeria, the findings of this study could have significant implications for policymakers in their effort to improve rural livelihoods and sustainable agricultural production. In general, the findings of this thesis can assist policymakers in their efforts to design and implement laws, regulations, policies, and initiatives that promote efficient agricultural production, food security, and improved rural livelihoods.

More specifically, the moderating effect of access to land on the impact of gender on household food security has important implications for policymakers. Such information will inform policymakers of the need to enact need-based policies and initiatives to improve access to land resources for women. This, in the long run, may lead to a more inclusive distribution of land resources. Investigating the nexus between the incidence and severity of FH conflicts and food insecurity of rural households will improve understanding of the nutritional and welfare implications of these resource-use conflicts. Information about the extent of the impact of FH conflicts on rural food insecurity will inform policymakers of the need to facilitate policies that prevent the onset of these conflicts and initiatives that limit the adverse impacts of these conflicts. For instance, evidence of the higher negative impact of the severity of FH conflict will show the need for the provision of more immediate safety nets like food aid to alleviate the suffering of the affected households or the establishment of conflict resolution mechanisms to prevent or curb the likelihood of severe FH conflicts.

In addition, evidence of the impacts of rural households' perceived risk of FH conflicts on their production decisions have vital implications for food systems in conflict-prone areas. Considering agricultural productivity is a function of the production decisions made (Bello, Baiyegunhi, & Danso-Abbeam, 2021; Zhang, Mishra, & Zhu, 2021), understanding how the risk perception of FH conflicts affects household production decisions will provide proof of the indirect effects of these conflicts on

rural households' productivity. This will further provide insights to policymakers and other stakeholders in their establishment of policies to promote agricultural productivity. Insight into socioeconomic factors that influence how rural households perceive the risk of FH conflicts is relevant for risk management policy decisions. Knowledge of the factors that influence rural households' risk perception of FH conflicts will inform policymakers of what matters most regarding the risk behaviour of rural dwellers concerning FH conflicts, as well as aid the designing of effective risk management projects and initiatives.

1.5 Structure of the Thesis

This thesis is organised into seven chapters and is structured in a thesis-by-publication format. Chapter 1 of the thesis presents the general introduction. Chapter 2 describes the empirical strategies adopted in this thesis, the methodological framework, secondary and primary data used in the study. Chapter 3 to Chapter 6 address the four research objectives presented as journal articles (Figure 1.3). Specifically, Chapter 3 examines the joint impact of gender of household head and land access on household food insecurity. Chapter 4 investigates the differential impact of the incidence and severity of FH conflicts on rural households' food insecurity. Chapter 5 evaluates the impact of the risk perception of FH conflicts on rural households' production decisions. An examination of the social, economic, and demographic factors that influence rural households' risk perception of FH conflicts is presented in Chapter 6. The final chapter, Chapter 7, summarises the results and suggests policy implications based on the findings of the thesis.

Chapter 2

Data and Methods

This chapter presents an overview of the data and methods used in this thesis. This chapter is structured as follows. First, the secondary data used for Chapter three are introduced. Second, the primary data used for empirical analyses in Chapters four, five, and six are discussed. It covers information such as an introduction of the study areas, sampling procedure, and approaches to addressing human ethics concerns. Finally, the chapter concludes with a summary of econometric methods used in each of the analytical chapters.

2.1 Secondary Data

In this thesis, secondary data were mainly used for empirical analysis in Chapter 3. In Section 2.1.1, I introduce the secondary data. Then, in Section 2.1.2, I summarise the procedures of secondary data cleaning.

2.1.1 Introduction to the Secondary Data

The secondary data used in Chapter 3 were derived from the third wave of the Nigerian general household survey (GHS) panel, conducted by the Nigerian Bureau of Statistics (NBS) and collected in 2015/2016. The survey collected data from about 5,000 households from the larger cross-sectional GHS consisting of 22,000 households. It was designed to be representative at the national and zonal levels (NBS, 2016a). The purpose of collecting the Nigerian GHS panel data is to develop an innovative model for collecting agricultural data, inter-institutional collaboration, and comprehensive analysis of welfare indicators and socio-economic characteristics. The NBS used a two-stage probability sampling design in selecting households to be included in the survey. In the first step, 500 Enumeration Areas (EAs) were selected using the probability proportional to size (PPS) of the total EAs in each state and Abuja, the federal capital territory, and the total households registered in the EAs.[3] In the second step,

[3] The Enumeration Areas are the primary sampling units or clusters of the GHS-Panel survey.

a systematic random selection of 10 households per EA was made, making a total of 5,000 households.[4] The survey collects rich information on personal and household-level characteristics, social-economic and demographic characteristics, agricultural production and marketing activities, household income, expenditure, and consumption activities (NBS, 2016a). Data collection was implemented in two household/community visits: the post-planting and the post-harvest visits. The GHS-Panel wave 3 administered three questionnaires: household, agriculture and community questionnaires. The household questionnaire captured household demographics, labour, food and non-food expenditure, food security and shocks, safety nets, assets, housing condition, and income-generating activities. The agricultural questionnaire captures information on farmland ownership, size, and use, input use, farm labour, irrigation, crop, and animal holdings. The community questionnaire solicits information on community organisations, infrastructure, resource management, and local retail price.

The rich information covered in the Nigerian GHS data has allowed scholars working in the fields of agricultural and development economics to explore various research questions (Adeosun & Owolabi, 2021; de Brauw & Herskowitz, 2021; Gibson & Alimi, 2020; Jaiyeola & Choga, 2021). For example, Adeosun and Owolabi (2021) analysed used the 2015–2016 wave of the Nigerian GHS to examine the determinants and outcomes of gender equality in Nigeria. They found that geographical area has a higher effect on earnings disparity and is pronounced among women, while higher levels of education contribute to increased wages for women. de Brauw and Herskowitz (2021) investigated evolving dietary patterns in Nigeria using the first three waves of the Nigerian GHS panel data. They provide evidence of no increase in the consumption of highly processed food over this period.

In Chapter three of the thesis, I only use the post-planting round of the GHS-panel wave three (2015-2016) for two key reasons. First, given the focus of the investigation is on food insecurity, it was important to focus on the post-planting period when availability of food is lower. Second, the key

[4] Households were not chosen using replacements, hence the number of successfully interviewed households was less than 5,000.

explanatory variables (e.g., educational level of the household head and the number of respondents) used in Chapter 2 at the time of analysis were only available in the third wave of the GHS data.

2.1.2 Secondary Data Cleaning

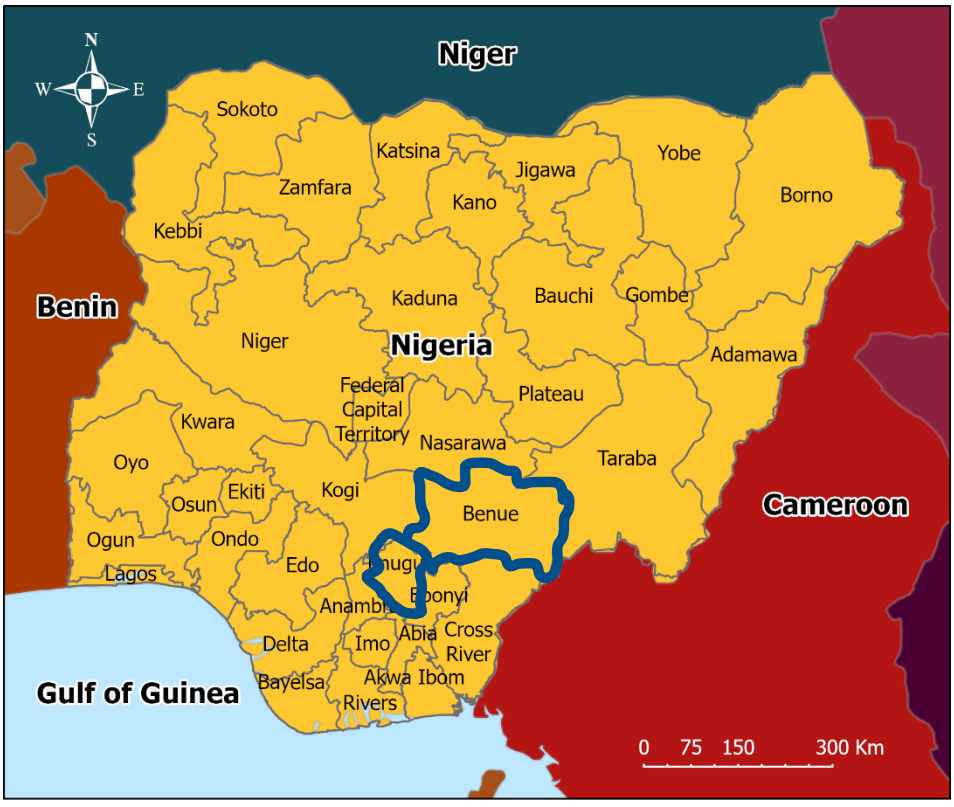
The data cleaning involved several steps. First, the analysis focused on data from the post-planting visits. This is to particularly capture household food insecurity in the lean months before harvest. Although Gibson and Alimi (2020) showed that low correlation between both rounds of the second (2010-2013) wave of the GHS dataset and argue that there may be a mismeasurement in the food and agriculture module of the survey, we stick to the post-planting round of the 2015-2016 GHS survey. This is because one of the key variables for this analysis, the food insecurity measure, is a self-assessment consumption index that captures if households in the sample had to reduce the size of meals eaten in their households at least once because of insufficient food in a 7-day recall period. The food insecurity measure captures household behaviour as a result of inadequate food availability and doesn't directly capture the annual household food and non-food consumption. Second, data files were merged based on key variables included in the analysis. For example, individual data files containing socioeconomic characteristics of household members were collapsed and merged with the sum of cultivated land for each household after generating other key control variables like household size, and amount of remittance received amongst others. This process effectively reduced the number of observations from about 22,000 individuals to about 2,869 households. Similarly, when selecting key variables to be included in the food insecurity model specification in Chapter 3, many observations were dropped because of missing values. For instance, after selecting for the educational level of household heads, the number of observations in the sample was reduced from 1,878 to 1,096 households. Finally, 1,096 households were used to address research question 1 in Chapter.

2.2 Primary Data

Primary data were collected from rural Nigeria to support the empirical analyses in Chapters 4, 5 and 6. Section 2.2.1 introduces the survey area. Section 2.2.2 discusses the primary data sampling procedure and section 2.2.3 presents the methods of addressing the human ethics concerns.

2.2.1 Study Area

The study area is Nigeria; it is the most populous country in Africa, with a population of above 206 million (NBS, 2021a). It is located on the coast of West Africa, between latitudes 4° to 14° North and longitudes 2° 2′ and 14° 30’ East, occupying about 927,768 square kilometres of land (Aregheore, 2009). It is bounded by Niger in the North, Benin in the West, Cameroon in the Southeast, and the Gulf of Guinea in the South. Administratively, Nigeria has six geopolitical zones which are made up of 36 states and one capital territory (see Figure 2.1).



Shapefile source: ESRI (2018) and HDX (2017)

Figure 2.1 Map of Nigeria highlighting the Study Area

The Nigerian labour force makes up more than 52% of the total population, of which about 29.5% of males and 19.6% of females are employed in agricultural activities (NBS, 2020a). The share of men and

women engaged in agricultural activities is higher in rural areas (41.5% and 28.1%) compared to urban areas (9.9% and 5.4%). Hence, men are more engaged in agricultural activities. According to the 2020 Nigeria Living Standards Survey, an average household in Nigeria has 5.06 members and a dependency ratio of about 0.97 (NBS, 2020a). On average, 18.8% of households are female-headed, and this share is lower in rural areas (17.1%) and higher in urban areas (21.4%) (NBS, 2020a).

The primary data were collected from the North Central and South-East geopolitical zones in Nigeria. The Northcentral geopolitical zone comprises of six States and the federal capital territory (FCT). It is also referred to as the "Middle Belt" because it longitudinally stretches across central Nigeria, creating a transition zone between northern and southern Nigeria. The North Central zone is an agrarian region with more than half of its population involved in agricultural activities and where most of the food consumed in the country is grown (Aregheore, 2009). Women spend more time doing agricultural activities than men on average (NBS, 2019) and agricultural activities here include farming, livestock rearing and fishing. The predominant crops grown in this region include cassava, yam, maize, cowpea and sorghum. The North Central zone consists of a multitude of ethnic groups and has been the site of countless conflicts ranging from ethno-religious clashes to farmer-pastoralist conflicts (Akov, 2017; Higazi, 2011).

Conversely, the South East geopolitical region is made up of five States and is located towards the south of the Benue valley and east of the lower Niger (Okali, Okpara, & Olawoye, 2001). Some of the main agricultural products in this region are cassava, rice, cocoyam, oil palm, rubber etc (Ndaeyo, Umoh, & Ekpe, 2001). Apart from agriculture, the South East zone is known for its commercial and trading activities comprising of mainly small and medium sized businesses. The population in this region consist of mainly of people of the Igbo ethnic group (Okali et al., 2001). The sampling of both zones was done purposively as a result of preliminary results from the secondary data described in section 2.1 above. Specifically, the North Central region was found to be the most food-secure while the South East was food insecure. Benue and Enugu States were purposively selected as a result of the

occurrences of FH conflicts in those state. This was done to increase the likelihood of capturing conflict incidences. FH conflicts in these states have increased in recent times (Madu & Nwankwo, 2020).

2.2.2 Sampling Procedure of Primary Data

The primary data were collected in North Central and South-East geopolitical zones between May and June 2019. A multistage sampling procedure was adopted in selecting households for the survey. In the first stage, the North Central and South-East geopolitical zones were purposively selected based on previous occurrences of FH conflicts and food security status.[5] Second, two states in each geopolitical zone and five local government areas (LGAs) were selected purposively based on a previous occurrence of FH conflicts. In the third stage, two towns in each LGA and two villages in each town were randomly sampled. Table 2.1 presents the list of the randomly sampled towns and villages in the survey and the number of households also randomly selected in each village. Finally, about ten households in each village were randomly selected, and the household head was interviewed, contributing to a total of 401 farm households, 24% of which are female-headed. Although a stratified random sampling in the third and fourth stages would have been ideal to account for population bias and ensure an equal probability of all households in the study area being selected, it was not possible in this case. This is because of a lack of reliable data on the exact population size of the selected towns and villages, leading to an inability to confidently classify every household into subgroups. If there are significant differences within groups (like the gender of the household head, ethnicity, and religion), this might introduce sampling bias, leading to an inaccurate representation of the population under study. To correct this potential problem, we include a rich set of variables in our analysis. For example, location variables are included in the model to control for unobserved region-specific characteristics such as institutional arrangements, social-economic conditions, cultures, ethnicity, religion, and climate conditions. Structured questionnaires were used for primary data collection. A pilot study was carried out to test the efficiency and reliability of the questionnaire. Also, feedback on the questionnaire was sought and gotten from research analysts at the International Food Policy Research

[5] Based on preliminary analysis of data from the 2015/16 Nigerian general household survey, the North Central zone was food secure while the South East zone was food insecure.

Institute (IFPRI), Nigeria Office. The survey collected information on household and household head characteristics (e.g. age, gender, education, off-farm work participation. household size, income, and consumption), farm-level characteristics (e.g., farm size and soil types), FH conflicts, and production decisions for the previous planting season (see Appendix for the survey questionnaire). Sampling bias from nonresponse from respondents was mitigated through follow-up field visits by enumerators to track non-responders and reduce the likelihood of attrition in the sample.

Table 2.1 List of Towns and Villages in the Survey

Zone (State)	LGAs	Towns	Villages	Households
North Central (Benue State)	Agatu	Ogbaulu District	Ogbaulu	10
			Olegabulu	10
		Odugbeho District	Odugbeho	10
			Odejo	10
	Buruku	Shorov District	Tyowanye	10
			Garagboghol	10
		Adi-Etulo	Ugye	10
			Agia	10
	Guma	Mbaduem District	Tse-Akenyi	10
			Torkula	10
		Udei District	Ingbian	10
			Yelewatta	10
	Gwer West	Raav District	Udam	10
			Akume	10
		Mbakpa District	Borkem	10
			Tse-Tor	10
	Makurdi	Mbalagh District	Adigbe	10
			Anter	10
		Kyundo-Usha District	Bam-Bam	10
			Ijaha	10
South East (Enugu State)	Uzo-uwani	Nimbo	Ekwuru	10
			Ugwuachara	10
		Ojor	Umuitodo	10
			Umuasaba	10
	Enugu East	Nike District	Edem Nike	10
			Ibagwa Nike	10
		Ugwuogo District	Umunagbo	10
			Utazi	10
	Udi	Eke	Ogui Agu Eke	10
			Amankwo Eke	10
		Ebe	Umuavulu	10
			Amagu	11
	Nkanu West	Ozalla	Enugwueagu	10
			Obeagwu	10
		Akegbe Ugwu	Amagu	10
			Omokwo	10

	Ezeagu	Akama Oghe	Imama	10
			Isiokwe	10
		Awha Imezi	Ikenga Awha Imezi	10
			Ogwofia Agha Imezi	10
Total		20	40	401

Note: An extra household was interviewed in Amagu village of Enugu state making a total of 401 households in the sample.

The survey was implemented with the aid of trained enumerators. These enumerators were selected based on their multiple survey experiences with IFPRI, Nigeria, and more importantly, their ability to speak the local languages, which helped facilitate effective data collection. They were trained on the correct ethical behaviour on how to collect data safely and efficiently. Before entry into each community, a visit to the chief or custodian of the community was undertaken to inform them of our purpose and presence in their community. The enumerators were supervised and accompanied throughout the data collection process to ensure the survey was implemented efficiently. Figures 2.2, 2.3, and 2.4 provide pictures of respondent interviews conducted in Nkanu West, Buruku, and Agatu LGAs.

Figure 2.2 Interview with a respondent in Nkanu West LGA in Enugu State, South East Region, Nigeria

Figure 2.3 Interview with a respondent in Bururku LGA, Benue State, North Central Region, Nigeria

Figure 2. 4 Interview with a respondent in Agatu LGA in Benue State, North Central region, Nigeria

2.2.3 Approaches to Addressing Human Ethics Concerns

Personally identifiable socioeconomic information was obtained from rural households in our primary data collection. As such, a human ethics clearance application was made and obtained from the Lincoln University Human Ethics Committee. Before the start of the survey, respondents were informed of the purpose of the research and assured of the confidentiality of the information provided. Both verbal and written consents were sought from each selected respondent. They were also informed of their ability to withdraw from the survey at any time voluntarily. The contact details of the lead supervisor were made available to respondents to authenticate the purpose of the research further, or in case they wanted to withdraw from the survey. A copy of the human ethics approval letter obtained from the Lincoln University Human Ethics Committee is presented in Appendix B.

2.3 Methods

Several econometric approaches have been adopted based on their suitability for answering the

specific research questions addressed. The approaches used in each chapter are discussed in the subsections below.

2.3.1 Chapter Three: Logistic Regression Model

Chapter 3 addresses the first research question by examining the joint effect of gender of household head and land access on household food insecurity. In our analysis, the key outcome variable, food insecurity, is an indicator that takes the value of 1 if households reduced at least one meal eaten in the household in the last seven days and 0 otherwise. A linear probability model (LPM) can be used to estimate linear regression with a binary dependent variable (Betts & Fairlie, 2001; Gazoni & Brasileiro, 2021; Reiley, 2006). The LPM has a major setback that assumes the conditional probability function to be linear, and hence, does not restrict the expected value of the outcome variable to between 0 and 1. The binary logit regression model corrects for this inefficiency. Therefore, a logistic regression model is employed due to the dichotomous nature of the self-reported food insecurity variable. It is estimated with a maximum likelihood estimator to maximise the log-likelihood function under the assumed statistical model. The maximum likelihood estimators are consistent, asymptotically normal, and efficient if the assumption of holds. It estimates the probability of the household's being food insecure as a non-linear function of a vector of control variables. The binary logistic regression has been used in various studies where the dependent variable is binary (Abonazel & Ibrahim, 2018; Aliyu, Bashar, & Usman, 2021; Kharisma & Abe, 2020).

Furthermore, given research question one, the non-linear interaction effect of the gender-land interaction variable is analysed following Norton, Wang, and Ai (2004). Norton et al. (2004) and Ai and Norton (2003) show that the full interaction effect for non-linear models like the logit model is not equal to the coefficient or marginal effect of the interaction term. Consequently, the correct interaction effect of the gender-land interaction term is estimated by calculating the cross partial derivative of the expected value of food insecurity with regards to the gender of household head at different levels of covariates (Norton et al., 2004).

2.3.2 Chapter Four: Two Staged Prediction Substitution Models

In Chapter 4, the differential impact of the incidence and severity of FH conflict on rural households' food insecurity is investigated. Based on a constrained utility maximisation problem, the study defines a conceptual framework in the form of a food consumption demand model to describe how FH conflicts may affect rural households' food insecurity. Two hypotheses based on the conceptual model are then tested.

There is a well-established reverse causality bias between conflict and food insecurity in the literature (Martin-Shields & Stojetz, 2019). This implies that FH conflicts may not be random and are more likely to occur in communities with particular attributes. For example, agrarian communities may be more prone to FH conflicts because of herders' need to graze their animals. Similarly, how severe a FH conflict is may not be random as households with more arable land and assets may be more likely to be targeted by herders. The study accounts for the endogeneity bias introduced by employing a two-staged predictor substitution (2SPS) control function instrumental variable (IV) approach following Nie, Ma, and Sousa-Poza (2020) and Wan et al. (2015). The choice of a 2SPS approach instead of the two-stage least squares (2SLS) approach is because of the proportional nature of the severity of the FH conflict variable. This is to apply alternative methods of estimating the first and second stage models. In the case of the severity of FH conflict, the first stage equation would be a fractional regression model, and the second stage equation will be an ordinary least square model (OLS).

This IV approach estimates a two-stage model and addresses endogeneity issues of the FH conflict variables, which will render the ordinary least squares estimates inconsistent and biased. In the first stage, the FH conflict variables are regressed against a vector of control and instrumental variables.[6] After which, the conflict variables are predicted and included in the second stage food insecurity model. The predicted FH conflict variables control for endogeneity and improve the effectiveness of model estimations. Robustness checks were carried out using the conditional mixed process (CMP) models in accounting for possible sample selection bias. Also, using 2SPS models, three additional

[6] The instrumental variables passed the falsification test to check their validity and effectiveness.

analyses were performed using alternative FH conflict and food insecurity variables. This is done to further our understanding of the association between these two concepts.

2.3.3 Chapter Five: Simultaneous Equation Models

Chapter 5 addresses a part of the second research question by exploring the indirect effects of FH conflict on rural households' livelihoods. Specifically, the chapter investigates the influence of the risk perception of FH conflict on rural households' production decisions. Here, a theoretical model of resource use conflict is developed by extending the classic farm household model with the inclusion of a shock in the form of the risk perception of FH conflict. Three hypotheses were derived to assess the influence of the risk perception of FH conflicts on (i) fertiliser use and investment, (ii) area of cropland rented-in, and (iii) household time allocation for farm work. The risk perception of the FH conflict index was constructed by modifying the risk ranking method adopted by Smith, Barrett, and Box (2000) and Doss, McPeak, and Barrett (2008). The risk perception of FH conflict index constructed is also split into three groups to capture households exhibiting the different stages of risk behaviour (risk-loving, risk-neutral, and risk-averse). The influence of being in each risk group on their production decision was also determined.

Extant literature shows that farmers make production decisions concurrently (Höhler & Müller, 2021; Savikhin & Sheremeta, 2013). To account for this joint decision-making process, the hypotheses made were empirically tested using a system of simultaneous equations and implemented following the Conditional mixed process (CMP) framework (Chege, Andersson, & Qaim, 2015; Ntakirutimana et al., 2019; Roodman, 2011). Robustness checks were carried out using logit, Tobit and fractional regression models to account for various production decision variables. Furthermore, additional analyses using objective FH conflict variables were carried out to enhance understanding of the relationship between FH conflicts and production decisions of rural households.

2.3.4 Chapter Six: Ordinary Least Squares and Seeming Unrelated Regression Models

Chapter 6 addresses research question three by examining the social, economic, and demographic determinants of rural households' risk perception of FH conflicts using ordinary least squares regression analyses. This chapter used exploratory factor analysis to construct a holistic FH conflict risk perception index from nine risk items. To determine the joint effect of FH conflict occurrence and gender of household head on rural household's FH conflict risk perception, a gender-FH conflict interaction term is included as an explanatory variable. The study then checks the robustness of the main results by including controls for the household local government areas to capture location-based fixed effects for lower levels of geographic disaggregation.

Afterwards, the study probes the sources of perceived risk and differences in risk judgement in more detail by splitting the holistic FH conflict risk perception index into two sub-indices capturing FH conflict risk perception regarding food production and supply on the one hand and physical insecurity and wellbeing on the other hand. Considering that both sub-indices are most likely related to a particular household but, depending on inherent socioeconomic characteristics that may differ across multiple households, there is a possibility that the error terms of the sub-indices single equations are correlated. This may be because of household-specific unobservable factors associated with the FH conflict risk perception subindices. To account for the possibility of correlated error terms in the estimation, the study employs a seeming unrelated regression equation (SURE). Here, the regression coefficients are simultaneously estimated by using Aitken's generalised least squares to the system of equations to account for correlated error terms. It is more efficient than single-equation least squares estimators (Srivastava & Giles, 2020; Zellner, 1962). The SURE model differs from the simultaneous equation because all independent variables are assumed exogenous. Subsequently, the study tests the hypothesis of correlated residuals by implementing a Breusch-Pagan test of independence.

Chapter 3

Gendered Access to Land and Household Food Insecurity: Evidence from Nigeria

This chapter fulfils objective one and is based on the published journal article below:

Nnaji, A., Ratna, N., & Renwick, A. (2021). Gendered access to land and household food insecurity: Evidence from Nigeria. *Agricultural and Resource Economics Review*, 1-23. doi:10.1017/age.2021.13. (ABDC ranking: B)

Chapter 3 – Statement of Authorship

Title of Paper	Gendered access to land and household food insecurity: Evidence from Nigeria	
Publication status	■ Published	☐ Accepted for Publication
	☐ Submitted for Publication	☐ Unpublished and Unsubmitted work written in manuscript style
Publication Detail	Nnaji, A., Ratna, N., & Renwick, A. (2021). Gendered access to land and household food insecurity: Evidence from Nigeria. *Agricultural and Resource Economics Review*, 1-23. doi:10.1017/age.2021.13.	

Principal Author

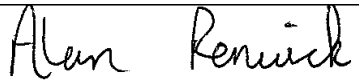
Name of Principal Author (Candidate)	Amaka Precious Nnaji		
Contribution to Paper	Conception and design of the study; data acquisition, analysis and interpretation; drafting of the manuscript; and reviewing the manuscript critically for significant intellectual content.		
Overall percentage (%)	65%		
Certification:	This paper reports on original research conducted during the period of my Doctoral study and is not subject to any obligations or contractual agreements with a third party that would constrain its inclusion in this thesis. I am the primary author of this paper.		
Signature		Date	28/10/2022

Co-Author Contribution

By signing the Statement of Authorship, each author certifies that:

1. the candidate's stated contribution to the publication is accurate (as detailed above);
2. permission is granted for the candidate to include the publication in the thesis; and
3. the sum of all co-author contribution is equal to 100% less the candidate's stated contribution.

Name of Co-Author	Assoc. Prof. Nazmun N. Ratna		
Contribution to the Paper	Supervising the development of the study, contributing to drafting the manuscript and revising the manuscript critically for important intellectual content.		
Signature		Date	16/11/2022

Name of Co-Author	Prof. Alan Renwick		
Contribution to the Paper	Supervising the development of the study, contributing to drafting the manuscript and revising the manuscript critically for important intellectual content.		
Signature		Date	15/11/2022

Abstract

In this article, we examine the joint influence of land access and gender of household head on household food insecurity by employing a logit model and using data from the 2015/2016 Nigerian General Household Survey. Our results show that female-headed households (FHHs) are more food insecure than male-headed households. However, with a 1-acre increase in their access to land, FHHs are 16 per cent less likely to be food insecure. This finding provides policy insights into how improving access to arable land for land-poor FHHs can enhance food security in Nigeria.

Keywords: food security, gender, households, land access, Nigeria.

3.1 Introduction

Food insecurity remains a major concern in most developing countries. Although more food is produced than the world's population needs, close to half of it ends up as food waste (FAO, 2011a; Lundqvist, de Fraiture, & Molden, 2008), while millions of people are left without adequate food, especially in sub-Saharan Africa (FAO et al., 2017; Lundqvist et al., 2008). This is even worse for female-headed households (FHHs) in developing countries, who have unequal access to productive resources (Adekola et al., 2013; Twum et al., 2020). It is accepted that timely access to arable land is an important way to decrease hunger and poverty, especially in developing countries (Pindiriri, 2021; Tekwa, 2020). Target 5A of the fifth Sustainable Development Goal (SDG 5) identifies the need to undertake changes to provide women with equal rights and opportunities to financial services and productive resources, like land, in accordance with the current national laws. Several studies in developing countries find that women having more access to productive resources will have a positive effect on the well-being of their household members as well as their own health and education (Adereti, 2005; Doss, 1997; Duflo & Udry, 2004; Handa, 1996; Kennedy & Peters, 1992; Pindiriri, 2021; Rogers, 1996). Unfortunately, in most developing countries, women experience more barriers when accessing land than men (Brück & Schindler, 2009; Dokken, 2015; Khalid et al., 2015; Murugani et al., 2014; Wineman & Liverpool-Tasie, 2017). Often this obstacle is not just the area of the land itself they can access, but also it's quality and how productive they can make it (Gill, 1988; Quisumbing et al., 1998).

With the increasingly significant role of women in securing the nutritional status of their households (FAO, 2011b; Karl, 2009; Levin et al., 1999; Quisumbing et al., 1998), determining the influence of gender-specific access to land on food security is crucial. In addition, the impact of gendered access to land on the food security of households is necessary to aid in understanding the factors affecting agricultural production and the ways it can be improved. This study will also inform the facilitation of policies for ensuring food security and improving the livelihoods of rural dwellers.

A growing number of studies have identified the differences between the food security status of male- and female-headed households (Akadiri et al., 2018; Choithani, 2020; Joshi & Joshi, 2017; Ma et al.,

2021; Mallick & Rafi, 2010; Shin, 2020; Tibesigwa & Visser, 2016). Others have examined the differences in access to land by male- and female-headed households (Adelman & Peterman, 2014; Khalid et al., 2015; Lambrecht, 2016; Pindiriri, 2021; Tran et al., 2013; Wineman & Liverpool-Tasie, 2017), but the literature on how and to what extent gendered access to land affects food insecurity remains scant. Understanding the nexus among gender, land access, and food security is important for implementing agricultural policies in low income and lower middle-income countries.

The main objective of this study is to examine the joint effect of gender and access to land on households' food insecurity, which to the best of our knowledge, is the first study to address the research gap on gender-land access-food insecurity literature. In this paper, we use data from the 2015/16 Nigerian General Household Survey (GHS). A logistic regression model is used to analyse the data. In Nigeria, most studies on food security are confined to certain states and districts and not the entire country (Amaza et al., 2006; Arene & Anyaeji, 2010; Iruonagbe, 2011). Furthermore, most of the studies in Nigeria fail to empirically determine the association between gender, access to land, and food security (Adekola et al., 2013; Chikaire et al., 2016). Given the importance of land resources as well as the significant role women play in the well-being and nutritional status of their families, it is important to understand how, and to what extent, access to land can influence the effect of gender of household head on food insecurity.

The main finding of the study is that a one-acre increase in land accessed by female-headed households reduces their likelihood of being food insecure by 16% compared to male-headed households. This implies that female-headed households are so constrained in their access to arable land that additional access to land results in a greater impact on their food insecurity status in comparison to male-headed households. Existing literature has shown that women are disproportionately disadvantaged in terms of land access. This is as a consequence of structural inequalities, traditional and socio-cultural gender-roles that deny women the same economic opportunities as men. This is most probably the reason why increased access to land by female-headed households has a disproportionate ability to improve their food security compared to male-headed households. Findings of this study highlight the need for

polices in support of target 5A of SDG 5, which is to facilitate reforms to ensure women have equal rights to economic resources in addition to control over, and ownership of, land and other financial services.

This paper makes several contributions to the literature. First, we go further than the current literature by quantifying the joint impact of land access and gender of household head on the food insecurity status of households. Therefore, we test whether increasing access to land for female-headed households will influence their food insecurity status. Second, the study enhances understanding of the mediating effect of land access on the influence of gender of household head on food insecurity. Finally, the findings from this study will provide significant insights into agricultural policies that focus on enhancing food availability.

The remainder of this article is organised as follows: The next section presents a summary of the relevant literature on gendered land access and food security. After which, a conceptual model linking household and household head characteristics to food insecurity and an empirical model are presented. A detailed descriptive analysis of the data is then reported. The subsequent section reports the estimated results, followed by a discussion of the results, before the concluding remarks are presented.

3.2 Literature Review

3.2.1 Food Security and Access to land

Food security occurs when people have access to adequate, healthy, and nutritious food that meets their nutritional needs and preferences at all times (FAO, 2006; FAO et al., 2017; Sasson, 2012). Food insecurity is of great concern in both developed and developing countries, although it is worse in the latter (Sasson, 2012). In sub-Saharan Africa, insufficient food production as a result of the adverse effects of climate change is the major cause of food insecurity, although conflicts and soaring food prices are contributing factors (Day & Caus, 2020a; Xie et al., 2021).

Increases in access to land are found to have a positive influence on households' food security (Jayne et al., 2003; Muraoka et al., 2018; Rammohan & Pritchard, 2014), although income from owned land is found to be higher than that from rented land (Abdulai & Goetz, 2014; Abdulai, Owusu, & Goetz, 2011; Ali, Abdulai, & Goetz, 2012; Muraoka et al., 2018). Tenure security influences households' rights to use, manage, and control land and its resources (Holden & Ghebru, 2016). This has a clear and positive impact on land rights, agricultural productivity and hence, household food security (Deininger & Jin, 2006; Ghebru & Holden, 2013; Holden & Ghebru, 2016). If total food production is a key factor affecting the food security of developing countries (Sasson, 2012), then security of tenure and the resulting area of land accessed is key in determining the influence of land access on the food security of households in these countries. Disparities in access to productive resources like land can be the difference between a food secure and a food insecure household (Tekwa, 2020), while variation in the ability of the different genders to access land will have a further influence on their food security.

3.2.2 Gender and Food Security

Many previous studies have sought to determine the influence of the gender of household head on the household's food security status. Male-headed households (MHH) are found to be more food secure than female-headed households (FHH) in Nigeria, Ethiopia, Nepal, Kenya and South Africa (Akadiri et al., 2018; Joshi & Joshi, 2017; Kassie et al., 2014; Larson et al., 2019; Maharjan & Joshi, 2011; Shin, 2020; Tibesigwa & Visser, 2016). On the other hand, in a study by Mallick and Rafi (2010) in Bangladesh, no significant difference between the food security of male- and female-headed households is found. The authors suggest that the lack of evidence of a difference could be as a result of a lack of socio-cultural restrictions among indigenous ethnic groups, permitting women more freedom to participate in the labour market. In addition, they suggest that another reason is that female-headed households are given priority during food redistribution by informal institutions, for example, '*Khiang*' in indigenous communities. The authors also use a subjective measure for food security, i.e., perception of respondents about their households' food security, which can be a potential limitation given the evidence of gender-based differences in perceptions about food security (Lutomia et al., 2019).

Some of the main reasons given for variations in the food security status of female-headed households in comparison to their male counterparts are inadequate access to productive resources, over-reliance on household food production, lower assets, and off-farm income (Iruonagbe, 2011; Joshi & Joshi, 2017; Pindiriri, 2021; Tibesigwa & Visser, 2016). Kassie et al. (2014) also find that land quality and social capital have a positive influence on female-headed households' food security. Belonging to a farmers' group and being connected with more traders in their neighbourhood increases the likelihood of food security for female-headed households. These farmer groups may provide financial support, access to improved inputs and extension services, which, in turn, increases the productivity of female farmers.

3.3 Conceptual Framework

Figure 4.1 presents our conceptual framework on the gender-land access-food security nexus. It illustrates that social and demographic factors like age, education of household head, and social networks influence household food security (Akadiri et al., 2018; Brück & Schindler, 2009; Joshi & Joshi, 2017; Kassie et al., 2014; Rammohan & Pritchard, 2014). Material assets of the household (Joshi & Joshi, 2017), farm income (Akadiri et al., 2018; Joshi & Joshi, 2017), off-farm income (Tibesigwa & Visser, 2016), location of the household (Tibesigwa & Visser, 2016), as well as the infrastructure available to households, also influences food security.

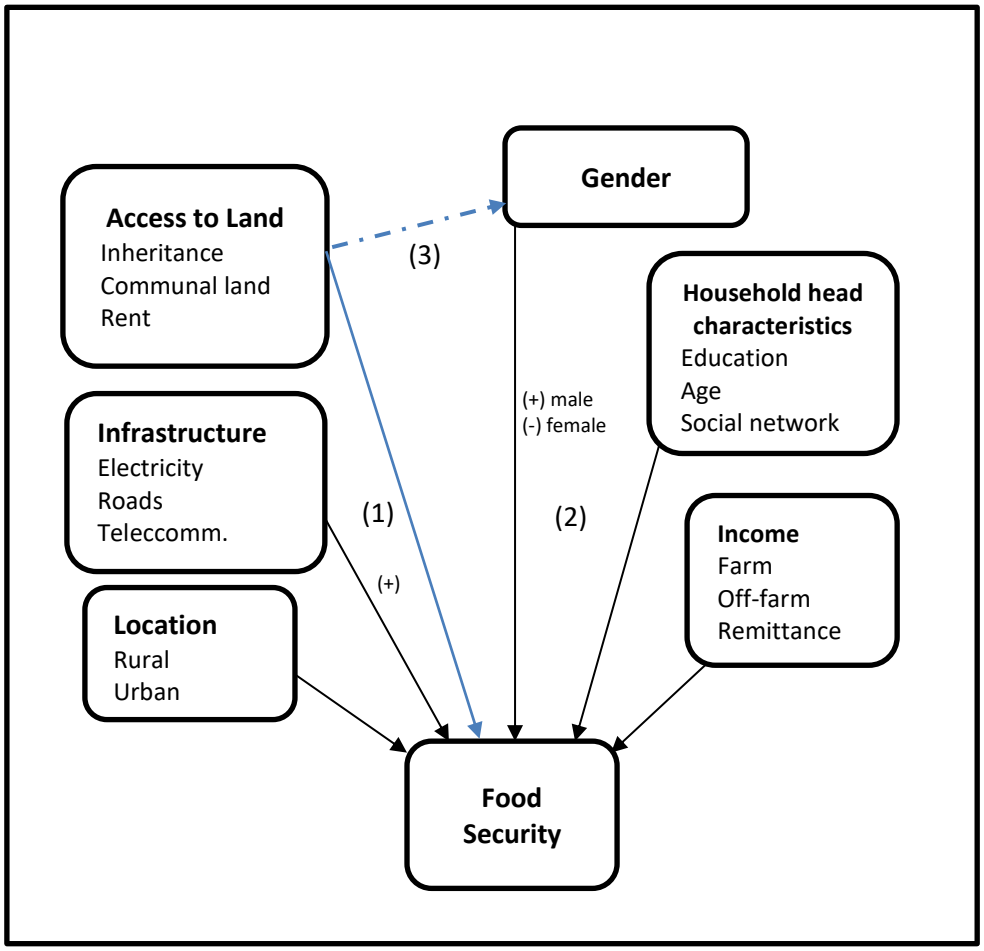


Figure 3.1 Conceptual framework linking household and household head characteristics with food security

The most important determinant for food availability is land access (Kassie et al., 2014; Muraoka et al., 2018), which is the focus of this paper and is depicted by arrow 1 in Figure 3.1. We identify three ways to access land: inheritance, communal land, and rent. Among the household characteristics, we consider gender one of the most important determinants of food security (arrow 2, Figure 3.1). In most low income and lower-middle income countries, female-headed households are usually disadvantaged in comparison to their male counterparts in the access and use of productive resources such as arable land (arrow 3, Figure 3.1) (Adekola et al., 2013; Agarwal, 2003; Brück & Schindler, 2009; Lambrecht, 2016). This is mainly because of cultural norms that impede women from gaining equal access to land. Some communities, especially patriarchal ones, do not allow women to inherit land, and women only have access to land through their husbands and (or) male relatives (Chikaire et al., 2016; Khalid et al., 2015). Sometimes, existing norms and culture inhibit women from having adequate

access to land. For example, in some parts of Ethiopia, it is taboo for women to plough (Dokken, 2015). Murugani et al. (2014) report that married women have more secure land access than single women, although most times, they do not own the land themselves (Iruonagbe, 2011). In developing countries, especially in patriarchal societies, women achieve access to land through their husbands when they are married and, if unmarried, through their male relatives (father, brother, etc.). In the case of communal land, although it is in collective ownership, women are often disadvantaged in the allocation of such land (Iruonagbe, 2011). Land accessed through a third party usually has insecure tenure and can be reclaimed at any time (Murugani et al., 2014). This can have negative implications for their finances, as land use without full rights cannot be used as collateral for credit facilities. In turn, this can lead to adverse consequences for their food security, as access to productive resources, like land, will have an effect on their scale of production as well as on productivity and output.

Figure 3.1 also reveals that three characteristics of household heads: education, age, and their social network, influence households' food security. This indicates that households with educated heads tend to be more food secure (Akadiri et al., 2018; Rammohan & Pritchard, 2014). With a higher level of education, the household head will have more human capital, information, and the skills to use the right inputs; and therefore, increase productivity. This may also improve participation in off-farm work and hence, they can generate more income to purchase food. Social networks are found to increase household food security (Kassie et al., 2014).

We also include the farm size and the availability of infrastructure as determinants of household food security. Farm size and land quality are found to improve female-headed households' food security status (Kassie et al., 2014), while distance to the market has a negative effect on food security (Akadiri et al., 2018; Kassie et al., 2014). Those further away from markets may be more limited in terms of both their information about the prevailing prices and also their ability to sell and purchase food in the absence of efficient transport infrastructure. Access to electricity also has a positive influence on household food security (Faridi & Wadood, 2010). This can also be an indicator of the households'

welfare and subsequent access to other resources. For example, the availability of electricity makes automated irrigation possible.

In our conceptual model, we also include household location as a determinant of food security. Tibesigwa and Visser (2016) report that the gap between the food security of both male-headed households and female-headed households is much wider in rural areas than in urban areas. This implies that female-headed households in rural areas, with unequal access to land, are more susceptible to food insecurity as their number of off-farm opportunities is greatly reduced. They rely on land for sustenance to a greater extent.

3.4 Empirical Model

In this study, we capture food insecurity as a dummy variable that specifies households that had to reduce meal sizes as a result of lack of food.[7] Given the dichotomous nature of the dependent variable, we specify a binary logit model to determine the impact of gendered access to land on household food insecurity. The conditional probability of being food insecure (Y) is given as follows:

$$P(Y = 1|\boldsymbol{X}) = 1/(1 + e^{\alpha+\tau Gender+\eta Land+\gamma Gender*Land+\boldsymbol{\beta X}}) \quad (1)$$

where *P* is the conditional probability of a household being food insecure; *Y* is a dummy variable that indicates whether or not households have reduced meal sizes over the last seven days because they do not have enough food and represents the likelihood of the household being food insecure; *Gender* is a dummy variable that indicates the household head is female; *Land* denotes the area of land households access for cultivation; *Gender*Land* is an interaction variable which captures the mediating effect of land access on the influence of gender of household head on household food insecurity status; ***X*** is a vector of household, household head and farm-level explanatory variables; while α, τ, η, and $\boldsymbol{\beta}$

[7] This self-assessed measure of food insecurity is used because the 2015/2016 Nigerian General Household Survey does not have information that can be used to construct food insecurity indices like HFIAS or DDS.

are estimated coefficients. Norton et al. (2004) show that for non-linear models, the full effect of the interaction variable is not equal to its coefficient (γ), nor can its statistical significance be efficiently determined by just a *t*-test. Rather, the interaction effect is the discrete difference with respect to land access of a single derivative with regards to the gender of household head. This implies that the sign, magnitude and statistical significance of the interaction effect must be estimated from the cross-partial derivative of household food insecurity and not the coefficient of the gender-land interaction variable in Equation (1). Following Norton et al. (2004), we estimate the correct interaction effect of the gender-land interaction variable by calculating the cross-partial derivative of the expected value of household food insecurity at different values of covariates as follows:

$$\Delta\frac{\delta P(Y=1|\boldsymbol{X})}{\delta Gender}_{\Delta Land} = (\tau+\gamma)(P\{(\tau+\gamma)Gender+\eta+\boldsymbol{\beta X}\}\times(1-P\{(\tau+\gamma)Gender+\eta+\boldsymbol{\beta X}\})-$$
$$\tau[P(\tau Gender+\boldsymbol{\beta X})\{1-p(\tau Gender+\boldsymbol{\beta X})\}] \quad (2)$$

Equation (2) shows that the full interaction effect of the gender-land interaction variable is conditional on the independent variables. Also, the interaction effect of the gender-land interaction variable may have different signs for different values of covariates, because there are two additive terms which could be negative or positive. Consequently, the sign of the coefficient of the gender-land interaction variable in Equation (1), γ, does not necessarily indicate the sign of the interaction effect.

Table 3.1 presents the definitions and summary statistics of the variables in the model. Following the main premise of this paper, a gender-land interaction term is included in the food insecurity model to capture the intervening impact of land access on female-headed households' food insecurity status. All analyses are carried out using the STATA 15 statistical software.

Table 3.1 Variable definition and summary statistics

Variable	Definition	Mean	SD	Min	Max
Food insecurity	1 if household is food insecure, 0 otherwise	0.314	0.464	0	1
Farm size	Size of total cultivated farmland (acres)	2.208	3.524	0	36.792
Gender	1 if household head is female, 0 otherwise	0.066	0.248	0	1
Gender*land	Interaction term between gender and farm size	0.032	0.301	0	8.084
Age	Age of household head (years)	50.971	12.924	23	103
Age squared	Squared age of household head	2,764.99	1,407.19	529	10609
Household size	Number of household members	6.932	3.154	1	22
Location	1 if household is located in a rural area, 0 otherwise	0.848	0.360	0	1
Electricity	1 if household is connected to the national electricity grid, 0 otherwise.	0.467	0.499	0	1
Education	1 for no education, 4 for tertiary education	2.179	0.970	1	4
Non-farm income	Household income from non-farm sources (NG₦1000)	32.128	103.597	0	2,247.5
Farm income	Household income farm sources (NG₦1000)	192.700	366.166	0	5,050
Remittance	1 if household received remittance, 0 otherwise	0.961	0.192	0	1
Extension officer visits	Number of extension officer visits in the last cropping season.	0.159	1.081	0	20
Land title	1 if household has formal land title to farmland, 0 otherwise	0.06	0.238	0	1
Fertiliser use	1 if household used fertiliser, 0 otherwise	0.634	0.673	0	1
Soil quality	1 if soil quality of farmland is good, 0 otherwise	0.835	0.371	0	1
Distance to market	Distance from household to closest market (km)	68.31	37.57	0.9	214.3

Note: NG₦ is Nigerian currency; US$1 = NG₦380.50 in 2021; SD is Standard Deviation

3.5 Data, Variable Measurements, and Descriptive Statistics

3.5.1 Data

We use data from the third wave of the Nigerian General Household Panel Survey (GHS) conducted in 2015/16 (NBS, 2016b). Data collection included three questionnaires (agriculture, household and community) for the post-planting and post-harvest periods. The GHS-Panel sample is selected from the 2010 GHS sample and comprises about 22,200 households from 2220 Enumeration Areas (EA) and 60 Primary Sampling Units (PSU). For the panel component, 5,000 households from 500 EAs are chosen. Some key variables like the educational level of household head are missing from the first and second waves of the GHS-Panel, so this study makes use of the third wave alone. In the third wave of the GHS-Panel, only 4,581 households completed the questionnaire. After data cleaning, transforming, and selecting for key variables, the sample for this study is reduced to 1,096 households from both urban and rural areas.

3.5.2 Variable Measurements

In this study, we use a self-assessment measure of household food consumption as a proxy for food insecurity. This food insecurity measure is an experiential indicator that is measured using days of food shortages. Household heads are asked if they had to reduce the size of meals eaten in their households because of insufficient food. The choice of this measure is informed by our focus on the food availability pillar of food security. It is a binary variable that takes the value of one when households report they had to reduce the portion sizes of meals in their household over the last week (food insecure) and zero otherwise (if food secure) (Li & Yu, 2010). Land access is captured by a household's farm size, which is their total area of cultivated land measured in acres. We use the sex of the household head to examine gender differences influencing food insecurity. The gender variable takes the value of 1 for female-headed households and 0 for male-headed households.[8] The gender-land

[8] The study does not capture possible intra-household impacts of gender. This may be a limitation of the study because women in male- and female-headed households may face different challenges (Doss & Morris, 2000).

interaction variable is included to establish the intervening effect of land access on the influence of gender of household head on household food insecurity status is a product of the gender and land access variables.

Control variables were included in the model to control for other household and farm-level characteristics influencing household's food insecurity. The *age* variable measures household heads age in years. The *agesquared* variable is included to determine the quadratic impact of age of household head on household food insecurity. The *location* variable captures whether the household is located in a rural area. The *education* variable measures the educational attainment of the household head, while household farm and non-farm income is measured in terms of Naira, the Nigerian currency. The *remittance* variable captures those household's that received remittances and controls for their effect on household food insecurity. The interaction with extension officers, defined by *extension officer visits*, is measured as the number of visits from extension officers in the preceding year. This controls for the positive influence of the adoption of improved technologies resulting from contact with extension agents (Bogale, 2012; Gebrehiwot & van der Veen, 2014; Tefera & Tefera, 2014). The *land title* variable, included as an indicator for tenure security, is measured as households that have legal title and certification for their farmland. In the literature, tenure security has been found to improve household food security (Ajefu & Abiona, 2020; Ghebru & Holden, 2013).

The *fertiliser* variable, a dummy variable, captures households that use fertiliser for agricultural production. This controls for the positive effect of productive input use on production and subsequent food availability (Jena et al., 2021). It may also account for the gender-based inequity in accessing agricultural input (Ankrah et al., 2020). The *soil quality* variable is included as an indicator for land quality and measures if the soil quality of household farmland is good. In the literature, women have been shown to be more likely to access farm plots with lower soil quality compared to men (Burke &

This suggests that obstacles women in male-headed households face in accessing land and other productive resources may be different from what women in female-headed households experience and this will have consequences for their food security.

Jayne, 2021). Accounting for soil quality will control for the possibility of female-headed households only having access to lower quality land and the effect this will have on household food insecurity. Finally, we control for household access to markets by including a variable that captures the distance from household to the closest market (*distance to market*). Distance to input and output markets have been found to significantly influence household food security negatively (Aragie & Genanu, 2017; Kassie, Ndiritu, & Shiferaw, 2015; Mengistu, Degaga, & Tsehay, 2021).

3.5.3 Descriptive Analysis

Table 3.1 presents descriptive statistics for the variables included in Equation (1). In our sample, about 31 per cent of households are food insecure and cultivate an average of 2.21 acres. Less than 10 per cent of households are female-headed, while average household size is about 10. The mean age of household head is 51 years, with about 85 per cent of households located in rural areas. The average annual household farm income is ₦192,700 (equivalent to 507 USD), while mean annual off-farm income is ₦32,061 (equivalent to 84 USD). Households in our sample had an average of two extension officer visits, are located about 68 kilometres from the nearest market on average, with a majority receiving remittances (96%). On average, about 47 per cent of households are connected to the national electricity grid, 6 per cent have formal land titles to their farmland, about 84 per cent reported good soil quality of their farmland, while 63 per cent used fertiliser for cultivation.

Table 3.2 presents the mean differences in key variables by gender of household head. On average, male-headed households are significantly less food insecure, have higher access to land, higher farm income, more household members, and are located farther away from the market than female-headed households. Female household heads are also significantly older and less educated than male household heads on average. There were no significant differences in terms of the location of household, non-farm income, remittance receipt, extension officer visits, land title and soil quality.

Table 3.2 Mean difference in key variables by gender of household head

Variables	Male		Female		Difference
	Mean	SD	Mean	SD	(*t*-stat)
Food insecurity	0.30	0.46	0.47	0.50	-2.78***
Farm size	2.33	0.11	0.49	1.08	10.84***
Age	50.58	12.97	56.56	10.91	-4.43***
Household size	7.09	3.12	4.63	2.65	7.54***
Location	0.85	0.36	0.81	0.40	0.93
Education	2.19	0.98	1.97	0.84	2.14**
Non-farm income	32.69	105.32	22.53	73.57	1.10
Farm income	202.04	376.20	59.93	97.48	8.65***
Remittance	0.96	0.19	0.94	0.23	0.66
Extension officer visits	0.14	0.91	0.38	2.42	-0.81
Land title	0.06	0.24	0.06	0.23	0.18
Fertiliser use	0.65	0.67	0.39	0.64	3.35***
Soil quality	0.83	0.37	0.83	0.38	0.04
Distance to market	69.45	37.76	52.08	30.62	4.57***

Note: *, **, *** represent significance at 10%, 5%, and 1% levels, respectively.

Source: Authors' calculation from the 2015/16 Nigerian GHS data

Table 3.3 indicates that about 93 per cent of the sample are male-headed households, with about three-quarters of them being food secure. In comparison, about 57 per cent of the female-headed households were food secure, with a greater share of these households residing in rural areas (Table 3.4). Table 3.3 reports that about 24 per cent of male-headed households and 43 per cent of female-headed households in our sample were food insecure. The gender variable has a statistically significant positive correlation with the food insecurity variable (0.090) at the 1% significance level (Table 3.A1 in the appendix). This implies that female-headed households are more likely to be food insecure in comparison with male-headed households.

Table 3.3 Mean distribution of households by demographic characteristics and food insecurity status

Gender	Age	Food insecurity				Total	
		No		Yes			
Male	50.57	781	76.27%	243	23.73%	1024	93.43%
Female	56.55	41	56.94%	31	43.06%	72	6.57%
Total		822	100%	274	100%	1096	100%

Source: Authors' calculation from the 2015/16 Nigerian GHS data

Table 3.4 Mean distribution of characteristics of male- and female-headed households

Gender	Rural (N)	Urban (N)	Land size (acres)	Non-farm income	Farm income	Household Size
Male	871	153	2.33	32.69	202.04	7.09
Female	58	14	0.49	22.53	59.93	4.62

Source: Authors' calculation from the 2015/16 Nigerian GHS data

Female household heads are older than their counterparts on average and also have much lower access to land.[9] One reason for the difference in age maybe because a majority of the female heads are either divorced or widowed in comparison with the male heads; hence, they are more likely to be older.[10] Similarly, Milazzo and Van de Walle (2015) and Ruwanpura and Humphries (2003) also find female heads to be older, with the main cause of female headship being widowhood and divorce. Household size of female-headed households are almost 50 per cent lower, on average than those of male-headed households. Oginni, Ahonsi, and Ukwuije (2013) and Milazzo and Van de Walle (2015) also find that male-headed households are larger than female-headed households.[11]

Table 3.4 shows that, on average, male-headed households have about 3.4 and 1.4 times more farm and non-farm income than female-headed households, respectively.[12] One reason for the large difference in farm income between both types of households is that female-headed households generally have less access to agricultural land. Even in cases where they do have similar access, they may not have enough family labour, access to markets and inputs to cultivate their land productively.

[9] Tibesigwa and Visser (2016) also found female household heads to be older on average.

[10] In our sample, about 87% and 67% of widowed and divorced household heads, respectively, are females.

[11] Milazzo and Van de Walle (2015) also report female-headed households have a higher dependency ratio than male-headed households, contrary to the findings of Oginni, Ahonsi, and Ukwuije (2013).

[12] Agrees with the findings of Kennedy and Peters (1992) and Akadiri, Nwaka, and Jenkins (2018).

Table 3.5 illustrates that most household heads had a primary education, with relatively few male- or female-headed households having a tertiary education.

Table 3.5 Distribution of households by educational attainment and gender

Education	Gender					
	Male			Female		
	n	%	% total HH	n	%	% total HH
No education	287	28.03	26.19	22	30.56	2.01
Primary education	374	36.52	34.12	34	47.22	3.10
Secondary education	241	23.54	21.99	12	16.67	1.09
Tertiary education	122	11.91	11.13	4	5.56	0.36
Total	1,024	100	93.43	72	100	6.57

Note: HH denotes Household

Source: Authors' calculation from the 2015/16 Nigerian GHS data

Table 3.6 shows descriptive statistics by geopolitical regions in Nigeria. Households in the northeast and the North Central zones were found to have the largest access to land compared to households in the South East and South South geopolitical zones. Figure 3.2 illustrates that the northern region makes

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Source: Ekong et al. (2012)

Figure 3.2 Map of Nigeria showing the geopolitical zones

up about two-thirds of the landmass of Nigeria, even though most of the population is situated in the southern region. Consequently, households in the northern regions have more access to land than those in the south, as illustrated in Table 6. Households in the northern geopolitical zones, on average, also have more household members than those in the south. In agrarian regions, this could signify more family labour, which will reduce costs and increase productivity. But, on the other hand, this could also imply more mouths to feed and a subsequent lack of food. The average age of household heads is lower in the northern regions than in the southern regions (Table 3.6). On average, households in the South East zone have the highest age for household heads, smallest land sizes, and the second to smallest household sizes.

Table 3.6 Demographic characteristics of households by geopolitical zone

Zone	Mean			
	n	Age (years)	Land size (acres)	Household size
North Central	140	47.87	3.63	7.58
North East	181	47.32	4.66	8.69
North West	272	47.69	2.14	8.31
South East	206	57.54	0.32	5.18
South South	186	51.98	0.55	5.82
South West	111	54.95	2.80	4.95

Source: Authors' calculation from the 2015/16 Nigerian GHS data

3.6 Results and Discussion

3.6.1 Gendered Access to Land and Food Security

We estimate equation (1) using a maximum likelihood estimator and present the results in Table 3.7. The estimated coefficients in Column 2, Table 3.7 indicate that the gender of household head, area of land accessed, and educational level of household head is statistically significant at the 5% level. Total farm income, fertiliser use, and soil quality are significant at the 1%, level while the gender-land interaction variable is significant at the 10% level. Of the significant variables, the area of land accessed, gender-land interaction, educational level, fertiliser use, and soil quality negatively influence food insecurity, while the gender of the household head has a positive influence.

Table 3.7 Estimation result of the food insecurity model

Explanatory variables	Food insecurity model	
	Odds ratio	Marginal effect
Farm size	0.938 (0.028)**	-0.012 (0.006)**
Gender	2.008 (0.659)**	0.138 (0.064)**
Gender*land	0.299 (0.197)*	-0.239 (0.129)*
Age	1.001 (0.006)	0.000 (0.001)
Age squared	1.000 (0.000)	0.000 (0.000)
Household size	0.975 (0.024)	-0.005 (0.005)
Location	1.076 (0.209)	0.014 (0.038)
Electricity	1.054 (0.161)	0.010 (0.030)
Education	0.833 (0.066)**	-0.036 (0.016)**
Non-farm income	1.000 (0.000)	-0.000 (0.000)
Farm income	1.000 (0.000)***	-0.000 (0.000)***
Remittance	1.900 (0.779)	0.127 (0.081)
Extension officer visits	0.960 (0.078)	-0.008 (0.016)
Land title	0.948 (0.289)	-0.011 (0.060)
Fertiliser use	0.682 (0.076)***	-0.076 (0.022)***
Soil quality	0.611 (0.108)***	-0.097 (0.034)***
Distance to market	0.997 (0.002)	-0.001 (0.000)
Constant	1.167 (0.636)	
Sample	1096	1096
P > chi^2	0.000	0.000
R-squared	0.0701	0.0701

Note: *, **, *** represent significance at 10%, 5%, and 1% levels, respectively; SE in parenthesis.

Dependent variable equals 1 if household is classified as food insecure, and 0 otherwise

The estimated marginal effect for the gender variable (Column 3, Table 3.7) shows that female-headed households are about 14 per cent more likely to be food insecure than male-headed households. This finding is similar to the vast majority of studies in the literature (Akadiri et al., 2018; Joshi & Joshi, 2017; Kassie et al., 2014; Tibesigwa & Visser, 2016), although, as noted earlier, Mallick and Rafi (2010) found no significant difference in the food security status of male-headed households and female-headed households in Bangladesh using a generalized threshold model. One reason given for this contradictory result is the lack of traditional and social limitations among indigenous groups in the Chittagong Hill Tracts in Bangladesh. This affords women the freedom to partake in the labour market and other income-generating activities. In contrast, our findings are explained by the fact that in the case of Nigeria and most other developing countries, women are still discriminated against in their access to most productive resources.

The estimated marginal effect for farm size, which is the variable representing land access (Column 3, Table 3.7) indicates that a one-acre increase in total land area accessed by households reduces the likelihood of food insecurity by 1.2 per cent. This result is in line with those in other studies from Kenya, Ethiopia and Myanmar (Ghebru & Holden, 2013; Muraoka et al., 2018; Rammohan & Pritchard, 2014), but disagrees with a study in South Africa that finds land grant recipients are more food insecure than non-recipients in land redistribution projects (Valente, 2009).[13] In this case, it may be that the majority of households that are land reform beneficiaries are disadvantaged to start with and are further burdened by relocation and travel costs of participating. In general, with more access to land and the corresponding yields and income, rural households are better equipped to combat food insecurity either by consuming their own produce or by selling their outputs and purchasing food with the proceeds.

The estimated marginal effect of the education variable in Column 3, Table 3.7, indicate that households with the household head having a tertiary education are less likely to be food insecure, as higher education reduces the probability of household food insecurity by about 3.6 per cent in comparison. Pinckney and Kimuyu (1994), Rammohan and Pritchard (2014), Tibesigwa and Visser (2016), and Akadiri et al. (2018) also find a positive relationship between the educational level of the household head and household food security. This suggests that with a higher level of education, the household head may have access to more human capital, information, and skills needed to use the right inputs, therefore increasing their productivity. This may also increase participation in off-farm work and therefore result in more income to purchase food.

In agreement with Gebrehiwot and van der Veen (2014), the estimated coefficient for farm income is negative and statistically significant. Considering that most households in the survey are located in rural areas, this suggests that households with higher farm income have more access to food and are therefore less food insecure. The estimated marginal effect of the fertiliser use variable in Column 3,

[13] Land grant recipients had extra access to land compared with non-recipients.

Table 3.7 indicates that using fertiliser for cultivation reduced the likelihood of a household being food insecure by 7.5 per cent. Fertiliser use has been found to improve agricultural productivity, which in turn increases household income and subsequently their capacity to access a variety of food through the market (Jena et al., 2021). The estimated marginal effect of the soil quality variable in Column 3, Table 3.7 show that households cultivating on farmland with good soil quality are 9.8 per cent less likely to be food insecure. This implies that households cultivating land with good soils may have better yields resulting in increased food availability and income.

Most importantly, the estimated marginal effect of the interaction term between female-headed households and land (Column 3, Table 3.7) is negative and statistically significant at the 10% level. Following Allison (2014), a Wald test (χ^2= 3.37 and p<0.10) and likelihood ratio test (χ^2= 5.31 and p< 0.05) is carried out to compare models with and without the interaction variable.[14] We reject the null hypothesis that the coefficient of the interaction variable is statistically equal to zero at the 0.10 and 0.05 significance levels, respectively. This shows that the coefficient of the interaction variable is statistically different from zero and improves the fit of the model.

Table 3.8 Average marginal effect of gender on food insecurity at different levels of land access

Land access	dy/dx	SE	Z	P>|z|	95% CI	
1SD<$\bar{x}$	-0.257	0.139	-1.85	0.065	-0.530	0.016
$\bar{x}$	-0.241	0.131	-1.85	0.065	-0.497	0.015
1SD>$\bar{x}$	-0.221	0.121	-1.83	0.067	-0.458	0.015

Note: SE is Standard Error; $\bar{x}$ is mean

We probe the significance of the gender-land interaction variable by computing the average marginal effects of the gender of household head on household food insecurity at three different levels of land access - one standard deviation (SD) below the mean, at the mean and one SD above the mean area

[14] To probe the discrepancy in statistical significance of the interaction term in the Wald and likelihood ratio tests, Table 3.A1 in the appendix compares results of the food insecurity models with and without the gender-land interaction variable. The model with the interaction term has a higher log likelihood and hence is preferred.

of land (Table 3.8). The estimated coefficients in Column 2, Table 3.8, indicates female-headed households are more likely to report food security with additional access to land, not only at the mean land access but also at both one SD below and one SD above the mean land access. Although, the probability is higher for female households with lower levels of land access in comparison with those with higher access to land. These results show that the likelihood of female-headed households being food secure increases depending on the area of land they have access to. Female-headed households with a small area of land access, have a slightly higher probability of being food secure with increased access to land. This reveals that the efficiency by which increased access to land improves food security of households depends on the area of cultivated land they have access to. Improving access to land has more impact in terms of increasing the likelihood of being food secure for those female-headed households that had less access originally. This finding is in line with that of Pindiriri (2021), who finds that the transfer of arable land to female-headed households will only lead to reduced poverty and hunger if it targets the households with fewer than three acres of land or no land at all.

3.6.2 Estimating the Non-Linear Interaction Effect

As noted earlier, the coefficient of the gender-land interaction variable in Equation (1) (Table 3.7) does not take into consideration the non-additive effect of the interaction term over the individual effect of both the gender and land variables. To overcome this problem, we estimate the full interaction effect by estimating Equation (2). Table 3.9 reports the full interaction effect and standard errors of the gender-land interaction variable by estimating the cross-partial derivatives of the expected value of food (in)security at different values of covariates. Results show that the mean interaction effect is -0.1615 and varies between -0.304 and 0.015. This implies that for some female-headed households, the interaction variable is negative while, for others, it is positive. The mean interaction effect reveals that with an extra one-acre of arable land, the likelihood of female-headed households self-reporting food insecurity decreases by about 16 per cent compared to male-headed households, *ceteris paribus*. This confirms the hypothesized causal pathway, denoted by Arrow 3 in Figure 3.1, and implies that improving timely access to productive resources like land will help in preventing the vulnerability of female-headed households to food shortages.

Table 3.9 Mean interaction effect of the gender-land interaction variable

Variable	Mean	Std. Dev.	Min	Max
Interaction effect	-0.1615	0.1268	-0.3039	0.0148

Note: Std Dev. is Standard Deviation

This finding may be a result of female household heads being better household resource managers than their counterparts (Levin et al., 1999), even when they are disadvantaged in their access to productive resources (Adesina & Djato, 1997). Also, many studies find that resource decisions made by female household heads improve the welfare of their households more than that of male household heads (Agarwal, 2003; Felker-Kantor & Wood, 2012; Levin et al., 1999; Rao, 2006). Although the results show that the interaction effect could be positive for different values of the covariates, this suggests that for some female-headed households, extra access to land has no effect on their food security. This is possible when households with ample access to land do not have adequate inputs or sufficient labour to make the land productive.

To investigate the significance of our results further, we plot graphs of the gender-land interaction effect against the predicted probability of households being food insecure and the z-statistics of the interaction effect against the predicted probability of being food insecure (see Figures 3.3 and 3.4). These illustrate how the significance and magnitude of the gender-land interaction effect varies.

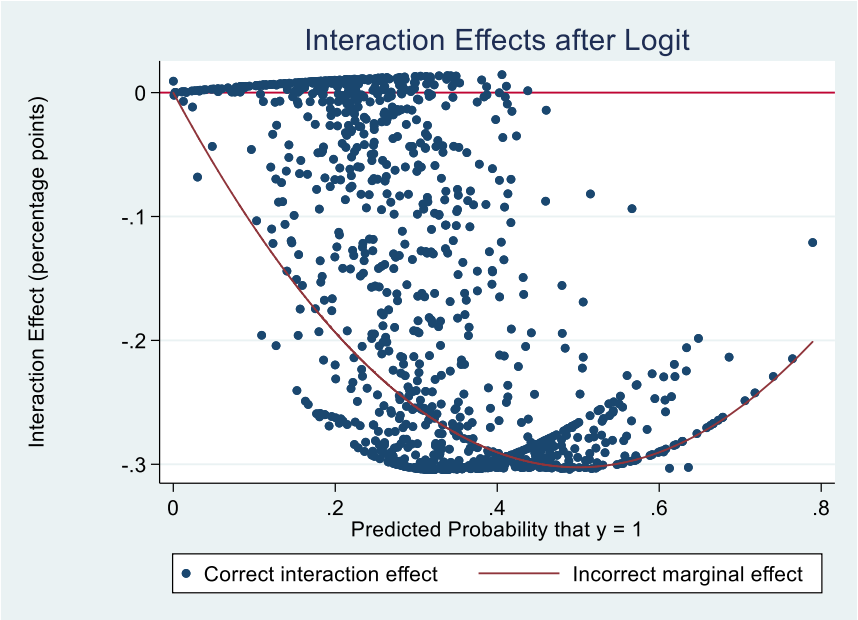

Figure 3.3 Plot of interaction effects and predicted probability of reporting food insecurity

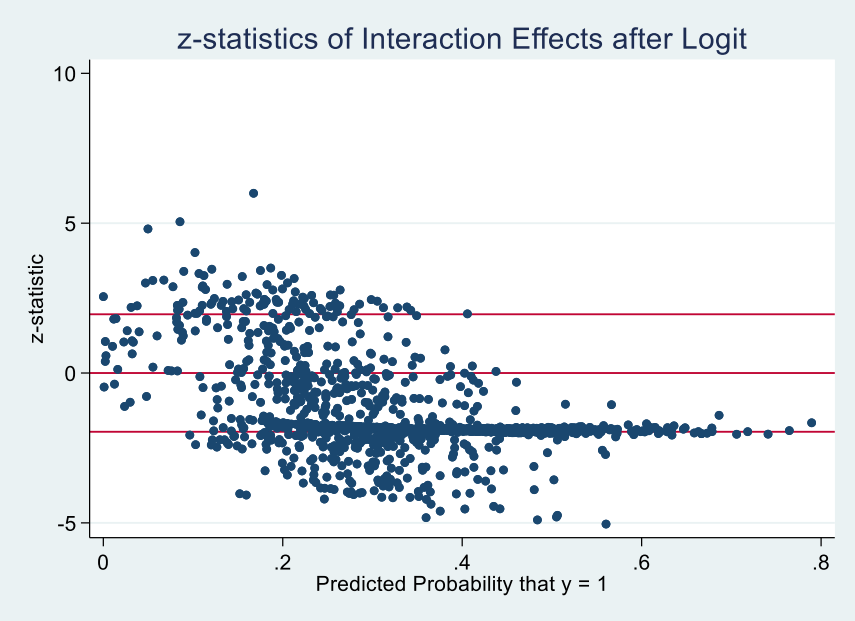

Figure 3.4 Plot of z-statistics of interaction effects and predicted probability of reporting food insecurity

For households with a predicted probability of reporting food insecurity between 0 to 0.3 (towards the left side of Figure 3.3), the gender-land interaction effect is positive for some households but negative for the majority. On the right side of Figure 3.3, we can see that for households with predicted probabilities of above 0.5, their interaction effects are mainly negative. This suggests that the more food insecure a female-headed household is, the higher the positive effect of extra land access will be on their food security.

Figure 3.4 indicates that in terms of significance, most of the households with a predicted probability of reporting food insecurity below 0.5 have statistically significant interaction effects. On the other hand, for households with predicted probabilities above 0.5, their interaction effects are mostly insignificant (Figure 3.4). Consequently, even with a significant coefficient for the interaction variable in the logit regression output, the estimation of the interaction effect based on cross-partial derivatives of food insecurity shows that not all gender-land interaction effects are significant. This highlights the importance of capturing the non-linear interaction effect of the gender-land interaction term, which to the best of our knowledge, has not been done in previous studies.

3.7 Conclusion

Using Nigerian data from 1096 households, this article has extended the current literature by quantifying the joint effect of the gender of household head and access to land on food insecurity using a binary logit model. Findings show that female-headed households are more food insecure than male-headed households. Also, an increase in land access diminishes the probability of households being food insecure. Analysis of the interaction effect of the gender-land interaction term shows that with a one acre increase in land access, the likelihood of female-headed households being food insecure decreases by about 16%, in comparison with male-headed households. However, our results also show that for some female-headed households, extra access to land has no effect on their food security status. This could be because they do not have the means and resources to cultivate the land and make it productive.

The study does have some limitations. First, it does not capture possible intra-household gender differences. This is a limitation because women in both male- and female-headed households may face different challenges in access to productive resources. Second, the sample is not inherently a representation of the Nigerian population. Also, the lack of observations in some regions means that zonal differences are not accounted for adequately and this may result in zonal misrepresentation.

Notwithstanding these limitations, the results of this study not only add to the literature but also have implications for policy and food security interventions. First, it emphasizes the need for gender equity in accessing land in order to ensure food security. Discrepancies in educational attainment and income between men and women may further increase the food security disparity between male- and female-headed households. Second, the findings can help inform policy implementation around issues of land access and land tenure systems, not only in Nigeria but also in other developing countries, in support of the fifth SDG for gender equality and empowerment of marginalized women. These initiatives have to take into consideration the deep-rooted traditional and cultural beliefs in Nigeria that strengthens the discrimination against women. For example, land redistributive reforms that tackle discrimination

against women in terms of land ownership and timely access to land for economic advancement will invariably improve food security for their households.

Appendix 3.0

Table 3.A1 Estimation results of the food insecurity model with and without the gender-land interaction term

Explanatory variables	With IT	Without IT
Farm size	0.938 (0.028)**	0.935 (0.029)**
Gender	2.008 (0.659)**	1.336 (0.354)
Gender*land	0.299 (0.197)*	
Age	1.001 (0.006)	1.000 (0.006)
Age squared	1.000 (0.000)	1.000 (0.000)
Household size	0.975 (0.024)	0.974 (0.024)
Location	1.076 (0.209)	1.079 (0.209)
Electricity	1.054 (0.161)	1.064 (0.162)
Education	0.833 (0.066)**	0.832 (0.066)**
Non-farm income	1.000 (0.000)	1.000 (0.000)
Farm income	1.000 (0.000)***	0.999 (0.000)***
Remittance	1.900 (0.779)	1.925 (0.784)
Extension officer visits	0.960 (0.078)	0.958 (0.075)
Land title	0.948 (0.289)	0.958 (0.292)
Fertiliser use	0.682 (0.076)***	0.686 (0.076)***
Soil quality	0.611 (0.108)***	0.620 (0.109)***
Distance to market	0.997 (0.002)	0.997 (0.002)
Constant	1.167 (0.636)	1.147 (0.623)
Sample	1096	1096
P > chi^2	0.000	0.000
R-squared	0.0701	0.0662
Log likelihood	-634.096	-636.752

Note: *, **, *** represent significance at 10%, 5%, and 1% levels, respectively; SE in parenthesis; IT denotes interaction term

Dependent variable equals 1 if household is classified as food insecure, and 0 otherwise

Chapter 4

Farmer-herder conflicts and food insecurity: Evidence from rural Nigeria

This chapter fulfils objective two and is based on the published journal article below :

Nnaji, A., Ma, W., Ratna, N., & Renwick, A. (2022). Farmer-herder conflicts and food insecurity: Evidence from rural Nigeria. *Agricultural and Resource Economics Review, 51*(2), 391-421. doi:10.1017/age.2022.9 (ABDC ranking: B)

Chapter 4 – Statement of Authorship

Title of Paper	Farmer-herder conflicts and food insecurity: Evidence from rural Nigeria	
Publication status	■ Published	☐ Accepted for Publication
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Publication Detail	Nnaji, A., Ma, W., Ratna, N., & Renwick, A. (2022). Farmer-herder conflicts and food insecurity: Evidence from rural Nigeria. *Agricultural and Resource Economics Review, 51*(2), 391-421. doi:10.1017/age.2022.9	

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Contribution to Paper	Conception and design of the study; data acquisition, analysis and interpretation; drafting of the manuscript; and reviewing the manuscript critically for significant intellectual content.		
Overall percentage (%)	65%		
Certification:	This paper reports on original research conducted during the period of my Doctoral study and is not subject to any obligations or contractual agreements with a third party that would constrain its inclusion in this thesis. I am the primary author of this paper.		
Signature		Date	28/10/2022

Co-Author Contribution

By signing the Statement of Authorship, each author certifies that:

1. the candidate's stated contribution to the publication is accurate (as detailed above);
2. permission is granted for the candidate to include the publication in the thesis; and
3. the sum of all co-author contribution is equal to 100% less the candidate's stated contribution.

Name of Co-Author	Assoc. Prof. Nazmun N. Ratna		
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Signature		Date	16/11/2022

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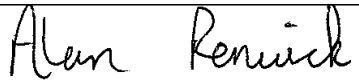
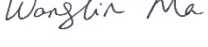
Contribution to the Paper	Supervising the development of the study, contributing to drafting the manuscript and revising the manuscript critically for important intellectual content.		
Signature		Date	15/11/2022

Name of Co-Author	Assoc. Prof. Wanglin Ma		
Contribution to the Paper	Supervising the development of the study, contributing to drafting the manuscript and revising the manuscript critically for important intellectual content.		
Signature		Date	28/10/2022

Abstract

Food security in many developing countries has been threatened by several factors such as unequal land distribution, ineffective land reform policies, inefficient agricultural value chains, and an increasing number of climate disasters. In Nigeria, these threats are exacerbated by rapid population growth and extreme weather events, which have resulted in farmer-herder conflicts in most agrarian communities. This paper examines the differential impacts of the incidence and severity of farmer-herder resource-use conflicts on food insecurity of rural households in Nigeria. We estimate a two-stage predictor substitution model to using survey data collected from 401 rural households in Nigeria. The empirical results show that both the incidence and the severity of farmer-herder conflicts significantly increase food insecurity, and the severity of these conflicts has a larger impact than their incidence. The estimates of the conditional mixed process models confirm the robustness of our results. Additional analysis reveals that the incidence and severity of farmer-herder conflicts positively and significantly affect food insecurity, measured by the number of days with limited varieties of food eaten. Our findings highlight the importance of policy interventions that address ongoing farmer-herder conflicts in affected countries like Nigeria to enhance food security from a sustainable development perspective.

Keywords: Farmer-herder conflicts; food insecurity; 2SPS model; Nigeria

4.1 Introduction

Despite achieving remarkable progress in the first-millennium development goal (MDG) of eradicating extreme poverty globally, food and nutrition security concerns persist in many low-income countries in the post-MDG era. Countries in the Global South are struggling to make substantial progress in sustainable development, especially in countries prone to conflicts, civil wars and political instability. It is estimated that about 381.4 million of the 650.3 million chronically undernourished people in 2019 originate from countries plagued with conflict, usually aggravated by climate-related shocks (FAO et al., 2021). Also, about three-quarters of children aged under five with stunted growth live in war-torn and conflict-ridden countries (FAO et al., 2017, 2021).

Disruptions like political instability, natural disaster, pandemics or conflicts have significant detrimental impacts on social, economic, and human development (George, Adelaja, & Awokuse, 2021; Hamoodi, 2021; Menton et al., 2021; Okunlola & Okafor, 2020; Qayyum, Anjum, & Sabir, 2021; Schillinger et al., 2020; Von Einsiedel et al., 2017). These disruptions also challenge the United Nations' Sustainable Development Goals regarding "No poverty (goal 1)", "Zero hunger (goal 2)", "Good health and well-being (goal 3)", "Responsible consumption and production (goal 12)", and "Peace, justice and strong institutions (goal 16)". For example, George, Adelaja, and Awokuse (2021) revealed that armed conflicts (Fulani ethnic militia) in Nigeria negatively affected farm outputs, areas harvested, and cattle holding. The occurrence of the Covid-19 pandemic in 2020 has exacerbated the ongoing conflicts. A case study by Menton et al. (2021) finds that the Covid-19 pandemic intensifies resource conflicts and indigenous resistance in Brazil.

Resource use conflicts between farmers and herders have been on the increase in most countries in the Sahelian African region due to rapid population growth and the escalating effects of climate change (Day & Caus, 2020a). Farmer-herder (FH) conflicts occur when nomadic herders graze their animals (e.g., cattle) in farmers' cropland, leading to yield and income losses for farmers. Farmers sometimes retaliate by maiming the cattle or forcing herders out of their communities. In response, herders fight back, and FH conflicts occur (Blench, 2010; Dimelu, Danjuma, et al., 2017). Although conflicts between

herders and farmers have been ongoing historically (Mbih, 2020), their frequency and intensity are increasing (George et al., 2022). These conflicts directly influence rural households' food insecurity because of their direct impacts on the ability to cultivate land the herders want to access and/or to access food via markets. There is a dynamic causal relationship between conflicts and food insecurity, as food insecurity can either be an outcome of or a cause of conflicts (Bora et al., 2011; D'Souza & Jolliffe, 2013; George, Adelaja, & Awokuse, 2021; Martin-Shields & Stojetz, 2019; Messer, Cohen, & Marchione, 2001; Teodosijevic, 2003). As most developing countries are already inundated by hunger and poverty (Corral et al., 2020; FAO et al., 2020), the recent increase in resource-use conflicts will invariably have adverse impacts. For example, while the prevalence of extreme poverty has rapidly diminished in many countries since 2000, for countries in conflict-affected areas, poverty rates are stagnant or increasing (Corral et al., 2020). In this study, we focus on farmer-herder (FH) resource use conflicts. This is because of the dearth of literature empirically examining the food and nutritional consequences of FH conflicts on rural livelihoods.

Most of the studies on conflicts and food security have focused on armed and violent conflicts causing deaths (Brück, d'Errico, & Pietrelli, 2019; D'Souza & Jolliffe, 2013; George, Adelaja, & Awokuse, 2021; George, Adelaja, & Weatherspoon, 2020; Jeanty & Hitzhusen, 2006). Only three studies have investigated the relationship between armed conflicts and food consumption (Adelaja & George, 2019; George, Adelaja, & Awokuse, 2021; George et al., 2020). These studies used secondary data on fatalities perpetrated by Boko Haram terrorists and the Fulani ethnic militia (FEM) from Nigeria. To the best of our knowledge, there are no studies that capture how and to what extent ongoing FH conflicts influence rural households' food insecurity.

The objective of this study is to address this gap by focusing on the incidence and severity of FH conflicts and analyze how they affect food insecurity, measured by the household food insecurity access scale (HFIAS) and the coping strategies index (CSI). Specifically, the HFIAS food insecurity indicator captures household anxiety and uncertainty over insecure access to food, as well as their attitude indicating quality and quantity of food (Coates, Swindale, & Bilinsky, 2007; Maxwell, Coates,

& Vaitla, 2013). The CSI food insecurity indicator encapsulates households' behaviour when they do not have access to enough food (Maxwell & Caldwell, 2008). These two measures focus on the food availability and accessibility pillars of food security, and they have been used in previous studies (Benti, Biru, & Tessema, 2022; Dompreh, Asare, & Gasparatos, 2021; Ike, Jacobs, & Kelly, 2017). FH conflicts in our context refer to disagreements, fights, and clashes that occur between farmers and herders. Given the rapid population increases in most Sahelian African countries where nomadic herding is still practised, the impacts of these FH conflicts will continue to increase if the fundamental issues that trigger them are not addressed. Therefore, estimating the impact of FH conflicts on farm households' food security will allow evidence-based policy formulation in Nigeria and many other countries that are also prone to resource-use conflicts. Following Nie, Ma, and Sousa-Poza (2020) and Wan et al. (2015), a two-stage predictor substitution (2SPS) approach is employed to address the endogeneity issues of FH conflict variables and to estimate the data collected from rural farming households in Nigeria. We check the robustness of our empirical results using a conditional mixed process model. To enrich our understanding, we also present and discuss the results estimated for the impacts of FH conflict exposure on food insecurity, as well as the impacts of FH conflicts on food insecurity, measured by the number of months with insufficient food supply and the number of days with limited varieties of food eaten.

We contribute to the literature by developing a conceptual framework to identify causal pathways between the incidence and severity of FH conflicts and food insecurity. We then empirically examine these relationships using farm household data from Nigeria. This issue has been overlooked in the literature, even though FH conflicts have increased in most sub-Saharan African (SSA) countries (ACLED, 2019). Previously, most studies on this topic have been descriptive and exploratory (Audu, 2013; Dary et al., 2017; Dimelu, Salifu, et al., 2017; Dimelu, Salifu, & Igbokwe, 2016; Muhammed, Ismaila, & Bibi, 2015), with very few studies quantifying the magnitude of the impact on the food insecurity of rural households. The study by George, Adelaja, and Awokuse (2021) is an exception, which empirically examines the effect of fatalities resulting from armed conflicts perpetrated by the Boko haram terrorist group on household food security using panel data provided by the Nigerian

General Household Survey. However, our analysis differs from George, Adelaja, and Awokuse (2021) by focusing on primary data collected from rural households in Nigeria and measuring types of FH conflicts differently. Specifically, we consider the incidence and severity of FH conflicts. The incidence of FH conflicts accounts for the number of FH conflicts that occurred in the community in 2018, reported by interviewed farming household heads. The severity of FH conflicts is a weighted index that captures how severe previously occurred FH conflicts were, which is calculated based on survey questions and ranges between 0 and 1. Besides, we consider all FH conflicts, encompassing disagreements and clashes over land resources between farmers and herders, irrespective of whether they result in deaths or not.

Our focus on FH clashes stems from empirical evidence that uncertainties caused by exposure to conflicts prompt farmers to opt for sub-optimal strategies like shifting to lower investment crop portfolios and land use, hiding visible assets, and labour reallocation (Arias et al., 2019; Bozzoli & Brück, 2009; Brück et al., 2019; Gáfaro, Ibáñez, & Justino, 2014). FH clashes negatively influence agricultural production (George et al., 2021b), influencing food availability and accessibility in affected areas. We argue that as rural households are primarily involved in agricultural production, FH clashes will have consequences not just for their livelihoods but also for their production efficiency and, subsequently, their food security. Households that are neither directly involved nor exposed to FH conflicts in their community may also change their production decisions.

Nigeria is an interesting example because, as one of the most affected countries in Africa regarding the occurrence of armed conflicts (Raleigh et al., 2010), the economic consequences of FH conflicts are severe (Dimelu, Salifu, et al., 2017). According to the 2019 Global Terrorism Index, violence between Nigerian farmers and herders accounted for about a third of the increase in deaths, resulting in the nearly 300,000 people displaced in 2018. These FH conflicts have adverse economic effects on farming communities and pastoralists, resulting in enormous financial consequences for all involved (Sulaiman & Ja'afar-Furo, 2010). They limit the activities of herders and farmers, and this constitutes a threat to their livelihoods (Dary et al., 2017). The ongoing FH conflicts also negatively influence agricultural

productivity and output, farmers' cattle holdings, and the harvested land area (George, Adelaja, & Awokuse, 2021).

The rest of this paper is structured as follows. Section 2 provides a background on FH conflicts and food insecurity. We discuss our conceptual framework and estimation strategy in section 3. Section 4 describes the data, variable measurements, and descriptive statistics. Section 5 presents and discusses the empirical results, while Section 6 summarises the results and discusses policy implications.

4.2 Farmer-Herder (FH) Conflicts and Food Insecurity

Incidences of FH conflicts have been increasing in most parts of SSA. Several reasons attributing to FH conflicts have been discussed in the literature. These include: changing climatic conditions (Adano et al., 2012; Buhaug et al., 2015; Hendrix & Salehyan, 2012; Theisen, 2012), unfavourable land zoning, and national agricultural policies affecting herders (Benjaminsen & Ba, 2009; Mertz, Rasmussen, & Rasmussen, 2016), population growth (Day & Caus, 2020a), conflicting national and state government policies leading to diverted use of grazing land (Lenshie et al., 2020; Seter, Theisen, & Schilling, 2018), and reallocation of water resources away from grazing land to farming (Clanet & Ogilvie, 2009).

In Nigeria, pastoral activities date back to the inward migration of Fulani clans that have been grazing their cattle for centuries across the Sahelian African region (ICG, 2017), with peaceful coexistence with farming communities (Ahmed & Muhammad, 2021; Seddon & Sumberg, 1997). The rapid increase in FH conflicts in Nigeria can be attributed to the following factors. First, rising temperatures and the resulting droughts and desertification from climate change stressors have led to increased migration of nomadic herders from Nigeria's northern region to the central and southern regions (Benjaminsen et al., 2012; Buhaug et al., 2015). Here, climate and environmental factors prompt herders to graze their animals further south and away from their primary grazing areas in the northern region. This leads to increased competition with farmers in the central and southern regions over scarce land resources, resulting in disagreements and fights between farmers and nomadic herders (Eke, 2020).

Majority of these nomadic Fulani herders being Muslim and sedentary farming communities being Christian also incorporate an ethnoreligious hostility in their interactions (Usman, 2019a). Recently, the situation has been intensified by collective conflicts between sedentary farming communities (mostly mainly Christian and non-Fulani ethnic groups) and non-sedentary herders (mainly Muslim Fulani populace) over land claims, community resource distribution, as well as control of local administrative authorities (George et al., 2022; Vaughan, 2016). The current land tenure system exampled by communal access to land, insecure private property rights, expensive land administration costs and the resulting lack of access to formal land titles further exacerbate the situation (Vanger & Nwosu, 2020). Second, the increasing terrorist insurgency of Boko Haram in the north-eastern region has led to the forced displacement and increased migration of individuals towards the southern region (George, Adelaja, Awokuse, et al., 2021; George et al., 2022). Invariably, this places increased pressure on scarce resources resulting in inadequate land resources. This leads to conflicts between farming communities and nomadic herders in the central and southern regions of the country (Ojo, 2020). Finally, ineffective implementation of existing land policies on open grazing and grazing routes fosters nomadic pastoralists' relegation. In 1965, the grazing reserve law was passed to assign land resources to herders. Yet, some of the land allotted under this law has been commandeered by non-herders for non-grazing activities (Ojo, 2020), often expedited by the failure of the government to enforce the law. Fewer than a quarter of the grazing reserves initially allocated for herders are currently being used for grazing purposes (ICG, 2017).

We argue that the occurrence of FH conflicts could impact the four main pillars of food security, as reported by the (FAO, 2006), including: (1) food availability, (2) food accessibility, (3) food utilization, and (4) food stabilization. For the food availability dimension, the existing literature concludes that conflicts reduce food security through their adverse impacts on agricultural labour supply (Blattman & Miguel, 2010; Serneels & Verpoorten, 2015; Verwimp & Muñoz-Mora, 2018), production decisions (Arias et al., 2019), and outputs (Adelaja & George, 2019; George, Adelaja, & Awokuse, 2021). Conflicts affect the food accessibility dimension of food security through their harmful impacts on physical and economic access to food. For example, conflicts may lead to the destruction of infrastructure like

roads, markets and farms (Kah, 2017). For the food utilization dimension, the adverse impacts of conflicts are usually captured through anthropometric outcomes (Akresh, Lucchetti, & Thirumurthy, 2012; Martin-Shields & Stojetz, 2019; Tranchant, Justino, & Müller, 2014). Finally, for the food stabilization dimension, the adverse effects of conflicts appear to be captured through its impact on variability of food prices and the value of food imports (George et al., 2020).

Since FH conflicts are most likely to affect rural food production and market supply, our food insecurity measurements focus on the food availability and accessibility pillars of food security. In the following section, we discuss how FH conflicts affect food insecurity theoretically before we introduce our data and discuss the empirical results.

4.3 Conceptual Framework and Empirical Strategy

4.3.1 Conceptual Framework

Following George et al. (2020), we define a household food consumption demand model based on a constrained utility maximization problem to explain how FH conflicts influence rural households' food insecurity. Consider an agricultural household that derives utility from the consumption of its own-produced food (F_o) and market-purchased food (F_m). Let F be the total consumption demand for food, then the equilibrium demand for food consumption can be presented as follows:

$$F = F_o + F_m \tag{1}$$

To facilitate our analysis, we assume that total food consumption demand (including the level of food insecurity) is affected by household income (*Y*) and production inputs (*X*). We further assume that FH conflicts (τ) have impacts on household income and production inputs, which finally affects household food consumption. Thus, the equilibrium demand for food consumption can be derived as:

$$F = (Y(\tau), X(\tau)) \tag{2}$$

where Y is household income, X indicates inputs used in the production process, and τ denotes FH

conflicts.

When FH conflicts occur, not all farming households in the community are directly affected. Therefore, we make a case for this by splitting the impact of FH conflicts into two – incidence of FH conflict and severity of FH conflict. Figure 4.1 depicts the key channels through which the two types of conflicts affect food insecurity.

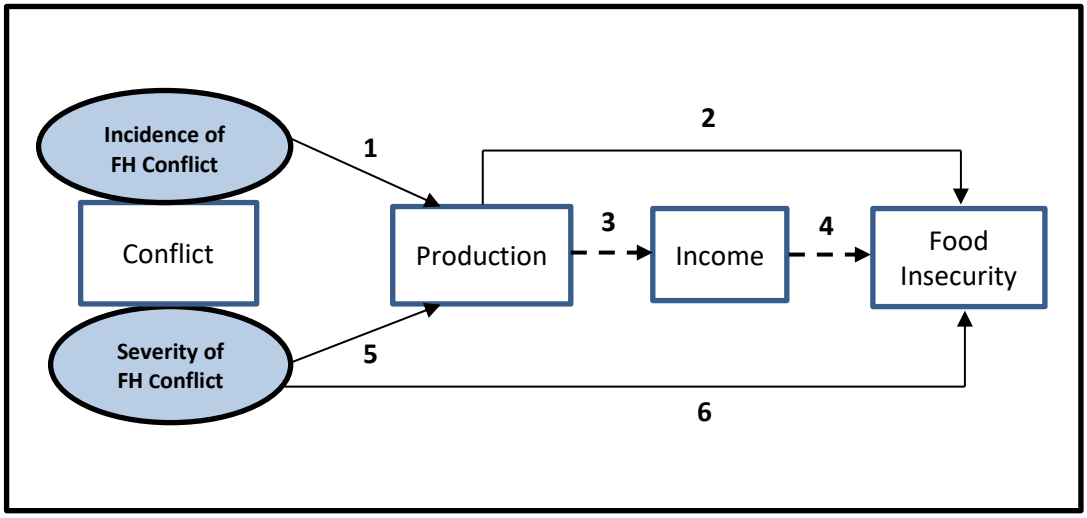


Figure 4.1 Conceptual framework capturing the impacts of FH conflict on food insecurity

The incidence of FH conflicts can affect food insecurity by directly influencing farm production (arrows 1 and 2) or by directly influencing farm production and then indirectly affecting household income (arrows 1, 3 and 4). The incidence of FH conflicts causes uncertainty and anxiety. Therefore, farmers influenced by the FH conflicts tend to make less efficient production decisions. For example, in agricultural production, farmers affected by conflicts may shift away from high investment activities like perennial cropping to short-term, lower yield seasonal cropping, as depicted by the arrow (1) in Figure 4.1. This argument is supported by previous studies showing that incidences of terrorist events reduce the availability of hired labour, total outputs and productivity (Adelaja & George, 2019; Arias et al., 2019; George et al., 2020). Reduced production can directly impact food insecurity in terms of food availability for subsistence farmers (arrow 2). It can also negatively impact sales revenue and household income (arrow 3), increasing food insecurity because of decreased food purchasing power

(arrow 4). Brück et al. (2019) also found that violent conflicts reduce households' adaptive capacity via abridged income stability and diversification, which, in turn, increase food insecurity (arrows 3 and 4).

The severity of FH conflicts can also affect food insecurity either directly (arrow 6) or indirectly (arrows 5, 3 and 4). Violent clashes, which lead to the injury and/or death of household members, loss of crop yield, and destruction of farm property, may directly and immediately affect household food insecurity through a reduction in the immediate availability of food (arrow 6). Farmers severely affected by FH conflicts may also shift their production practices from profitable commercial cultivation to subsistence farming to ensure the food demands of their households, resulting in negative consequences for farm productivity (Adelaja & George, 2019; Arias et al., 2019) (arrow 5). Similarly, risk-averse farmers may also change from perennial cultivation to less risky and less profitable seasonal cultivation (Arias et al., 2019). This will have consequences for their food security through a reduced income trajectory and the subsequent inability to access food through the markets (Deininger, 2003; Justino, 2011) (arrows 3 and 4).

Econometrically, the influence of FH conflicts on food insecurity can be derived from the Kuhn-Tucker condition with respect to τ based on Equation (2). Formally, it can be expressed as follows:

$$\frac{\partial F}{\partial \tau} = \left(\frac{\partial F}{\partial Y}.\frac{\partial Y}{\partial \tau}\right) + \left(\frac{\partial F}{\partial X}.\frac{\partial X}{\partial \tau}\right) \quad (3)$$

where τ denotes the conflict measures – incidence or severity of FH conflicts. Equation (3) indicates that FH conflicts affect food consumption through their impacts on total household income and production inputs demanded.

As indicated earlier, we are focusing on the availability and accessibility pillars of food security in this study. Measures of food insecurity capturing the accessibility and availability of food will have an inverse relationship with household food consumption demands. For the purpose of analytical settings, we introduce ρ_j, a food insecurity (FI) shock, related to *F* such that $FI_j = \rho_j F$, where FI_j is the food insecurity measure (i.e., either the incidence or severity of FH conflicts) and ρ_j is the coefficient related to the j-th food insecurity measure. Given the inverse relationship between F and

FI_j, ρ_j is assumed to be negative i.e., $\rho_j < 0$. The effects of FH conflict on household food insecurity can then be denoted as:

$$\frac{\partial FI_j}{\partial \tau} = \rho_j[\left(\frac{\partial F}{\partial Y}.\frac{\partial Y}{\partial \tau}\right) + \left(\frac{\partial F}{\partial X}.\frac{\partial X}{\partial \tau}\right)] \quad (4)$$

where $\frac{\partial FI_j}{\partial \tau}$ captures the impact of FH conflicts on food insecurity. $\frac{\partial F}{\partial Y}.\frac{\partial Y}{\partial \tau}$ and $\frac{\partial F}{\partial X}.\frac{\partial X}{\partial \tau}$ are expected to be negative because, as discussed earlier, FH conflicts have negative impacts on household income and farm production. The intensity of food insecurity will vary as ρ_j varies. Consequently, this will be reflected in the differential impacts of FH conflicts on various food insecurity measures.

Following our conceptual framework above, we define the indirect and direct effects of FH conflicts as the incidence of FH conflicts (τ_{in}) and severity of FH conflicts (τ_{se}) and make the following two hypotheses:

Hypothesis 1: The incidence of FH conflict affects household food insecurity positively ($\frac{\partial FI_j}{\partial \tau_{in}} > 0$).

Hypothesis 2: The severity of FH conflict affects household food insecurity positively ($\frac{\partial FI_j}{\partial \tau_{se}} > 0$).

4.3.2 Empirical Strategy

It is challenging to estimate the impacts of FH conflicts on food insecurity using an ordinary least square (OLS) regression model because of potential endogeneity issues related to FH conflicts. FH conflicts do not occur randomly (Eberle, Rohner, & Thoenig, 2020). These conflicts usually break out in agrarian communities with specific institutional and environmental characteristics. When it happens, the severity of an FH conflict is not random either, as households with more assets and access to farmlands may be targeted. Following previous studies (Nie et al., 2020; Wan et al., 2015), we employ a two-stage predictor substitution (2SPS) approach to account for endogeneity issues.

In the first stage, the incidence and severity of FH conflict variables are regressed as functions of a vector of control variables and instrumental variables. Then, the FH conflict variables are predicted. Formally, the first stage equations are estimated as follows:

$$Incidence_i = \alpha_i X_i + \beta_i IV1_i + \varepsilon_i \quad (5a)$$

$$Severity_i = \gamma_i X_i + \delta_i IV2_i + \eta_i \quad (5b)$$

where $Incidence_i$ indicates the incidence of FH conflicts; $Severity_i$ indicates the severity of FH conflicts; X_i represents a vector of the control variables (e.g., age, gender, education, household size, and farm size); $IV1_i$ and $IV2_i$ are the two instrumental variables used for the 2SPS model identification; α_i, β_i, γ_i and δ_i are the parameters to be estimated; ε_i and η_i are two error terms.

$IV1_i$ refers to a variable (IV1) defined as the time taken when travelling from the household to the closest police station, and $IV2_i$ refers to a variable (IV2) capturing the distance from the household to the closest police station.15 The majority of rural households live in their ancestral homes and so do not choose where to live. Under this condition, the further away a household is from a police station with security operatives in attendance, the higher the likelihood of an incidence of FH conflicts. Thus, the distance variables can be justified as valid IVs. Following previous studies (Amadu, McNamara, & Miller, 2020; Di Falco, Veronesi, & Yesuf, 2011; Manda et al., 2019), we employ a falsification test to check the validity and effectiveness of the IVs in this study. The results (Table A1 in the Appendix) show that distance variables are significantly correlated with the FH conflict variables, but they are not significantly associated with the two food insecurity variables. Thus, we can conclude that both IV1 and IV2 can be used as valid IVs in the 2SPS models.

In the second stage, the food insecurity variable is regressed as a function, in which the predicted conflict variable is used to replace the original conflict variable. Formally, we estimate the following two equations:

$$Insecurity_i = \theta_i Incidence_i^P + \zeta_i X_i + \nu_i \quad (6a)$$

[15] We attempted to use the same IV in Equations (5a) and (5b) to simplify our analysis. However, the validity tests of the IV using the falsification tests suggest that we should use different IVs (IV1 and IV2) in the two equations for efficient model estimations.

$$Insecurity_i = \varphi_i Severity_i^P + \phi_i X_i + \omega_i \quad (6b)$$

where $Insecurity_i$ refers to food insecurity indicators. $Incidence_i^P$ refers to the predicted variable representing the incidence of FH conflict; $Severity_i^P$ refers to the predicted variable representing the severity of FH conflict. As shown in previous studies (Mishra & Moss, 2013; Wooldridge, 2015a), the predicted variables control for endogeneity issues and improve the efficiency of model estimations. X_i is defined earlier. θ_i, ζ_i, φ_i and ϕ_i are parameters to be estimated. ν_i and ω_i are error terms capturing the unobserved heterogeneities.

4.4 Data, Variable Measurements, and Descriptive Statistics

4.4.1 Data

The study uses primary farm household data collected between May and June 2019 in Nigeria. The information collected refers to the 2018 planting season. The sample was selected using a multistage sampling approach. First, we purposively selected the North Central and South-East geopolitical zones in Nigeria because they are the most food secure and least food secure zones (Nnaji, Ratna, & Renwick, 2020). According to the preliminary analysis, the North central zone was found to be the most food-secure zone, while the South-East was food insecure. Other secondary sources also suggest that the North Central zone had the most occurrence of FH conflicts, while the South-East zone had fewer incidences of FH conflicts. The purposive selection of these two regions helps increase the chances of variation in the data collected, making our samples more representative. Second, we purposively selected one state in each zone, then five local government areas (LGAs) in each state, based on the previous occurrences of FH conflicts. Third, two towns from each LGA and then two villages from each town were randomly selected. Finally, approximately ten households in each village were randomly selected to answer the interview questionnaire, contributing to a total of 401 households.

We conducted the survey with the assistance of enumerators who usually help the projects of the International Food Policy Research Institute (IFPRI), Abuja office, Nigeria. The enumerators spoke both

English and local dialects so they could control the survey quality. Before the formal survey, we improved the questionnaire based on the feedback collected from the pre-test samples. We also trained the enumerators to make sure they clearly understood the survey objectives and questions covered in the questionnaire, guaranteeing accuracy and efficiency of data collection. The information derived from the survey related to the 2018 planting season and focused on information, such as household, household head, and farm-level characteristics, asset ownership, and land tenure rights. Questionnaires were administered to household heads on behalf of the household. The households in our sample mainly cultivate crops such as cassava, yam, soybean, and maize and raise livestock such as poultry, sheep, and goats for livelihoods.

4.4.2 Variable Measurements

Food Insecurity

In this study, we employ both the household food insecurity access scale (HFIAS) and the coping strategies index (CSI) to proxy food insecurity. These two indicators allow us to capture food insecurity in the form of consumption behaviours that clearly indicate the food availability and accessibility pillars of food security. They also capture the elements of sufficiency, quality, and psychological factors (Maxwell, Vaitla, & Coates, 2014). Both HFIAS and CSI have been used in previous studies (Belayneh, Loha, & Lindtjørn, 2021; Oldewage-Theron & Egal, 2021; Pakravan-Charvadeh et al., 2021).

The HFIAS is a behavioural and psychological measure that captures household behaviours that reflect the insufficient quantity and quality of food as well as worry over access to it. It covers a 30-day period and is based on occurrence questions about households' anxiety and uncertainty regarding food supply, inadequate food quality, insufficient food intake, and its consequences. Responses were collected based on the frequency of the condition (rarely, sometimes, or often) and then used to construct an index that captures the prevalence of household food insecurity. The HFIAS ranges from 0 to 27 – households that are entirely food secure to those that are severely food insecure. The HFIAS not only captures the physical aspects of sufficient quantity and quality of food (availability) but also

detects the psychosocial expressions of worry and uncertainty about insecure food access (accessibility) (Castell et al., 2015).

The CSI is an indirect measure of food insecurity that captures the frequency and severity of households' behaviour when they do not have enough food or funds to buy food. It evaluates what people do when they do not have enough food by assessing the severity and frequency of coping behaviours used to manage food shortages. As with the HFIAS, the CSI is based on a 30-day recall of coping strategies that are then weighted (a household that just changes to a less preferred food is less food insecure than one with members that go a whole day without food) and combined into an index. It has a value ranging between 0 to 93. The CSI captures household behaviours and coping approaches in times of food deficit (Maxwell, Caldwell, & Langworthy, 2008).

FH conflicts

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Our measurements of FH conflicts differ from the armed conflicts defined in the Uppsala Conflict Data Program. In particular, the conflicts captured by this program captures armed conflicts with the government as one of the parties and perpetuate the use of armed forces resulting in battle-related deaths (Gleditsch et al., 2002). Their definition of conflicts imposes restrictions on the number of fatalities and the types of actors involved; hence, they are not suited for household-level studies. FH conflicts in the context of this study diverged from the armed FH conflict studied in George, Adelaja, and Awokuse (2021) and captured in the Armed Conflict Location and Event Dataset (ACLED), which

cover only violent FH conflict occurrences that result in fatalities. In our study, we capture both incidences of FH conflicts and the collateral damage from such conflicts. This allows us to specify the severity of conflicts in the number of deaths and injuries, loss of yield, and property. Our comprehensive definitions cover nuances not usually captured by solely a record of the number of battle deaths and these are integral to addressing our research questions.

Control variables

Food insecurity is affected by a plethora of factors. Hence, in addition to our key variables of interest – incidence and severity of FH conflict, we include control variables selected based on the literature on the determinants of food security (Baba & Abdulai, 2021; Dasgupta & Robinson, 2022; Delvaux & Paloma, 2018; Gallegos et al., 2022; Goli et al., 2021; Ingutia & Sumelius, 2022; Joshi & Joshi, 2017). Household-level socio-economic characteristics that are most likely to influence household food security are included in our model specification. The household heads' age, gender, and educational attainment are included to capture the influence of the household heads' personal characteristics on household food insecurity.

An asset ownership index is included to measure the effect of household wealth on their food insecurity status. The dependency ratio is specified as the number of household members aged between 15 and 65 years to household size. The road quality variable is measured as a dummy indicating household perception of the road quality from their village to their closest farmland. Farm size is total farmland measured in hectares. The household income variable is measured as total income per household member. The formal land title variable is captured as a dummy indicating whether a household has a formal title deed to their largest farmland. Crop diversification is captured as the number of crops cultivated by households, while the land tenure variables measure the total bundle of rights households have on their largest farmland. The land tenure variable captures households' total bundle of rights to their largest farmland. This measures the exclusive use rights rural households have to their land, which is a proxy for how secure the tenure on their farmland is.

4.4.3 Summary Statistics

Table 4.1 provides the summary statistics of the selected variables in the study. The control variables are selected by drawing upon the existing literature on conflicts and food security (Arias et al., 2019; Brück & d'Errico, 2019; Brück et al., 2019; D'Souza & Jolliffe, 2013; George et al., 2020; Martin-Shields & Stojetz, 2019). The food insecurity measures, HFIAS and CSI, are continuous variables. In particular, the value of HFIAS ranges between 0 to 27, and has a mean of 11.27. The value of CSI ranges from 0 to 93, and has a mean of 22.12. The incidence of the FH conflict variable is continuous, with a mean of about 4 (out of 28). This implies that, on average, FH conflicts occurred about four times in the communities surveyed in 2018. The severity of the FH conflict variable is a proportion that has a mean of 0.59 with a standard deviation of 0.39. The closer the value is to one for a household, the more

severe its food insecurity.

In our sample, the average rural household head is aged about 49, which is very close to the age reported in previous studies (Delvaux & Paloma, 2018; Etowa, Nweze, & Arene, 2014; George, Adelaja, & Awokuse, 2021). The average education is just more than eight years of formal education (Table 4.1). Twenty-four per cent of our sampled household heads are female. On average, the households have

Table 4.1 Variable definitions and descriptive statistics

Variables	Definitions	Mean (S.D.)
Dependent variables (Food insecurity)		
HFIAS	Household Food Insecurity Access Scale (0-27)	11.27 (6.33)
CSI	Coping Strategies Index (0-93)	22.12 (19.77)
Key explanatory variables (Conflict)		
Incidence of FH Conflict	Number of farmer-herder conflicts in the community in 2018 (0-28)	3.95 (6.20)
Severity of FH Conflict	Index for the severity of farmer-herder conflicts (%)	0.59 (0.39)
Control variables		
Age	Age of household head (years)	49.43 (14.46)
Gender	1 if household head is female, 0 otherwise	0.24 (0.43)
Education	Education of household head (years)	8.64 (5.18)
Asset index	Household asset ownership index	0.22 (0.21)
Dependency ratio	Ratio of the number of members aged below 15 years and above 65 years to household size (%)	0.40 (0.23)
Household size	Number of household members (persons)	9.44 (6.82)
Road quality	1 if household head perceives the quality of road from village to farmland is good, 0 otherwise	0.25 (0.43)
Farm size	Total area of cultivated farmland (hectares)	1.59 (1.55)
Formal land title	1 if household has formal title for their land, 0 otherwise	0.14 (0.35)
Household income	Household's total income (₦10,000/capita)[a]	4.48 (4.47)
Crop diversification	The number of crops cultivated by a household (0-17)	7.52 (3.15)
Land tenure	Bundle of property rights on their largest farmland (0-12)	10.47 (2.45)
Instrumental variables		
Time taken to police station	Time taken to travel from household to the closest police station (minutes)	35.97 (34.27)
Distance to police station	Distance from household to the closest police station (km)	7.87 (8.65)
Sample size	401	

a ₦ is Nigerian currency (US$1 = ₦ 380), S.D. refers to standard deviation

around nine members and cultivate around seven different crops on about 1.59 hectares of land. In comparison, Ecker and Hatzenbuehler (2021) reported an average farm size of about 2.35 hectares when estimating the Nigerian General Household Survey (GHS) data, and George, Adelaja, and Awokuse (2021) reported an average farm size of 3.77 hectares when estimating the same dataset. The difference is not impossible, given the fact that the GHS captures households in all geopolitical zones in Nigeria, especially zones with higher landmass than the zones captured in this study (North Central and South East). A quarter of household heads perceive that the quality of the road from their residing village to farmland is good. Only 14% of households have formal land titles. The average household income is 44,800 naira/capita/year (US$1=380 naira), which is higher than the income reported by Etowa et al. (2014), which is 29,504.06 naira/capita/year. The difference could be attributed to inflation over time.

4.5 Results and Discussion

4.5.1 Impacts of the Incidence of FH Conflicts on Food Insecurity

Table 2 reports the impacts of the incidence of FH conflicts on food insecurity, which are estimated by Equations (5a) and (6a) using the 2SPS model. As discussed earlier, we used the predicted variable representing the incidence of FH conflicts in the two food insecurity equations to address the endogeneity issues.

The results of the first-stage estimations (column 2 of Table 4.2) show that the age and gender of the household head and the perceived road quality to farmland are the main factors that negatively affect the incidence of FH conflicts. For example, the age variable appears to affect the incidence of FH conflicts negatively and significantly, suggesting that households with older heads experience fewer FH conflicts. This indicates that younger farmers may draw more FH conflicts due to a higher probability of them confronting herders and a lack of experience in peaceful coexistence and resolution of grievances. This finding aligns with that of Usman (2019b), who pointed out that younger farmers are more vicious in handling issues with herders, leading to more occurrence of FH conflicts in the Northern Senatorial District, Kaduna State, Nigeria. On the other hand, household size, crop

diversification, land tenure, and the time taken to the closest police station are the main factors that positively influence the incidence of FH conflicts. For example, the variable representing land tenure has a positive and statistically significant coefficient. This finding suggests that the more rights households have to their farmland, the more FH conflicts. This may be explained by the fact that with secure tenure, farming households are less likely to tolerate encroachment onto their land by herders who may be reluctant to obey formal land rights held by farming households leading to more incidences of FH conflicts. This implies that with a higher bundle of rights to their farmland, rural households are more protective of their farm assets which result in more lashes with herders. Our finding is in line with Rugadya (2020), who found land tenure to be a cause of tension and a driver of conflict among mining communities in Karamoja, Uganda.

Table 4.2 Impacts of the incidence of FH conflict on food insecurity: 2SPS model estimation

	First stage	Second stage	
Variables	Incidence of FH conflict (Coefficients)	HFIAS (Coefficients)	CSI (Coefficients)
Incidence of FH conflict (predicted)		0.074 (0.338)**	1.967 (1.076)*
Age	-0.067 (0.028)**	0.021 (0.036)	0.110 (0.109)
Gender	-1.824 (0.459)***	1.230 (1.077)	4.289 (3.307)
Education	-0.065 (0.064)	0.087 (0.077)	-0.073 (0.242)
Asset index	-1.531 (1.712)	-6.538 (1.698)***	-3.330 (5.166)
Farm size	-0.158 (0.144)	0.046 (0.211)	0.649 (0.575)
Formal land title	-0.205 (1.023)	3.275 (0.898)***	17.888 (3.140)***
Household income	-0.004 (0.059)	0.001 (0.069)	-0.188 (0.188)
Dependency ratio	-0.011 (0.012)	0.003 (0.014)	0.013 (0.042)
Household size	0.036 (0.069)**	-0.157 (0.063)**	-0.512 (0.182)***
Crop diversification	0.207 (0.110)*	-0.257 (0.141)*	-1.125 (0.447)**
Road quality	-1.490 (0.523)***	-0.775 (0.921)	0.173 (2.986)
Land tenure	0.199 (0.011)**	-0.503 (0.148)***	-2.081 (0.492) **
Time taken to police station	0.026 (0.011)**		
Constant	3.861 (2.259)*	16.071 (3.134)***	41.128 (9.044)***
Sample size	401	401	401
R-squared	0.183	0.152	0.151

Note: Robust standard errors in parentheses. *, **, *** represent significance at 10%, 5%, and 1% levels, respectively.

We used the variance inflation factor (VIF) to test the multicollinearity between independent variables, and did not find the existence of such an issue.

The results of the second-stage estimations (last two columns) show that the predicted variable representing the incidence of FH conflicts has positive and statistically significant coefficients. The findings suggest that a single increase in the incidence of FH conflicts increases food insecurity by 0.07 HFIAS units and 1.97 CSI units. The findings of the positive impacts of the incidence of FH conflicts on

food insecurity support Hypothesis 1. Incidences of FH conflicts may increase households' food insecurity through reduced income resulting from losses of crop yields or the destruction of farm property (as depicted in Figure 4.1). The finding is similar to that of George et al. (2020), who examined the effect of terrorism and armed conflicts on food insecurity and found that the frequency of terrorist attacks reduced household food consumption scores.

Among other control variables, the asset index variable is negative and statistically significant in column 3 of Table 4.2. This finding implies that a unit increase in a household's asset index reduces their food insecurity by 6.54 HFIAS units. The asset index is used as a proxy for wealth. The wealthier households are, the less food insecure they are. This finding agrees with previous studies (Chamberlin & Ricker-Gilbert, 2016; Mulwa & Visser, 2020; Mutisya et al., 2016; Neelakantan et al., 2020). The estimated coefficients for the variable representing formal land titles are positive and statistically significant. These findings suggest that having a formal title deed to farmland increases food insecurity. This implies that with formal rights to their farmland, rural households are more likely to protect their farmlands from encroaching herders. This will invariably lead to more occurrences of FH conflicts if herders do not respect the formal land rights of rural households and the subsequent increase in household food insecurity. Additionally, the high costs of obtaining land titles would limit title registration to lands situated in most urban and peri-urban areas, increasing household food insecurity. Our finding is supported mainly by Kehinde et al. (2021) for Nigeria. The household size variable's negative and statistically significant coefficients suggest that households with more members are negatively associated with food insecurity. A larger household size indicates more labour endowments to some extent; thus, they can benefit more from the farm and off-farm work and increase their food security.

4.5.2 Impacts of the Severity of FH Conflicts on Food Insecurity

Table 4.3 presents the results for the impacts of the severity of FH conflicts on food insecurity. The results are estimated by the 2SPS model using Equations (5b) and (6b). The first stage estimation results (column 2) reveal that farm size and household size have statistically significant and negative

impacts on the severity of FH conflicts. In contrast, crop diversification, road quality, and the distance from the household to the closest police station have statistically significant and positive impacts on the severity of FH conflicts. For example, the significant and negative coefficient of the household size variable suggests that households with more members are less severely affected by FH conflicts compared to households with fewer members. A possible explanation for this is that a larger household size offers more fighting power and hence, experience less severe FH conflicts. This finding agrees with that of Chamo et al. (2020). The significant and negative coefficient of the farm size variable indicates that households cultivating larger areas of farmland are less severely affected by FH conflicts. A reason for this may be that households with larger farmlands under cultivation may have other means of protecting themselves in the event of a FH conflict. They may also have means of protecting their farmlands and enforcing their property rights than those cultivating smaller pieces of farmland. The significant and positive coefficient of the crop diversification variable illustrates that households cultivating diverse crops are more severely affected by FH conflicts. Farmlands with diversified crops cultivated may attract grazing animals. The farmers lose more income and fight herders in retaliation, resulting in more severe FH conflicts because of competition. On the other hand, with increased diversified crops, herders may be less able to dissuade their animals from grazing on the farmland, which ultimately results in increased severity of FH conflict. This finding is in agreement with that of D'Errico, Bori, and Campos (2021), who found crop diversification to increase the likelihood of conflict in Mali.

Table 4.3 Impacts of the severity of FH conflict on food insecurity: 2SPS model estimation

	First stage	Second stage	
	Severity of FH conflict	HFIAS	CSI
Variables	(Marginal effect)	(Coefficients)	(Coefficients)
Severity of FH conflict (predicted)		2.044 (0.610)***	5.407 (1.981)***
Age	0.001(0.001)	-0.023 (0.024)	-0.015 (0.075)
Gender	0.058 (0.041)	-0.217 (0.810)	0.250 (2.517)
Education	0.000 (0.004)	0.032 (0.071)	0.230 (0.220)
Asset index	0.077 (0.089)	-7.720 (1.478)***	-6.729 (4.668)
Farm size	-0.021 (0.012)*	0.107 (0.216)	0.794 (0.562)
Formal land title	0.042 (0.005)	2.844 (0.864)***	16.718 (2.979)***
Household income	0.004 (0.005)	-0.030 (0.070)	-0.272 (0.187)
Dependency ratio	-0.000 (0.001)	-0.003 (0.013)	-0.005 (0.042)
Household size	-0.007 (0.003)**	-0.032 (0.044)	-0.167 (0.129)
Crop diversification	0.027 (0.005)***	-0.280 (0.126)**	-1.159 (0.386)***
Road quality	0.045 (0.042)**	-1.337 (0.744)*	-1.478 (2.437)
Land tenure	0.009 (0.008)	-0.411 (0.130)***	-1.815 (0.434)***
Distance to police station	0.021 (0.003)***		
Constant		20.064 (2.468)***	52.246 (7.350)***
Sample size	401	401	401
R-squared	0.132	0.169	0.163

Note: Robust standard errors in parentheses. *, **, *** represent significance at 10%, 5%, and 1% levels, respectively.

We used the variance inflation factor (VIF) to test the multicollinearity between independent variables, and did not find the existence of such an issue.

The second-stage results (columns 3-4 of Table 4.3) show that the estimated coefficients of the predicted variable indicate that the severity of FH conflicts has statistically significant and positive impacts on food insecurity for both the HFIAS and CSI models at the 1% level. These results imply that a unit increase in the severity of FH conflicts increases household food insecurity by 2.04 HFIAS and 5.41 CSI units. Hence, Hypothesis 2, 'the severity of FH conflicts positively impacts food insecurity', is supported. The severity of FH conflicts increases households' food insecurity through its negative impacts on the scarcity of food and income losses, crop yields, injury to livestock as well as the destruction of farm property (as depicted in Figure 4.1). Our findings are in line with the results of extant studies showing that violent conflicts reduce agricultural production and food security (Adelaja & George, 2019; Arias et al., 2019; Brück et al., 2019; George, Adelaja, & Awokuse, 2021; George et al., 2020).

Among other factors affecting food insecurity, the estimated coefficients for crop diversification are statistically significant and negative at the 1% level, indicating that increased diversification in crop cultivation reduces food insecurity. The finding is supported by the result of Goshu, Kassa, and Ketema (2012), who found a positive association between crop diversification and food security in rural Ethiopia. The finding of the negative relationship between crop diversification and food insecurity may be because areas, where a variety of crops are cultivated may imply fertile soils with an abundance of crops and foliage for grazing cattle. Hence, those areas are most likely to have increased availability of diverse types of food crops despite facing a higher probability of the incidence and severity of FH conflicts. The significant and negative coefficient of the road quality variable in column 3 shows that good quality roads from villages to farmland decreases food insecurity. Farmers can conveniently transport inputs from the markets to the farmland when the road is of good quality, which helps improve production efficiency and land productivity, contributing to food security. Land tenure affects HFIAS and CSI negatively and significantly, suggesting that land tenure security reduces food insecurity. Higher land tenure security motivates farmers to invest more in their farms, enhancing farm productivity and food security (Ghebru & Holden, 2013; Rockson, Bennett, & Groenendijk, 2013).

4.5.3 Robustness Check

We estimated the impact of FH conflicts on food insecurity using conditional mixed process (CMP) models for robustness check purposes. The CMP model can help address the endogeneity issues of the FH conflict variables (Baum, 2016; Zhu, Ma, & Leng, 2020). The results estimated for the impact of the incidence of FH conflicts on food insecurity are presented in Table 4.A2 in the Appendix. Table 4.A3 in the Appendix shows the results for the impact of the severity of FH conflicts on food insecurity. Overall, the estimates in the two tables show that the coefficients of the variables representing the incidence and severity of FH conflicts are positive and statistically significant. The findings suggest that FH conflicts increase food insecurity, which echoes our results from the 2SPS models and confirms the robustness of our estimates.

4.5.4 Additional Analyses

To enrich our understanding of the relationship between FH conflicts and food insecurity, we conducted three additional analyses using the 2SPS models. First, we estimated the impacts of FH conflict exposure on food insecurity. Here FH conflict exposure is measured as a binary variable, which is given the value of one if households have been exposed to FH conflicts and zero otherwise. This variable captures households in communities that have had at least one FH conflict incidence in the preceding year. Exposure to FH conflicts may not directly affect household production and food availability, but it may instil fear in rural people, making them modify their typical production investments and limit their economic activities (Arias et al., 2019). The results are presented in Table 4.A4 in the Appendix. We show that FH conflict exposure has a positive and statistically significant impact on HFIAS and CSI. The findings imply that FH conflict exposure also leads to food insecurity.

Second, we use two other outcome variables to capture food insecurity: the number of months with insufficient food supply and the number of days with limited varieties of food eaten. The results for the impact of the incidence of FH conflicts on the two outcome variables are presented in columns 2-3 of Table A5 in the Appendix, and the results for the impact of the severity of FH conflicts on them are shown in the last three columns of the table. Our estimates show that the incidence of FH conflicts positively impacts the number of days with limited varieties of food eaten. The severity of FH conflicts significantly increases food insecurity, as measured by the number of months with insufficient food supply and the number of days with limited varieties of food eaten. In general, the results presented in Tables 4.A4, and 4.A5 in the Appendix are largely consistent with our main findings in Tables 4.2 and 4.3.

Third, we have re-estimated our food security models by including the interactions between female-headed households and the main conflict variables. This exploration is interesting. Because women cannot inherit land in some tribes in Nigeria, the prevalence of women having access to land and land titles is low. Legally though, women can own land. The results presented in Table 4.A6 in the Appendix show that the coefficients of the interaction terms are insignificant, even at the 10% significance level.

The findings suggest that the gendered differentials do not necessarily influence the impact of FH conflict on food insecurity.

4.6 Conclusion and Policy Insights

Although any kind of conflict is detrimental to food security in general, studies on the impact of FH conflicts, the predominant type of conflict in SSA, is scarce in the literature. To fill in the research gap, this study estimated the impacts of the incidence and severity of FH conflicts on rural households' food insecurity, using data of 401 farm households collected from Nigeria. Food insecurity was captured using the HFIAS and CSI food insecurity measures. The 2SPS model was utilized to address the endogeneity issues of the conflict variables.

Empirical results revealed that both the incidence and severity of FH conflict significantly increase rural households' food insecurity. The severity of FH conflict has a larger impact on food insecurity than the incidence of FH conflict does. The positive relationship between FH conflicts and food insecurity is further confirmed by our estimates using the CMP model. We found food insecurity is negatively affected by asset index, household size, crop diversification, road quality, and land tenure, but it is positively influenced by formal title to farmland. The additional analysis showed that FH conflict exposure affects food insecurity positively and significantly. We also found that the incidence and severity of FH conflicts increase the number of days with limited varieties of food eaten, while the severity of FH conflicts also increases the number of months with insufficient food supply.

Our findings of the positive relationship between FH conflicts and rural households' food insecurity highlight the need for policy interventions to help households adversely impacted by ongoing FH conflicts. The results may expedite policy interventions to support households adversely impacted by ongoing FH conflicts. Such policies, for example, can include the provision of immediate safety nets, like food aid, to affected families, and planning post-conflict rehabilitation for both farmers and herders in regions severely affected by FH conflicts. Furthermore, while the above suggestions respond

to the conflict symptoms, there is a need to address the root causes. In particular, there is a need to consider policies that encourage more sustainable herding and farming practices. Early warning and alert systems that inform large farms and security forces about impending conflict will assist in preventing the onset of FH conflicts, which, in turn, will reduce their detrimental effect on rural livelihoods.

Additionally, since herders are mostly attracted to small farms in Nigeria establishing a community-wide solution where large farms cooperate with smaller farms would help prevent these conflicts. The need to curb the likelihood of FH conflicts in the future is paramount as the adverse effects of a changing climate are placing increased pressure on the land resources in Nigeria. This could be an interesting area for future research. The finding of the positive relationship between ownership of formal titles to farmland and food insecurity highlights the importance of establishing mechanisms or improving existing mechanisms that enforce formal land rights, aimed at reducing occurrences of these FH conflicts and subsequent food insecurity. This study focuses on the impacts of FH conflicts on the food insecurity of farmers. Future studies may look at how FH conflicts affect herders' herding behaviours and their food security.

Appendix 4.0

Table 4.A1 Falsification tests of instrumental variables

Variables	Instrumental variables			
	Time to police station		Distance to police station	
	F-value	*p*-value	*F*-value	*p*-value
HFIAS	2.15	0.143	1.52	0.218
CSI	1.69	0.194	1.69	0.195
Incidence of FH conflict	8.10***	0.005		
Severity of FH conflict			χ^2=56.08***; *p*=0.000	

Note: *** denote significance level at 1%

Table 4.A2 CMP parameter estimates for the impacts of incidence of FH conflict on food insecurity: Robustness check

	HFIAS		CSI	
Variables	First stage (Coefficient)	Second stage (Coefficient)	First stage (Coefficient)	Second stage (Coefficient)
Incidence of FH conflict		0.704 (0.369)*		1.968 (2.367)*
Age	-0.067 (0.028)**	0.021 (0.040)	-0.067 (0.028)**	0.110 (0.119)
Gender	-1.824 (0.466)***	1.230 (1.161)	-1.824 (0.452)***	4.289 (3.481)
Education	-0.065 (0.063)	0.087 (0.082)	-0.065 (0.063)	-0.073 (0.252)
Asset index	-1.531 (1.684)	-6.538 (1.937)***	-1.531 (1.684)	-3.330 (6.042)
Farm size	-0.158 (0.142)	0.046 (0.273)	-0.158 (0.142)	0.649 (0.625)
Formal land title	-0.205 (1.006)	3.275 (0.904)***	-0.205 (1.006)	17.888 (3.155)***
Household income	-0.004 (0.058)	0.001 (0.075)	-0.004 (0.058)	-0.188 (0.206)
Dependency ratio	-0.011 (0.012)	0.003 (0.015)	-0.011 (0.012)	0.013 (0.047)
Household size	0.136 (0.058)	-0.157 (0.075)**	0.136 (0.068)**	-0.512 (0.211)**
Crop diversification	0.207 (0.108)*	-0.257 (0.149)*	0.207 (0.108)*	-1.125 (0.461)**
Road quality	-1.490 (0.515)***	-0.775 (0.969)	-1.490 (0.515)***	0.174 (2.980)
Land tenure	0.199 (0.089)**	-0.503 (0.166)***	0.199 (0.089)**	-2.081 (0.531)***
Time taken to police station	0.026 (0.011)**		0.026 (0.011)**	
Constant	3.861 (2.222)*	16.071 (3.342)***	3.389 (2.037)***	41.128 (9.558)***
$\ln(\sigma_1)$	1.869 (0.157)***		2.987 (0.139)***	
$\ln(\sigma_2)$	1.722 (0.062)***		1.721 (0.062)***	
$\text{ath}(\rho_{\varepsilon v})$	-0.500 (0.332)		-0.447 (0.322)	
Sample	401	401	401	401

Note: Robust standard errors in parentheses. *, **, *** represent significance at 10%, 5%, and 1% levels, respectively.

Table 4.A3 CMP parameter estimates for the impacts of the severity of FH conflict on food insecurity

	HFIAS		CSI	
Variables	First stage (Coefficient)	Second stage (Coefficient)	First stage (Coefficient)	Second stage (Coefficient)
Severity of FH conflict		0.048 (0.008)***		0.111 (0.024)***
Age	-0.002 (0.004)	-0.028 (0.022)	-0.002 (0.004)	-0.032 (0.070)
Gender	0.112 (0.127)	-0.267 (0.795)	0.112 (0.127)	0.149 (2.492)
Education	0.007 (0.012)	0.031 (0.068)	0.007 (0.012)	-0.233 (0.213)
Asset index	0.217 (0.270)	-7.997 (1.387)***	0.217 (0.270)	-7.581 (4.547)*
Farm size	-0.081 (0.035)**	0.076 (0.192)	-0.081 (0.035)**	0.670 (0.630)
Formal land title	0.128 (0.158)	2.940 (0.795)***	0.127 (0.158)	17.013 (2.838)***
Household income	0.013 (0.013)	-0.024 (0.067)	0.013 (0.013)	-0.250 (0.186)
Dependency ratio	-0.001 (0.002)	-0.003 (0.013)	-0.001 (0.002)	-0.005 (0.041)
Household size	-0.016 (0.009)*	-0.032 (0.040)	-0.016 (0.009)*	-0.174 (0.121)
Crop diversification	0.073 (0.017)***	-0.239 (0.104)**	0.073 (0.017)***	-0.993 (0.327)***
Road quality	-0.222 (0.123)*	-1.420 (0.716)**	-0.222 (0.123)*	-1.848 (2.354)
Land tenure	0.020 (0.023)	-0.396 (0.124)***	0.020 (0.023)	-1.761 (0.421)***
Distance to police station	0.012 (0.001)***		0.012 (0.001)***	
Constant	-0.820 (0.415)	17.732 (2.403)***	-0.819 (0.415)	46.759 (7.169)***
$\ln(\sigma_1)$	1.720 (0.034)***		2.880 (0.040)***	
$\text{ath}(\rho_{\eta\omega})$	-0.013 (0.032)		-0.011 (0.033)	
Sample	401	401	401	401

Note: Robust standard errors in parentheses. *, **, *** represent significance at 10%, 5%, and 1% levels, respectively.

Table 4.A4 2SPS Parameter estimates for the impacts of FH conflict exposure on food insecurity

Variables	First stage	Second stage	
	FH conflict exposure (marginal effect)	HFIAS	CSI
		(Coefficients)	(Coefficients)
FH conflict exposure (predicted)		0.882 (0.424) **	2.466 (0.349) *
Age	-0.002 (0.002)	-0.018 (0.025)	0.001 (0.077)
Gender	0.140 (0.061)	-0.231 (0.821)	0.205 (0.220)
Education	0.005 (0.005)	0.019 (0.071)	-0.265 (0.220)
Asset index	-0.027 (0.127)	-7.497 (1.532)***	-6.011 (4.759)
Farm size	-0.025 (0.016)	0.043 (0.211)	0.640 (0.573)
Formal land title	-0.001 (0.068)	3.134 (0.888)***	17.493 (3.073) ***
Household income	0.005 (0.006)	-0.025 (0.069)	-0.261 (0.190)
Dependency ratio	-0.002 (0.001)*	0.003 (0.014)	0.012 (0.042)
Household size	-0.001 (0.004)	-0.056 (0.043)	-0.229 (0.125)*
Crop diversification	0.015 (0.008)**	-0.179 (0.120)	-0.909 (0.373)**
Road quality	-0.163 (0.052)***	-1.103 (0.837)	-0.743 (2.720)
Land tenure	0.007 (0.010)	-0.394 (0.135)***	-1.776 (0.442)***
Time taken to police station	0.004 (0.001) ***		
Constant		18.946 (2.563)***	49.165 (7.429)***
Sample	401	401	401
R-squared		0.152	0.151

Note: Robust standard errors in parentheses. *, **, *** represent significance at 10%, 5%, and 1% levels, respectively.

Table 4.A5 2SPS parameter estimates for the impacts of incidence and severity of FH conflict on alternative food insecurity indicators

Variables	Incidence of FH conflict			Severity of FH conflict		
	First stage	Second stage		First stage	Second stage	
		number of months with insufficient food supply	number of days with limited varieties of food eaten		number of months with insufficient food supply	number of days with limited varieties of food eastern
Incidence of FH conflict (predicted)		0.246 (0.156)	0.092 (0.051)*			
Severity of FH conflict (predicted)					0.378 (0.229)*	0.272 (0.088)***
Age	-0.067 (0.028)**	0.018 (0.015)	0.005 (0.006)	0.001 (0.001)	0.001 (0.009)	-0.001 (0.004)
Gender	-1.824 (0.459)***	0.642 (0.407)	0.067 (0.170)	0.058 (0.041)	0.144 (0.302)	-0.121 (0.123)
Education	-0.065 (0.064)	0.037 (0.028)	0.021 (0.012)*	0.000 (0.004)	0.017 (0.024)	0.014 (0.011)
Asset index	-1.531 (1.712)	-1.915 (0.624)***	-1.561 (0.251)***	0.077 (0.089)	-2.432 (0.545)***	-1.712 (0.212)***
Farm size	-0.158 (0.144)(0.144)	0.006 (0.072)	0.028 (0.037)	-0.021 (0.012)*	0.001 (0.070)	0.036 (0.038)
Formal land title	-0.205 (1.023)	0.148 (0.282)	0.312 (0.123)	0.042 (0.005)	0.034 (0.284)	0.256 (0.122)**
Household income	-0.004 (0.059)	-0.055 (0.023)**	0.009 (0.011)	0.004 (0.005)	-0.062 (0.024)***	0.005 (0.011)
Dependency ratio	-0.011 (0.012)	0.004 (0.005)	0.002 (0.002)	-0.000 (0.001)	0.001 (0.005)	0.001 (0.002)
Household size	0.036 (0.069)**	-0.075 (0.026)***	-0.011 (0.009)	-0.007 (0.003)**	-0.036 (0.016)**	0.005 (0.006)
Crop diversification	0.207 (0.110)*	0.042 (0.068)	0.011 (0.021)	0.027 (0.005)***	-0.015 (0.057)	-0.014 (0.019)
Road quality	-1.490 (0.523)***	-0.296 (0.344)	-0.078 (0.137)**	0.045 (0.042)**	-0.580 (0.251)**	0.149 (0.111)
Land tenure	0.199 (0.011)**	-0.111 (0.053)**	-0.061 (0.021)***	0.009 (0.008)	-0.069 (0.044)	-0.049 (0.019)***
Time taken to police station	0.026 (0.011)**					
Distance to police station				0.021 (0.003)***		
Constant	3.861 (2.259)*	3.080 (1.122)***	2.848 (0.489)***		4.428 (0.837)***	3.369 (0.366)***
Sample	401	401	401	401	401	401
R-squared	0.183	0.115	0.176		0.114	0.190

Note: Robust standard errors in parentheses. *, **, *** represent significance at 10%, 5%, and 1% levels, respectively.

Table 4.A6 2SPS parameter estimates for the impacts of incidence and severity of FH conflicts on food insecurity including gender-conflict interaction

	Incidence of FH conflict			Severity of FH conflict		
	First stage	Second stage		First stage	Second stage	
Variables		HFIAS	CSI		HFIAS	CSI
Incidence of FH conflict (predicted)		0.696 (0.338)**	1.946 (1.080)*			
Severity of FH conflicts (predicted)					1.944 (0.611)***	5.298 (1.957)***
Incidence of FH conflict (predicted) – Gender interaction		-0.612 (0.451)	-1.752 (1.367)			
Severity of FH conflict (predicted) – Gender interaction					1.284 (1.536)	1.415 (5.621)
Age	-0.067 (0.028)**	0.014 (0.35)	0.089 (0.110)	0.001 (0.001)	-0.025 (0.024)	-0.018 (0.075)
Gender	-1.824 (0.459)***	2.227 (1.196)*	7.143 (4.054)*	0.058 (0.041)	-0.448 (0.861)	-0.005 (2.797)
Education	-0.065 (0.064)	0.078 (0.076)	-0.099 (0.241)	0.000 (0.004)	0.029 (0.071)	-0.233 (0.220)
Asset index	-1.531 (1.712)	-6.557 (1.696)***	-3.383 (5.170)	0.077 (0.089)	-7.714 (1.478)***	-6.722 (4.676)
Farm size	-0.158 (0.144)	0.008 (0.209)	0.541 (0.576)	-0.021 (0.012)*	0.120 (0.222)	0.809 (0.565)
Formal land title	-0.205 (1.023)	3.147 (0.897)***	17.521 (3.139)***	0.042 (0.005)	2.925 (0.869)***	16.808 (2.998)***
Household income	-0.004 (0.059)	-0.001 (0.069)	-0.195 (0.187)	0.004 (0.005)	-0.034 (0.069)	-0.276 (0.186)
Dependency ratio	-0.011 (0.012)	0.002 (0.014)	0.010 (0.043)	-0.000 (0.001)	-0.003 (0.013)	-0.005 (0.042)
Household size	0.036 (0.069)**	-0.152 (0.063)**	-0.498 (0.182)***	-0.007 (0.003)**	-0.031 (0.043)	-0.166 (0.130)
Crop diversification	0.207 (0.110)*	-0.220 (0.147)	-1.019 (0.457)**	0.027 (0.005)***	-0.298 (0.130)**	-1.178 (0.397)***
Road quality	-1.490 (0.523)***	-0.997 (0.924)	-0.463 (3.032)	0.045 (0.042)**	-1.224 (0.733)*	-1.353 (2.438)
Land tenure	0.199 (0.011)**	-0.471 (0.150)***	-1.988 (0.502)***	0.009 (0.008)	-0.411 (0.131)***	-1.815 (0.434)***
Time taken to police station	0.026 (0.011)**					
Distance to police station				0.021 (0.003)***		
Constant	3.861 (2.259)*	16.016 (3.118)***	40.971 (9.057)***		20.347 (2.488)***	52.559 (5.621)***
Sample	401	401	401	401	401	401
R-squared	0.183	0.157	0.155		0.171	0.163

Note: Robust standard errors in parentheses. *, **, *** represent significance at the 10%, 5%, and 1% levels, respectively.

Chapter 5

Risk Perception, Farmer-Herder Conflicts, and Production Decisions: Evidence from Nigeria

This chapter fulfils objective three and is based on the published journal article below :

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Contribution to Paper	Conception and design of the study; data acquisition, analysis and interpretation; drafting of the manuscript; and reviewing the manuscript critically for significant intellectual content.		
Overall percentage (%)	65%		
Certification:	This paper reports on original research conducted during the period of my Doctoral study and is not subject to any obligations or contractual agreements with a third party that would constrain its inclusion in this thesis. I am the primary author of this paper.		
Signature		Date	28/10/2022

Co-Author Contribution

By signing the Statement of Authorship, each author certifies that:

1. the candidate's stated contribution to the publication is accurate (as detailed above);
2. permission is granted for the candidate to include the publication in the thesis; and
3. the sum of all co-author contribution is equal to 100% less the candidate's stated contribution.

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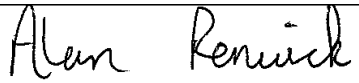
Signature		Date	15/11/2022

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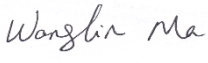
Signature		Date	28/10/2022

Abstract

This paper investigates the influence of the risk perception of farmer-herder conflicts on rural households' production decisions. Extending the farm household model to include the risk perception of farmer-herder-conflicts, we test hypotheses derived using primary data from 401 rural households in Nigeria. Results indicate that higher risk perception of farmer-herder conflict reduces fertiliser use and increases the time allocated for farm work. Dividing households based on their risk aversion, we find that risk-averse households rent-in significantly less cropland compared to risk-taking households. Findings highlight the need for policies that sustainably tackle farmer-herder conflicts for improved agricultural production.

Keywords: Risk perception; Farmer-herder conflicts; Production decisions; Farm households; Nigeria.

5.1 Introduction

In most sub-Saharan Africa (SSA) countries where nomadic herding is practised, clashes between herders and farming communities are recorded, and their occurrence frequency increasing (ICG, 2017). This is partly driven by rising global temperature and the resulting drought and desertification, which increases the likelihood of farmer-herder (FH) conflict because of greater competition for scarce land resources (George, Adelaja, Awokuse, et al., 2021; George et al., 2022; Lenshie et al., 2021). FH conflicts often result in dire consequences for the nutrition and food security of affected rural households (Nnaji, Ratna, et al., 2020a).

Extant literature shows that armed conflicts directly influence households involved in the conflict, particularly in terms of their productivity and livelihoods (Arias et al., 2019; Brück et al., 2019). However, in the case of FH conflicts, little is known about its wider impact on households who are not directly involved in the conflict. These impacts may include higher market prices for staple foods as a result of a reduction in supply to output markets (D'Souza & Jolliffe, 2013), reduced investments in production due to uncertainty and fear of conflicts occurring (Arias et al., 2019) and, a decline in productivity and the output of staple crops (Adelaja & George, 2019; George, Adelaja, & Awokuse, 2021).

Ascertaining the precise nature of the relationship between conflicts and rural household production is also essential because of its implications for household food security (Martin-Shields & Stojetz, 2019). Since most rural households are primarily involved in agricultural production, anything that affects their production will have a ripple effect not just on their productivity and livelihood but also on their food security. In 2016, more than half of the 815 million undernourished people were living in countries besieged with violent conflicts and fragility (FAO et al., 2017). In the microeconomic empirical literature, studies reveal that armed conflicts negatively affect agricultural investments (Arias et al., 2019), cropping practices (Bozzoli & Brück, 2010), agricultural outputs (Adelaja & George, 2019), livestock holdings (George, Adelaja, & Awokuse, 2021), efficient labour allocation (Bozzoli & Brück, 2009), and labour market outcomes (Kondylis, 2010). The fall in farm outputs due to armed conflict is

caused mainly by limited access to inputs, reduced labour supply, theft of farm produce, and the failure of supporting institutions (Blattman & Miguel, 2010; Rockmore, 2012; Verpoorten, 2009). Farmers also tend to react to the threat of conflicts occurring and violence by adopting short-term, low-risk, and less profitable production strategies, thus reducing their productivity in the long-term (Arias et al., 2019; Martin-Shields & Stojetz, 2019). Therefore, part of the process of tackling food insecurity requires a better understanding of the means and channels through which conflicts influence households' production decisions, and hence, their productivity.

Recently, there has been some interest in the literature about conflict, but almost all consider exposure to armed conflicts or terrorism rather than FH conflicts. For example, a study of armed conflict in Colombia explores the effect of violent conflicts and uncertainty on agricultural production (Arias et al., 2019), while a study on terrorist insurgency in Nigeria investigates the effect of armed conflicts on agricultural outcomes (Adelaja & George, 2019). Micro-level studies examining the influence of armed conflicts on agricultural outcomes suggest that conflict negatively affects land access, outputs, and labour supply for agricultural production (Adelaja & George, 2019; George, Adelaja, & Awokuse, 2021; Rockmore, 2015; Verpoorten, 2009). In addition, agrarian households in conflict-prone areas sometimes respond to a threat of conflict by adopting less profitable production strategies like seasonal cultivation, subsistence farming, and less efficient labour reallocation (Arias et al., 2019; Bozzoli & Brück, 2009; Brück et al., 2019; Gáfaro et al., 2014). Unlike armed conflicts and/or terrorism, FH conflicts occur mostly due to slow-onset crises such as those from changes in climatic conditions (Adano et al., 2012; Buhaug et al., 2015; George et al., 2022), increasing population, and disagreements about the access to and use of productive resources (Benjaminsen & Ba, 2019; Chukwuma, 2020; Clanet & Ogilvie, 2009). Apart from the study by George, Adelaja, and Awokuse (2021), there is a shortage of studies that empirically investigate the consequences of FH conflicts on agricultural outcomes or examine their effect on rural households' production decisions.

Recent studies examining terrorist attacks and resource competition in Nigeria have found that attacks by Boko haram have increased the number of violent FH conflicts (George, Adelaja, Awokuse, et al.,

2021; George et al., 2022). A reason given for this is that apart from the detrimental effects of climate change and other causes of FH conflicts, insecurity caused by terrorist attacks in the North East region drive herders to other regions in search of pasture for their animals, thereby leading to greater competition for land resources with farmers. Increased competition for limited land resources sets the stage for violent FH conflicts. Extant literature has found that violent FH conflicts influence agricultural outcomes, but there is still a gap in understanding the indirect impact of FH conflicts. Determining how rural households' risk perception of FH conflict influences their production decisions will not only show clearly the different impacts FH conflict has on agricultural production, but it will also highlight the other channels through which the ongoing FH conflicts can influence agricultural production.

This study endeavours to fill this gap in the literature by investigating the impact of risk perception of FH conflicts on rural households' production decisions. To the best of our knowledge, this is the first study to examine how the perceived risk of FH conflicts influences household production choices, which, in turn, affects their output. We use primary, cross-sectional, and household-level data collected from conflict-affected areas in rural Nigeria. The information covers the 2018 planting season and captures FH conflicts occurring that year. We employ a simultaneous equation model within a conditional mixed process (CMP) framework in our estimations to account for simultaneous production decision-making and to also account for possible selection bias in the sample. We check the robustness of our results using logit, Tobit, and fractional regression models. To determine variations in risk perception of FH conflict, we construct a novel risk variable that builds on an index from an earlier study (Doss et al., 2008). This study explores, in general, whether the risk perception of FH conflicts affects the production decisions of farming households in rural Nigeria. While this study focuses on Nigeria, similar issues are likely to be relevant for other SSA countries facing the possibility of FH conflicts due to slow-onset disasters like droughts, displacement, desertification, etc.

Our study contributes to the literature in the following ways. First, we contribute to the relatively scant empirical studies on FH conflicts, a type of resource use conflict, by adapting the farm household theoretical model to investigate how the uncertainty linked to FH conflicts in the form of individual

subjective risk can influence food production through its effect on farmers' production decisions. Second, we provide empirical evidence of the adverse impacts of ongoing FH conflicts by testing hypotheses derived from our theoretical model. Given the increasing number of occurrences of resource-use conflicts beyond Nigeria, findings from this study can provide a better understanding of the decision-making process for all stakeholders in conflict-prone areas.

Our results suggest that increased risk perception of FH conflict is associated with a reduction in farmers' likelihood of using fertilisers by 8.3% and their investment in fertilisers by about ₦1,734. This is consistent with the findings of Arias et al. (2019), who find that farmers opt for low productive, lower investments in agricultural activities due to uncertainty in the form of the presence of armed actors in their community. In addition, the risk perception of FH conflicts significantly reduces the area of cropland rented-in by risk-averse farmers compared to risk-taking farmers, and it increases household time allocations for farm work. Our findings are robust to alternative model specifications.

We structure the rest of the paper as follows. Section 2 presents the background. We develop a theoretical model, propose hypotheses, and discuss the empirical models in Section 3. Section 4 describes the data and presents the descriptive statistics. Empirical results are presented and discussed in Section 5. The final section concludes the paper.

5.2 Background

5.2.1 Farmer-Herder (FH) Conflicts in Nigeria

FH conflict in this study is defined as disagreements and clashes between nomadic herders and farming communities over limited land resources. In Nigeria, nomadic herders are comprised mainly of Fulani people, who own the majority of livestock (Ojo, 2020). The Fulani pastoralists traditionally live and graze their animals in the northern region of the country and usually migrate south during the dry season in search of pasture. With the increasing onset of drought and desertification (Adano et al., 2012; Buhaug et al., 2015), as well as terrorist insurgency (George, Adelaja, Awokuse, et al., 2021;

George et al., 2022), they migrate further south for longer periods in search of sufficient pasture to graze their animals. This increases their competition with farmers in the middle belt and southern parts of Nigeria for scarce agricultural land (Eke, 2020). Typically, FH conflicts arise because herders grazing their animals in areas growing crops cause damage, thereby reducing yields. In response, farmers chase herders from their community and injure their animals, leading to herders fighting back, and FH conflict ensues (CDD, 2021). Of late, FH conflicts in Nigeria have increased significantly (ACLED, 2019).

According to the 2019 Global Terrorism Index, the conflict between Nigerian herders and farmers was responsible for a third of the increase in deaths and the displacement of about 0.3 million people in 2018 in the country as a whole. The North Central geopolitical zone is the most affected region in Nigeria (Adeniran, 2020). This is because it is highly agrarian, and most of the agricultural production in Nigeria occurs in this region.

5.2.2 Conflicts and Agricultural Production Decisions

Studies on the impact of violent conflicts on agricultural production show that households in conflict-prone areas adjust their agricultural production portfolio. First, farmers tend to opt for sub-optimal agricultural activities like shifting from highly profitable perennial cash cropping to less profitable seasonal food crops and subsistence farming to protect their household consumption (Arias et al., 2019; Bozzoli & Brück, 2009; Deininger, 2003). Second, during violent conflicts, rural households tend to sell off their cattle portfolio to improve their household incomes and consumption (Blattman & Miguel, 2010; Rockmore, 2012, 2020; Verpoorten, 2009). Third, as their future income becomes increasingly uncertain due to violent conflicts, farmers tend to invest more in mobile assets to be less vulnerable to forced migration and displacement (Grun, 2008; Verpoorten, 2009). As a result of the above, armed conflicts lead to a decline in agricultural outputs (Adelaja & George, 2019; George, Adelaja, & Awokuse, 2021). A study examining the effect of armed conflict on smallholder agricultural decisions in Columbia finds that during times of uncertainty from conflicts, farmers tend to shift cultivation from high investment, highly productive perennial crops to lower investment, short term yield, and lower productive seasonal crops (Arias et al., 2019). Uncertainty is captured by the presence

of armed groups in farming communities. This implies that with the presence of armed actors in their community, farmers perceive a higher risk of violence and disruption and subsequently opt for less risky but also less productive agricultural activities. From the studies above, we can deduce that farming households alter their production decisions to reduce the impact of conflicts on their income and consumption.

Delving into the literature on the determinants of input use, the decision to use and the intensity of productive inputs use like fertilisers directly influence smallholder productivity (Endale, 2011). Several studies show that male farmers are more likely to use fertilisers than female farmers (Uaiene, 2011; Zondo, 2020), while Demeke (1998) finds that female-headed households positively influence the probability of fertiliser use. Farmer's age and fertiliser prices negatively influence both the decision to use fertilisers and the intensity of fertiliser use (Fufa & Hassan, 2006; Zondo, 2020). This implies that older farmers are less likely to use fertilisers than younger ones. Farming experience and cash crop cultivation were found to have an increasing effect (Freeman & Omiti, 2003; Ogola et al., 2011), suggesting experienced commercial farmers are more likely to use fertilisers. Farm size, manure application, soil fertility, and the distance to fertiliser markets negatively influence the intensity of fertiliser use (Olale, 2005; Zhou et al., 2010), while irrigation, average farm size, amount of livestock ownership, and increased crop yield are positively associated with the intensity of fertiliser use (Demeke, 1998; Zhang et al., 2017). Membership of farmer associations, access to agricultural extension services and the average distance from households to the nearest market positively influence the the decision to use fertilisers (Demeke, 1998; Uaiene, 2011; Zondo, 2020).

Bringing together the literature strands on conflict and agricultural production decisions, there is a gap in understanding not just how conflict influences input use but also the indirect pathways through which it happens. Studies on the impact of the risk perception of FH conflicts, a type of resource use conflict, on agricultural input decisions are almost non-existent. This is a clear gap in the literature despite how important these types of conflicts are. FH conflicts are on the rise as a result of the increasing consequences of climate change, among which are flooding, rainfall anomalies, drought,

and desertification (Fjelde & von Uexkull, 2012; Hendrix & Salehyan, 2012; Njiru, 2012; O'Loughlin et al., 2012; Raleigh, 2010). These will probably become more frequent if we do not address the issue of climate change or at least find sustainable ways to mitigate its effect. Considering agricultural productivity is largely influenced by agronomic decisions (Endale, 2011; Strasberg et al., 1999), determining the influence of risk perception of FH conflicts on the production decisions of rural households is vital to understanding how these reoccurring FH conflicts indirectly affect agricultural output. This study attempts to fill this research gap by developing a theoretical model of FH conflicts and empirically establishing the influence of the risk perception of FH conflict on rural households' production decisions.

5.3 Theoretical Model, Hypotheses, and Empirical Strategy

5.3.1 Theoretical Model of Farmer-Herder (FH) Conflicts

To examine the influence of the risk perception of FH conflicts on rural household production decisions, we extend the classical farm household model (Ma, 2016; Singh, Squire, & Strauss, 1986; Taylor & Adelman, 2003) by including the risk perception of FH conflict. This model assumes that rural households' risk perception of FH conflict will influence their investment in agricultural production.

The model assumes that farm households maximise utility over consumption over goods (*C*) and leisure (*L*):

$$Max\ U = U(C, L; H) \tag{1}$$

where *U* is the household utility function, which is assumed to be strictly concave with continuous second partial derivatives; H represents individual, household, and location characteristics that are external to household decisions.

Household utility maximisation is subject to technology, income, and time constraints. The agricultural technology constraint is:

$$Q = Q[X(\tau), T_F(\tau), F^i, F^r(\tau), H, R] \quad (2)$$

where Q is the output level; X is agricultural inputs such as fertiliser and seeds, which are functions of the risk perception of FH conflict, τ; T_F is household time allocation for farm work and also a function of τ; F^i is total owned cropland; F^r is total cropland rented-in and also a function of τ; R is a vector of external factors influencing production function.

The time constraint is as follows:

$$T = T_F(\tau) + T_N + L \quad (3)$$

where T expresses total time endowments of households, which include the time allocated for farm work T_F, off-farm work T_N, and leisure L. T_F is assumed to be a function of the risk perception of FH conflict, τ.

Utility maximisation is subject to income constraints. For agricultural households, amid an array of factors, income from production is highly associated with their land access and the productive investments on the land. Households' access to land may be constrained by insecure land tenure and high transaction costs in the land rental market (Huy et al., 2016). Since the emphasis of the study is on the impact of individual risk perception of conflict in the current production cycle, for ease of analysis, we model income constraints without transaction costs. Therefore, the income constraint of a household is:

$$P_C C = P_Q Q - P_X X(\tau) + W T_N + V \quad (4)$$

where P_c and C denote the price and quantity of consumption goods, respectively; P_Q and Q represent the price and quantity of output produced, respectively; P_X and X represent the price and quantity of inputs, respectively; τ is the risk perception of FH conflict; W indicates off-farm wages; T_N is time committed to off-farm work, and V embodies additional sources of income, including interest, pensions, rent, dividends, and government transfers.

The technology-controlled income constraint is derived by substituting equation (2) into equation (4):

$$P_c C = P_Q Q\left[X(\tau), T_F(\tau), F^i, F^r(\tau), H, R\right] - P_X X(\tau) + WT_N + V \quad (5)$$

The Lagrangian function of the household maximisation problem is then expressed as follows:

$$\mathcal{L} = U(G, L; H) + \lambda[P_Q Q\left[X(\tau), T_F(\tau), F^i, F^r(\tau), H, R\right] - P_X X(\tau) + WT_N + V - P_c C] + \mu\,(T - T_F + T_N + L) \quad (6)$$

where λ and μ are the Lagrangian multipliers for income and time constraints, respectively. The household decision problem is to determine household production based on the risk perception of FH conflict.

The first order Kuhn-Tucker conditions linked with maximising household utility subject to the constraints yield the following optimal choices for the household:

$$\partial\mathcal{L}/\delta X = \lambda(P_X(\partial Q/\delta X)) - P_X) = 0 \quad (7)$$

$$\partial\mathcal{L}/\delta T_F = \lambda(P_Q(\partial Q/\partial T_F)) - \mu = 0 \quad (8)$$

$$\partial\mathcal{L}/\partial F^r = \lambda(P_Q(\partial Q/\partial F^r) - \mu = 0 \quad (9)$$

$$\frac{\partial\mathcal{L}}{\partial\tau} = \lambda\left\{P_Q\left[\left(\frac{\partial Q}{\partial X}\right)\left(\frac{dX}{d\tau}\right) + \left(\frac{\partial Q}{\partial T_F}\right)\left(\frac{dT_F}{d\tau}\right) + \left(\frac{\partial Q}{\partial F^r}\right)\left(\frac{dF^r}{d\tau}\right)\right] - (P_X)\left(\frac{dX}{d\tau}\right)\right\} - \mu(dT_F/d\tau) \leq 0 \quad (10)$$

$$\partial\mathcal{L}/\partial T_N = \lambda W - \mu \leq 0, T_N \geq 0,\ T_N(\lambda W - \mu) = 0 \quad (11)$$

$$\partial\mathcal{L}/\partial C = U_c - \lambda P_c = 0, \quad (12)$$

$$\partial\mathcal{L}/\partial L = U_L - \mu = 0 \quad (13)$$

where $U_c = \partial U/\partial C$ and $U_L = \partial U/\partial L$ are partial derivatives of the utility function U.

The optimal household time allocation for leisure, off-farm work, and farm work can be calculated from the optimality conditions, equations (8), (11), (12), and (13):

$$\mu/\lambda = P_Q(\partial Q/\partial T_F) \geq W \quad (14)$$

where μ/λ signifies the marginal rate of substitution between consumption and leisure goods, as derived from equations (12) and (13); $P_Q(\partial Q/\partial T_F)$ denotes the value of the marginal product of farm labour. In equation (14), $\mu/\lambda = P_Q(\partial Q/\partial T_F) > W$ implies that the marginal value of households' leisure or farm labour exceeds their off-farm wage prospects, and the optimal time for off-farm work

is zero. When $\mu/\lambda = P_Q(\partial Q/\partial T_F) = W$, then the marginal value of a household's leisure or farm labour is equal to their off-farm wages, and the household's optimal time allocation to off-farm work may be positive (Huffman, 1991). Equations (7) and (8) can be solved to derive the demand functions for on-farm labour. The derivatives for off-farm work can be used to relate off-farm work to household production decisions due to their risk perception of conflict since off-farm work determines the value of the household's time ($W=\mu/\lambda$). In particular, income from off-farm work may increase rural household's liquidity and make them less risk averse to the effect of ongoing conflicts.

The optimal household decision, based on their risk perception of FH conflict, is obtained from optimality condition equations (10), (12), and (13). It is specified as follows:

$$P_Q(dQ/d\tau) - P_X(dX/d\tau) - P_c(U_L/U_c)(dT_F/d\tau) \leq 0 \quad (15)$$

where the total derivative of $dQ/d\tau$ is equal to $(\partial Q/\delta X)(dX/d\tau) + (\partial Q/\delta T_F)(dT_F/d\tau) + (\partial Q/\delta F^r)(dF^r/d\tau)$; $\mu/\lambda = P_c(U_L/U_c)$ signifies the marginal rate of substitution between consumption and leisure goods, as derived from equations (12) and (13). In equation (15), $P_Q(dQ/d\tau)$ can be interpreted as the value of the marginal loss or gain in production due to the risk perception of FH conflicts. Subsumed in $P_Q(dQ/d\tau)$ is $(\partial Q/\delta F^r)(dF^r/d\tau)$, which denotes the value of the marginal cost or gain to land rented-in by households for cultivation as a result of their risk perception of FH conflicts. $P_X(dX/d\tau)$ indicates the value of the marginal cost or gain of productive inputs as a result of the risk perception of FH conflict. $P_c(U_L/U_c)(dQ/d\theta_i)$ represents the marginal loss or gain in household production as a result of their risk perception of FH conflicts, valued at the marginal rate of substitution between the consumption of goods and leisure. Equation (15) specifies that with a shock in the form of the risk perception of FH conflict, there is either a marginal loss, zero change, or a marginal gain in production.

Given the cross-sectional data to be used, the implicit function theorem is used to derive expressions for the investment in productive inputs, time allocation for farm work, and area of cropland rented-in, which are functions of the risk perception of FH conflicts and other exogenous factors. These factors

are replaced in reduced form depictions of the household production decisions, observable household, household head, and farm-level characteristics.

5.3.2 Hypotheses

Our theoretical model implies that households' risk preferences and perceptions of FH conflicts affect their production through its influence on their investment decisions. Following the expected utility theory of risk aversion, we divide rural households into three risk groups by splitting their risk perception index into three tertiles to capture the different stages of risk behaviour (risk-taking, risk-neutral, and risk-averse). This is a relative measure of the risk aversion of households and not absolute. The model predicts that for risk-averse households, increased risk perception of FH conflicts will affect production through changes in their decisions to invest in productive inputs, rent-in cropland for cultivation, and their time allocated to farming. Their risk perception of FH conflicts can both reduce their investment in productive inputs and time allocation for farm work, depending on the risk preference of the household. On the one hand, for risk-neutral households, τ may not influence their optimal production level. On the other hand, for risk-taking households, the risk perception of FH conflicts may have an increasing effect on their production levels through their decisions to cultivate more land, increase investments in productive inputs, and increase their time allocation for farming.

From the theoretical model of FH conflict developed, we propose that marginal changes in production as a result of the risk perception of FH conflicts may be negative, zero, or positive (Equation 15). Specifically, we obtain the following hypotheses based on the model developed, and the proposition made, depending on the risk aversion of households:

H1: The risk perception of FH conflicts will not influence household investment in productive inputs like fertiliser.

H2: The area of cropland rented-in for agricultural production will not be influenced by their risk perception of FH conflicts.

H3: The time allocation for farm work will not be influenced by household risk perception of FH conflicts.

Our empirical analysis tests the hypotheses derived from the theoretical model above, using household-level data collected from rural Nigeria. In the next section, we develop the empirical strategy for testing our hypotheses.

5.3.3 Empirical Strategy

Our theoretical model of FH conflict postulates that the optimal choices of productive inputs like fertiliser, land, and labour by rural households depend on their risk perception of FH conflicts. Production decisions by crop farmers are usually undertaken concurrently (Höhler & Müller, 2021; Savikhin & Sheremeta, 2013). Farmers may simultaneously decide on the amount of productive input, land, and labour to invest in a particular cropping season. Given the significance of this joint decision-making process, we empirically test the hypothesis derived from our theoretical model of FH conflict by opting for a simultaneous equation specification following Ntakirutimana et al. (2019). This is because disregarding the joint decision of farmers may lead to inconsistent estimates of choice probabilities and erroneous standard errors. In this study, the decision to adopt fertilisers, investment in fertilisers, area of cropland rented-in, and household time allocation for farm work are defined as production decisions.

To investigate the influence between risk perception of FH conflicts and rural households' production decisions, we specify a simultaneous equation system in which the decision to use fertiliser, investment in fertilisers, area of land rented-in for cultivation and household time allocation for framework are the outcome variables. Specifically, the equation system is presented below:

$$FA_i = \beta_2 RPI + \theta^* X_i^* + \omega_i \quad (16)$$

$$FI_i = \beta_2 RPI + \beta^* Z_i^* + \varepsilon_i \quad (17)$$

$$LR_i = \beta_2 RPI + \alpha^* W_i^* + e_i \quad (18)$$

$$TF_i = \beta_2 RPI + \lambda^* K_i^* + \nu_i \quad (19)$$

where FA_i denotes rural household decision to use fertilisers, FI_i represents the amount of investment in fertilisers, LR_i indicates the amount of land rented-in for cultivation in hectares, and TF_i denotes a proxy for household time allocation for farm work for rural households *i*. Error terms

are normally distributed with pair-wise correlation coefficients ρ's. X_i^*, Z_i^*, W_i^*, and K_i^* are vectors of covariates for corresponding equations. $\theta^* = (\theta_1, \theta_2, .., \theta_k)$, $\beta^* = (\beta_1, \beta_2, .., \beta_j)$, $\alpha^* = (\alpha_1, \alpha_2, .., \alpha_s)$, and $\lambda^* = (\lambda_1, \lambda_2, .., \lambda_m)$ denote vectors of estimated parameters for corresponding equations. The decision to use fertilisers is a binary variable that is equal to one if the rural household uses fertilisers for cultivation; hence, equation (16) will be estimated with a binary logistic framework. Investment in fertilisers is a continuous measure for the amount of money (Nigerian naira) spent on fertiliser in the planting season under consideration. A continuous measure for the area of cropland rented-in for cultivation in hectares is adopted. Therefore, equations (17) and (18) are estimated by the ordinary least squares (OLS) method since the dependent variables are continuous. Income ratio, a proxy for household time allocation for farm work is a proportional variable that varies from 0 to 1. Consequently, equation (19) is estimated by a fractional regression model because the outcome variable is proportional in nature. Empirical models also include household socio-economic factors and farm-level characteristics as control variables, and these are described in Table 5.1.

Equations 16 to 19 are simultaneously estimated following the CMP framework and with robust standard errors (Roodman, 2011; Wooldridge, 2010). This is to account for potential concurrent production decision-making while investigating the relationship between risk perception of FH conflicts and rural households' production decisions. Using the conditional maximum likelihood technique, the CMP method jointly estimates the simultaneous equation system and correlation coefficients between error terms. The CMP framework also corrects for selection bias that may arise from unobserved factors affecting the outcome variables (Roodman, 2011). The challenge of maximising the likelihood function is resolved by using the Davidon-Fletcher-Powell (dfp) algorithm to eliminate the non-concave regions and achieve convergence of the estimation process (Gould, Pitblado, & Sribney, 2006).

The software package, STATA (version 15), is used to carry out all estimations. All analyses are estimated using robust standard errors. To check the robustness of our results, we estimate equations (16) to (19) individually using logit, Tobit, and fractional regression models.

We acknowledge possible sources of endogeneity that could affect our result estimates: omitted variable bias and selection bias.[16] To deal with the issue of omitted variable bias, we include possible confounding factors like extension officer visits and membership in farmer's associations.[17] Selection bias may arise from several sources. First, FH conflicts may occur disproportionately in highly agrarian areas and thus increase their perception of its risk. Alternatively, these FH conflicts may occur more in areas experiencing reduced productivity due to more competition over limited land resources between herders and farmers. These may further influence how rural dwellers perceive the risk of FH conflicts. Also, the concurrent production decisions rural households make may be highly correlated with their past experience of FH conflicts. We control for possible selection bias in our sample by opting for the CMP estimation framework. The CMP framework corrects for selection bias that may arise from unobserved factors affecting the outcome variables by building from the seemingly unrelated regression framework and accounting for cross-equation correlation of the error terms (Makate et al., 2016). We also distinguish between subjective and objective risks of FH conflicts by conducting two additional analyses on the influence of the number of FH conflicts and exposure to FH conflicts on rural household production decisions.

5.4 Data and Descriptive Statistics

5.4.1 Data

Cross-sectional household-level data from rural Nigeria is used for the study. The survey was carried out between May and June 2019. A multi-stage sampling technique was used to select households included in the sample. First, two geopolitical zones – northcentral and southeast zones, were

[16] We check for endogeneity of our key independent variable by implementing the Wu-Hausman Test and Durbin-Wu-Hausman test for endogeneity. In both tests, we fail to reject the null hypothesis of exogeneity, indicating the FH conflict risk perception variable is exogenous.

[17] Unfortunately, in this study, we cannot control for other confounding factors like innate entrepreneurial ability and time-varying factors due to the cross-sectional data we used.

purposively selected based on the frequency of occurrence of FH conflicts.[18] Second, one state in each geopolitical zone and five local government areas (LGAs) in each state were purposively selected based on a prior occurrence of FH conflicts. Finally, two towns in each LGA, two villages in each town, and approximately ten households in each village were randomly selected. A total of 401 households were selected for the survey. A pilot survey of 25 respondents in the study area was used to improve the quality and reliability of the questionnaire. The survey was conducted with the support of enumerators trained by the International Food Policy Research Institute (IFPRI), Abuja Office Nigeria.[19] Well-structured questionnaires were administered to the household heads on behalf of their households. Data collected includes information on the household, household head, and farm-level characteristics and covers the 2018 planting season. Table 5.1 presents the definition and summary statistics of variables.

5.4.2 Construction of the Risk Perception Index

Risk may be defined as the quantification of the probability or uncertainty of an event. It measures the uncertain consequences of possible adverse situations (Smith et al., 2000) and captures the value judgments individuals make when asked to describe and estimate hazardous events and activities (Slovic, 1987; Slovic & Peters, 2006). In the literature, risk is captured in two broad ways: the subjectivist approach and the frequentist approach (Hardaker, Huirne, & Anderson, 1997). On the one hand, the subjectivist approach concentrates on individual perceptions and preferences and allow for differences in the risk assessment of otherwise identical events. On the other hand, the frequentist approach is a more objective method that underscores consistent, measurable incidences of adverse and undesirable events. In the latter approach, 'risk' is described as imperfect knowledge of an event with a known likelihood of it occurring. It is different from 'uncertainty', where the possibility of occurrence is not known (Smith et al., 2000). Risk perception, which is the primary control variable for

[18] The northcentral zone has the most FH conflicts, while the southeast zone had the least FH conflicts (Okoro, 2018).

[19] All enumerators spoke both English and local dialects, they were trained for three days to guarantee precision and efficiency of data collection.

this study, is a psychological construct and is defined as the intuitive and subjective risk judgments made by individuals when characterising and assessing hazards (Slovic, 1987; Slovic & Peters, 2006), while the perceived risk is the probability of experiencing hazards personally and the likelihood of suffering negative consequences (Weber & Hsee, 1998). As the chances of FH conflicts occurring cannot be objectively quantified because of the nature of this type of conflict, in this study, we use the subjectivist route to capture the perceived risk of FH conflict. Subjective risk perception is a good alternative because it is not only closely correlated to the probability of the risky event occurring but also incorporates various aspects of individual behaviours. For example, subjective risk perception integrates an individual's understanding of the objective risks, their level of exposure to the risks, and their ability to mitigate any adverse events as a result of the said risk occurring (Doss et al., 2008; Knuth et al., 2014; Smith et al., 2000).

In this study, we construct an index capturing the risk perception of FH conflict by modifying the ranking method in Smith et al. (2000) and Doss et al. (2008). A series of possible concerns resulting from FH conflicts that occurred prior to the current agricultural season are presented to respondents (see table A1 in the Appendix).[20] Our goal was to capture the indirect effect of previous FH conflicts on investment in agricultural production. The respondents were then asked to choose the risks they were concerned about and rank them from the greatest to the least.[21] Here, we obtain rankings, in order of concern, for a series of possible hazards as a result of FH conflicts. Following Doss et al. (2008), we convert and standardise the rankings to evenly distribute the discrete rankings across the 0 to 1 interval, where 0 reflects no concern and 1 indicates the greatest concern. Following Doss et al. (2008), the risk assessment index is derived as follows:

$$R_{ij} = 1 - \left(\frac{(r_{ij}-1)}{n_i}\right) \qquad \text{for } i \text{ household head, and risks } j = 1,..,n_i, \tag{23}$$

[20] Household heads were asked risk perception questions about FH conflicts that occurred before the present agricultural season. They were asked to describe how concerned they are about certain issues based on their knowledge of previous FH conflicts.

[21] The list of possible risks as a result of FH conflicts is derived from a previous pilot survey in the study area.

where r_{ij} is the ordinal FH conflict risk ranking made by household heads and n_i is the number of risks chosen and ranked by household head i.

We then construct an index to measure the intensity of the households' risk perception of FH conflict by summing the risk assessment index of all risks for each household as follows:

$$\mathrm{RPI} = \sum_{i=1}^{n} R_{ij} \tag{24}$$

where RPI is the risk perception index. RPI captures the household heads' perceived level of risk averseness to potential hazards as a result of ongoing FH conflicts. The constructed risk perception index has a mean of 4.09, a standard deviation of 0.83, and ranges between 0 and 5.67. An advantage of this ranking method is that while R_{ij}, gives an ordinal measure of the risk perception of each concern across each household, RPI provides an intensity measure of the perceived risk of FH conflicts.

For further analysis, we split households according to their perceived FH conflict risk by dividing the FH conflict risk perception index into tertiles, each containing a third of the households. This comprises an ordinal grouping of households according to their risk perception. The three groups, therefore, separate households into risk-averse, risk-neutral, and risk-taking households, respectively.

5.4.3 Selection of Variables and Descriptive Analysis

The main dependent variables capturing household production decisions are: (i) the decision to use fertiliser, (ii) the total investment in fertiliser, (iii) the area of cropland rented-in for cultivation, and (iv) the income ratio of households. The area of cropland rented-in for cultivation is specified to capture the influence of risk perception on farm productivity. Studies find that participating in the land rental market improves the efficiency of production, food security, and the income of rural households (Chamberlin & Ricker-Gilbert, 2016; Huy et al., 2016; Muraoka et al., 2018). In the absence of detailed data on time use, the income ratio of households is used as a proxy for household time allocated to farm work. This helps capture the influence of the risk perception of FH conflict on households' time

allocation for farm work.[22] Finally, an index capturing the risk perception of FH conflicts by households is included to investigate its influence on households' production decisions.

We selected the control variables by drawing upon the existing literature on the determinants of agricultural input use (Demeke, 1998; Endale, 2011; Fufa & Hassan, 2006; Mapila et al., 2012; Ogola et al., 2011; Uaiene, 2011; Zondo, 2020). Socio-economic characteristics, such as age, educational attainment, and farming experience, are included in our model specification because they influence technology adoption. Extant studies have reported a negative impact of age on adopting improved technology (Dhraief et al., 2018; Michels et al., 2020), while educational attainment positively influences the adoption of improved production techniques (Khalid, Al-Badri, & Dhehibi, 2017). Gender of the household head is also included in the model to control for the differences in decision making by male and female household heads (Villanueva‐Moya & Expósito, 2021). An asset ownership index is included to capture the influence of household wealth on their production decisions. Household size, farm and off-farm income are also included to control for household characteristics.

[22] The ratio is used as a proxy based on the assumption that greater off-farm income is associated with more time spent on off-farm activities and vice versa.

Table 5.1 Definition and summary statistics of variables

Variable	Description	Mean	SD	Min	Max
Dependent variables					
Fertiliser use	1 if household uses fertiliser, 0 otherwise	0.75	0.43	0	1
Investment on fertilisers	Household investment in fertilisers per hectare of cultivated land (N1,000)	13.91	22.99	0	172.97
Land rented-in	Area of cropland rented-in for cultivation (hectares)	0.19	0.64	0	8.09
Income ratio	Proportion of household total income from farm work	0.35	0.36	0	1
Main independent variables					
RPI	FH conflict risk perception index	4.09	0.83	0	5.67
RP groups	FH conflict risk perception groups	1.55	0.71	1	3
Other control variables					
Age	Age of household head (years)	49.43	14.46	20	87
Gender	1 if household head is female, 0 otherwise	0.24	0.43	0	1
Education	Education of household head (years)	8.64	5.18	0	20
Farming experience	Household head's years of farming	26.83	15.25	3	70
Asset index	Household asset ownership index	0.22	0.21	-0.25	0.67
Religion	1 if the household is Christian, 0 otherwise	0.94	0.23	0	1
Household size	Number of household members	9.44	8.82	1	50
Road quality	Household head's perception of road quality (1=good condition, 0=not good condition)	0.25	0.43	0	1
Farm income	Household's total farm income (₦10000)	19.80	14.91	0	60.05
Off-farm income	Household's total off-farm income (₦10000)	8.98	9.97	0	45
Land tenure	Bundle of property rights on their largest farmland.	10.47	2.45	0	12
Member of farmers association	1 if the household head is a member of a farmer's association, 0 otherwise	0.22	0.42	0	1
Extension officer visits	1 if the household had visits from an extension officer, 0 otherwise	0.22	0.41	0	1
Location	1 if the household is located in the Northcentral zone, 0 otherwise	0.50	0.50	0	1

Note: ₦ is Nigerian currency (US$1 = ₦ 360), SD refers to standard deviation

The bundle of rights households' have to their land (a proxy for tenure security) is included to control for the effect of farm-level characteristics on households' production decisions. Tenure security is found to have a positive association with agricultural investment and productivity (Higgins et al., 2018; Keovilignavong & Suhardiman, 2020; Suchá et al., 2020). A dummy variable capturing the religion of rural households is included to account for the influence of religious affiliation on production decisions,

as well as capturing rural households' bias with respect to their religious association (Yikwabs & Tade, 2021). Matuschke and Qaim (2009) and Ramirez (2013) provide empirical evidence that rural households' social networks have a positive influence on-farm investment decisions. In this paper, we hypothesise that the networks of rural households' will influence their production decisions. Hence, membership of farmers and/or cooperative associations and visits from extension agents are included to control for the influence of rural household networks in making production decisions. A dummy variable to capture the geopolitical zone of the household is included to control for location heterogeneities.

Table 5.1 presents descriptive statistics of the variables used in the study. The survey showed that three-quarters of households used fertilisers, with an average investment in fertiliser of about ₦13,910 and about 0.19 hectares of land rented in for cultivation. The average age of household heads is 49 years, and on average, they have above 8 years of schooling. In our sample, 24% of the household were female-headed, while 22% of household heads are members of farmer's associations and had visits from extension officers. The average annual household farm income is ₦198,000 (roughly equivalent to 521 USD), while the mean annual off-farm income is ₦ 89,800 (roughly equivalent to 236 USD). Figure 5.1 shows the risk assessment index of the nine possible risks by gender of the household head. It suggests that men are more worried about the risk of FH conflicts compared to women, except for scarcity of food, crop failure, and the loss of crop and farm income. A reason for this could be that women are generally more involved in the planting and agronomic management of crops. They are also usually more concerned about the welfare and wellbeing of their families as crop failure and scarcity of food could threaten the food security of their households.

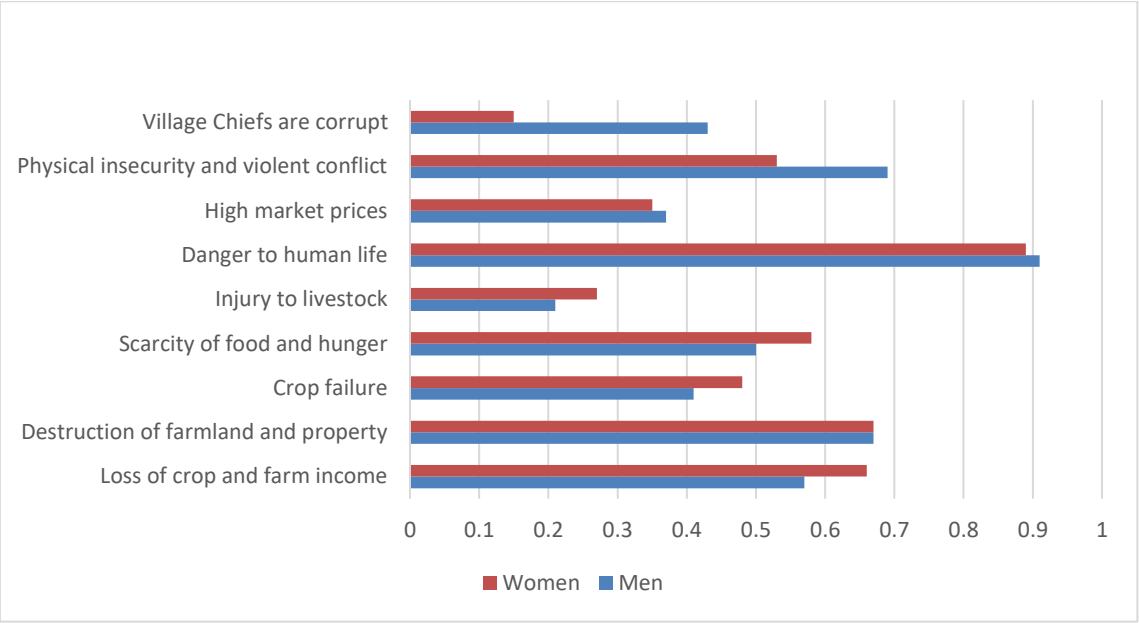


Figure 5.1 Individual risk assessment ranking by gender

5.5 Empirical Results and Discussion

Tables 5.2 and 5.3 report the regression results for the estimated effects of the perceived risk of FH conflicts on the production decisions of rural households. The production decisions considered are the decision to use fertilisers, the investment in fertilisers, the area of cropland rented-in, and income ratio, which serves as a proxy for households' time allocation for farm work. The results reflect how rural households change their production decisions in response to their perceived risk of FH conflicts. Next, we discuss each result in more detail.

5.5.1 Effect of Risk Perception of FH Conflict on Rural Household Production Decisions

Results for the CMP simultaneous equation regression of the effect of FH conflict risk perception on rural households' production decisions are presented in Table 5.2. Equations (16) to (19) were estimated to account for farmers' simultaneous decisions of productive input use in the agricultural production process. Models 1 to 4 in Table 5.2 present the regression results for fertiliser adoption, investment in fertilisers, the area of land rented-in for cultivation, and household income ratio, respectively. All regression models are estimated with robust standard errors. The log-likelihood ratio test for the simultaneous estimations (Equations (16) to (19)) is statistically significant at the 1% significance level, indicating that the explanatory variables fit the data reasonably well. The CMP

estimation results show a significant positive correlation between the error terms of fertiliser use (ω_i) and investment in fertiliser (ε_i) equations (Equations (16) and (17)). This implies that unobserved factors (e.g., motivations) are positively related to both rural households' fertiliser adoption decision and their investment in fertiliser; hence, single-equation models of rural household fertiliser input use will give biased estimates. In contrast, the error terms of the other equations are not statistically correlated.

Our results suggest that an increase in the risk perception of FH conflict has a statistically significant negative effect on households' decision to use fertilisers (Model 1, Table 5.2). Similarly, our results also report a negative and statistically significant effect of the risk perception of FH conflicts on households' investment in fertilisers (Model 2, Table 5.2). This suggests that a one-unit increase in the risk perception of FH conflict is associated with an 8.3% reduction in the likelihood of households using fertilisers and ₦1,734 decrease in their investment in fertilisers per hectare of cropland. The findings indicate that increased perceived risks of FH conflicts reduce both the likelihood of rural households using fertilisers and their subsequent investment in fertilisers. The negative relationship between FH conflict risk perception and productive input use implies that it will have adverse consequences for their efficiency, productivity, and income. Reductions in fertiliser input may result in lower crop yields, reducing both farm income and the food available for household consumption (Endale, 2011). These results support our first hypothesis using fertiliser use as a proxy for productive inputs.

Table 5.2 CMP simultaneous estimation results for the effect of FH conflict risk perception on household production decisions

Variables	(1) Fertiliser use (Marginal Effect)	(2) Fertiliser investment (Coefficient)	(3) Rented-in Land (Coefficient)	(4) Income ratio (Coefficient)
RPI	-0.083** (0.041)	-1.734** (0.879)	-0.069 (0.054)	0.101* (0.056)
Age	0.008 (0.005)	0.177 (0.115)	-0.003 (0.003)	-0.001 (0.004)
Gender	-0.234*** (0.091)	-5.237*** (2.036)	0.150 (0.121)	-0.140 (0.115)
Education	-0.002 (0.014)	-0.045 (0.309)	-0.002 (0.006)	-0.012 (0.009)
Asset index	-0.074 (0.297)	-1.418 (6.396)	0.345** (0.173)	-0.670*** (0.210)
Religion	0.155 (0.183)	3.563 (4.121)	-0.294* (0.152)	0.312* (0.188)
Farm income	0.007* (0.004)	0.150* (0.078)	0.004* (0.002)	
Off-farm income	0.008 (0.007)	0.171 (0.156)	0.001 (0.003)	
Household size	-0.013* (0.007)	-0.279* (0.157)	0.005 (0.004)	0.011* (0.006)
Road quality	-0.088 (0.111)	-1.925 (2.404)	-0.129* (0.077)	-0.041 (0.092)
Land tenure	0.018 (0.020)	0.373 (0.425)	-0.110*** (0.023)	0.002 (0.019)
Farming experience	-0.004 (0.005)	-0.087 (0.101)	-0.001 (0.002)	0.004 (0.004)
Farmers association	0.138 (0.150)	2.904 (3.247)	0.034 (0.052)	0.033 (0.088)
Extension officer visit	0.234* (0.129)	5.037* (2.723)	-0.037 (0.058)	-0.035 (0.098)
Location	0.427*** (0.134)	9.329*** (3.100)	0.085 (0.095)	-0.130 (0.115)
Constant	0.053 (0.380)	1.502 (8.086)	1.798*** (0.377)	-0.113 (0.372)
Pseudo R^2	0.115	0.114	0.233	0.077
ln (σ_1)		3.078*** (0.089)		
ln (σ_2)			-0.579*** (0.210)	
ath (ω_i)		5.774*** (1.855)	-0.025 (0.026)	0.026 (0.021)
ath (ε_i)			-0.028 (0.025)	0.026 (0.021)
ath (e_i)				0.027 (0.022)
Wald χ^2		279.08***		
Sample		401		

Note: Robust standard errors in parentheses. *, **, *** represent significance at 10%, 5%, and 1% levels, respectively

Estimated coefficients in Models 1 and 2, Table 5.2, show that being a female-headed household is associated with a negative and statistically significant influence on the adoption and investment in fertilisers. This suggests that female-headed households are 23% less likely to use fertiliser and invest ₦5,237 less in fertiliser per hectare of cropland than male-headed households. A reason for this could be that women are inherently disadvantaged in access to productive resources. This finding agrees with existing literature that finds women have less access to productive resources (Ankrah et al., 2020; Okonya & Kroschel, 2014; Zondo, 2020). We conclude that lower access to productive resources like land (physical capital) and education (human capital) makes them less inclined to invest in inputs. Household size is associated with a significant and negative influence on adoption and investment in fertilisers. This indicates that households with larger family sizes are less likely to adopt and invest in fertilisers. This finding agrees with that of Freeman and Omiti (2003). The result may reflect the case where rural households with greater labour availability may prefer alternative fertility practices, for example, animal manure, which may be more labour intensive than chemical fertilisers. Also, larger households may generally substitute labour for capital. Visits from extension officers and farm income are associated with positive and statistically significant effects on rural households' adoption and fertiliser investment. This finding implies that by being in contact with extension agents, they learn the importance of specialised productive inputs for their cultivation and are more likely to invest in them than households with no contact from extension officers (Demeke, 1998; Olale, 2005). Concerning farm income, the more involved a household is in agricultural production, the higher their probability of investing in productive inputs like fertilisers. The results show a statistically significant association between the location of households and their investment in fertilisers. Households located in the Northcentral zone invest ₦9,329 more on fertilisers compared to households in the Southeast zone. This is plausible because the northcentral zone is mostly agrarian and produces most of the food grown in Nigeria (Oseni & Winters, 2009).

Results in Model 3, Table 5.2 show no significant effect of the risk perception of conflict on households' degree of participation in the land rental market. One possible reason for this may be the poorly functioning land market in most parts of Nigeria (Kobe et al., 2018). Hence, rural households may not

fully participate in traditional land rental markets, even without the risk of an impending FH conflict. The religion and road quality variables are associated with a negative and statistically significant influence on the area of cropland rented-in for cultivation. This suggests that Christian households rent-in less land for cultivation compared to households of other religious affiliations, while with good road access to own cropland, rural households are less likely to rent-in more farm plots for cultivation. The land tenure variable is associated with a negative and statistically significant influence on the area of cropland households rented-in for cultivation. This implies that tenure security in owned land reduces the need to participate in the rental land market as a lessee. This will invariably lead to the development of the land rental market and potential gains from improved productivity and economies of scale.

Results in Model 4, Table 5.2 also reveal a positive and statistically significant influence of the risk perception of FH conflicts on rural households' time allocation for farm work. This implies that increased risk perception of FH conflicts is associated with an increase in rural households' time allocation for farm work. Based on our theoretical model, the risk perception of FH conflict leads to a change in households' time allocation for farm work - the higher the perceived risk of FH conflict, the higher their time allocation for farm work. This supports our third hypothesis described in Section 5.3.2. This finding is similar to that of Meraner and Finger (2019), who find that risk-averse farmers are more likely to opt for on-farm risk management strategies than off-farm strategies. Also, Adelaja and George (2019) show that direct exposure to violent conflict and terrorism reduced hired labour in Nigeria, implying that farmers do more of the farm work themselves. One reason for our finding could be that more risk-averse farmers commit more time to farming activities in preparation for adverse uncertainties because of the possibility of a FH conflict. This might result in a reduction in off-farm activities and increased use of family labour on-farm, which increases the proportion of their income from farm work. The estimated coefficient of the asset ownership index variable in Model 4, Table 5.2, indicates a statistically significant and negative association with household time allocation for farm work, implying that more wealthy households provide less time allocation for farm work. A possible reason for this is that wealthy rural households' have more resources and opportunities to diversify

their livelihoods to off-farm work. The estimated coefficients for religion and household size indicate a positive and statistically significant association with time allocation for farm work, suggesting that the more family labour households' have access to, the higher their time allocation for farm work.

5.5.2 Effect of FH Conflict Risk Perception Groups on Rural Household Production Decisions

To further probe the influence of FH conflict risk perception, we split households according to their risk behaviour by dividing the FH conflict risk perception index into three intervals with equal probabilities. Each contains a third of the households. As discussed in Section 5.3.2, for ease of exposition within this study, we class these groups as risk-taking, risk-neutral, and risk-averse households, respectively. For our estimation, the first risk group capturing risk-taking households is the reference group. The CMP regression results of the effect of FH conflict risk perception group on rural households' production decisions are presented in Table 5.3.

Results in Table 5.3 show that the estimated coefficients of risk-averse households in Models 1 to 3 are negative and statistically significant at the 1% significance level. This indicates that households with a high perceived risk of FH conflicts (risk-averse households) are 47% less likely to use fertilisers (Model 1), invest ₦10,061 less in fertilisers (Model 2), and rent-in about 0.21 hectares less cropland (Model 3) compared to risk-taking households. Households grouped into the third risk group are comparably more averse to risks compared to risk-taking and risk-neutral households. In Table 5.3, the estimated coefficient for risk-averse households in Model 4 and risk-neutral households in all models are not statistically significant. Compared to results in Table 5.2, findings suggest that the more risk-averse a rural household, is the higher the negative influence of their risk perception of FH conflict on their production decisions.

Table 5.3 CMP simultaneous estimation results for the effect of FH conflict risk perception groups on production decisions

Variables	(1) Fertiliser use (Marginal Effect)	(2) Fertiliser investment (Coefficient)	(3) Rented-in Land (Coefficient)	(4) Income ratio (Coefficient)
Risk-neutral	-0.017 (0.121)	-0.261 (2.591)	-0.067 (0.066)	-0.009 (0.089)
Risk-averse	-0.470*** (0.115)	-10.061*** (2.751)	-0.205*** (0.071)	0.009 (0.099)
Age	0.008 (0.005)	0.159 (0.112)	-0.004 (0.003)	-0.002 (0.004)
Gender	-0.187* (0.095)	-4.175** (2.067)	0.177 (0.124)	-0.172* (0.116)
Education	-0.002 (0.013)	-0.047 (0.297)	-0.004 (0.006)	-0.009 (0.009)
Asset index	0.018 (0.295)	0.588 (6.290)	0.389** (0.180)	-0.656*** (0.209)
Religion	0.177 (0.182)	3.956 (4.067)	-0.284* (0.152)	0.302 (0.186)
Farm income	0.008** (0.004)	0.170** (0.079)	0.004** (0.002)	
Off-farm income	0.009 (0.007)	0.192 (0.157)	0.002 (0.003)	
Household size	-0.016** (0.007)	-0.345** (0.155)	0.004 (0.004)	0.011* (0.006)
Road quality	-0.122 (0.113)	-2.615 (2.417)	-0.136* (0.078)	0.036 (0.094)
Land tenure	0.020 (0.019)	0.419 (0.409)	-0.112*** (0.024)	0.006 (0.019)
Farming experience	-0.001 (0.005)	-0.027 (0.101)	0.002 (0.002)	0.005 (0.004)
Farmers association	0.120 (0.151)	2.475 (3.241)	0.025 (0.052)	0.040 (0.087)
Extension officer visit	0.228* (0.131)	4.831* (2.755)	-0.037 (0.058)	-0.033 (0.099)
Location	0.453*** (0.138)	9.834*** (3.162)	0.094 (0.095)	-0.142 (0.113)
Constant	-0.318 (0.367)	-6.431 (7.828)	1.562*** (0.320)	-0.233 (0.326)
Pseudo R^2	0.105	0.128	0.235	0.065
ln (σ_1)		3.065*** (0.087)		
ln (σ_2)			-0.580*** (0.207)	
ath (ω_i)		5.871*** (1.863)	-0.034 (0.027)	0.021 (0.021)
ath (ε_i)			-0.037 (0.026)	0.021 (0.021)
ath (e_i)				0.019 (0.021)
Wald χ^2		315.62***		
Sample		401		

Note: Robust standard errors in parentheses. *, **, *** represent significance at 10%, 5%, and 1% levels, respectively

5.5.3 Robustness Check

To check the robustness of our results, we estimated single equation regressions for equations 16 – 19 using logit, Tobit, and fractional regression models to account for the respective outcome variables. Tables 5.A2-5.A5 in the appendix report the estimated results. Results in Table 5.A2 (Model 1) indicate that the risk perception of FH conflict is associated with a significant negative influence on rural households' fertiliser adoption decisions, while results of Model 2 indicate that risk-averse households are 12.8% less likely to use fertilisers compared to risk loving households. Table 5.A3 (Model 1) indicates that the risk perception of FH conflict has a statistically significant and negative influence on rural households' fertiliser investment, while Model 2 suggests that risk-averse households invest ₦15,710 less on fertilisers per hectare of cropland compared to risk loving households.

Results in Table 5.A4 indicate no significant influence of risk perception of FH conflict on the area of land rented-in for cultivation. Table 5.A5 (Model 1) indicates that the risk perception of FH conflict has a statistically significant and positive influence on rural households' time allocation for farm work. Results of Model 2 in Table 5.A5 shows no significant influence of the risk groups on household time allocation for farm work. These results agree with our main findings in Tables 5.2 and 5.3 and are robust to different model specifications.

5.5.4 Additional Analyses

The focus of this study has been on the perceived risk of FH conflict, but to enrich our understanding of the relationship between FH conflicts and rural households' production decisions, we also consider objective measures of FH conflict. We assess the effect of objective risks of FH conflict on household production decisions by conducting two additional simultaneous equation analyses using the CMP framework with the same dataset. First, we examine whether there is a relationship between exposure to FH conflict in the past five years and rural households' production decisions. The variable captures households in communities that have had at least one FH conflict in the preceding five years. Long-term exposure to FH conflicts may impart fear in rural dwellers, making them opt for less profitable production decisions, which eventually limits their productivity and economic activities (Arias et al.,

2019). The results are presented in Table 5.A6 in the Appendix. Results show that long-term exposure to FH conflicts has no statistically significant effect on rural households' production decisions.

Second, we examine whether there is a relationship between the number of FH conflict occurrences in the community in the past year and rural households' production decisions. The results are presented in Table 5.A7 in the Appendix. Results show that the number of FH conflict incidences in the past year has no statistically significant influence on rural households' production decisions. The results presented in Tables 5.A6 and 5.A7 contrast with our earlier findings based on a subjective measure of FH conflict risk perception. This has possible implications for previous studies on the impact of FH conflicts that have not considered how households have perceived the risk of these conflicts (George, Adelaja, & Awokuse, 2021). It also implies that policymakers need to recognise that it is not necessarily the actual occurrence and frequency of FH conflicts that impact rural households but how they are perceived.

5.6 Conclusion

This study examines the effect of the risk perception of FH conflict on rural households' production decisions. We extend the classical agricultural household model by including the risk perception of FH conflicts. The developed theoretical model predicts that households' perceived risk of FH conflicts will influence their investment in productive inputs, their intensity of participation in the land rental market, and their time allocation for farm work. Hypotheses were developed and tested using primary data from 401 rural households in Nigeria.

Our results show that the risk perception of FH conflicts is negatively associated with rural households' decisions to use fertilisers, their investment in fertilisers, and the area of cropland rented-in. In contrast, the findings show a positive association with households' time allocation for farm work. The reduction in the likelihood of fertiliser use can be attributed to concern and uncertainty about the outbreak of FH conflicts and the fear of losing their investment. Another interesting finding is that

being a female-headed household has a significant negative association with the likelihood of fertiliser use and amount of investment in fertilisers, but its influence on rented-in cropland and time allocation for farm work is statistically insignificant. Furthermore, membership of farmers' associations has a statistically significant positive association with fertiliser use and investment and an insignificant influence on the area of cropland rented-in for cultivation and time allocation for farm work.

We posit that the empirical evidence of the detrimental physical and psychological effect of FH conflict has enormous implications for rural livelihoods because of reduced investment in agricultural production. Hence, to ensure sustainable food systems, there is a need to develop a policy framework for more sustainable herding practices. This paper recommends that strategies targeted at improving agricultural production efficiency and productivity of rural farmers are needed to increase their perception of physical security, certainty, and safety. Future research needs to explore multiple ways to reduce the perceived risk associated with FH conflicts. We suggest that investment in rural infrastructure (e.g. access roads) as well as strengthening the formal (i.e. the rule of law) and informal (i.e. community groups) institutions in rural Nigeria can contribute to the reduction of uncertainty and help reduce perceived risks associated with FH conflicts.

A major limitation of the study is the lack of nationally representative data for analysis. Future research should collect nationally representative data at a longitudinal scale in order to facilitate the examination of seasonality effects of the risk perception of FH conflicts.

Appendix 5.0

Table 5.A1 Items used in the construction of the FH conflict risk perception index

Considering farmer-herdsmen conflicts, indicate which of these you are afraid could affect your household. *Responses (0=not worried, 1=slightly worried, 2=moderately worried, 3=very worried, 4=extremely worried)*					
Risks	**Response**				
	0	1	2	3	4
Loss of crop and farm income					
Destruction of farmland and property					
Crop failure					
Scarcity of food / Hunger					
Injury to livestock					
Danger to human life and death					
High market prices for food					
Physical insecurity and violent conflict					
Village Chiefs sell land indiscriminately and are corrupt					
Others ( )					

Table 5.A2 Estimation results for the effect of FH conflict risk perception on fertiliser use

VARIABLES	Fertiliser use (marginal effect)			
	(1)		(2)	
RPI	-0.075**	(0.031)		
Risk-neutral			-0.051	(0.047)
Risk-averse			-0.128*	(0.076)
Age	0.004*	(0.002)	0.003	(0.002)
Gender	-0.006	(0.058)	0.017	(0.059)
Education	0.012***	(0.005)	0.011**	(0.005)
Asset index	0.026	(0.120)	0.054	(0.122)
Religion	-0.200	(0.125)	-0.191	(0.130)
Farm income	0.007***	(0.002)	0.007***	(0.002)
Off-farm income	-0.004	(0.002)	-0.004	(0.002)
Household size	-0.003	(0.003)	-0.004	(0.003)
Road quality	0.008	(0.048)	0.007	(0.049)
Land tenure	0.014	(0.009)	0.012	(0.009)
Farming experience	-0.002	(0.002)	-0.001	(0.002)
Farmers association	0.173***	(0.065)	0.172***	(0.066)
Extension officer visit	0.110*	(0.059)	0.108**	(0.060)
Location	-0.041	(0.063)	-0.035	(0.064)
Pseudo R^2	0.115		0.105	
Sample	401		401	

Note: *, **, *** represent significance at 10%, 5%, and 1% levels, respectively; Robust standard errors in parenthesis.

Table 5.A3 Estimation results for the effect of FH conflict risk perception on investment in fertiliser

VARIABLES	Investment per hectare of land (coefficient)	
	(1)	(2)
RPI	-2.925** (1.528)	
Risk-neutral		-1.150 (3.480)
Risk-averse		-15.710*** (4.561)
Age	0.226 (0.167)	0.185 (0.162)
Gender	-8.640** (3.546)	-6.863* (3.538)
Education	0.149 (0.406)	0.149 (0.392)
Asset index	1.521 (8.578)	4.690 (8.489)
Religion	2.841 (5.355)	3.436 (5.302)
Farm income	0.332*** (0.103)	0.358*** (0.103)
Off-farm income	0.065 (0.195)	0.098 (0.195)
Household size	-0.404 (0.215)	-0.494** (0.212)
Road quality	-3.537 (3.437)	-4.690 (3.445)
Land tenure	0.573 (0.654)	0.601 (0.628)
Farming experience	-0.100 (0.145)	0.004 (0.147)
Farmers association	5.796 (3.957)	5.071 (3.945)
Extension officer visit	7.064** (3.471)	6.764* (3.479)
Location	11.080** (4.210)	11.831** (4.286)
Constant	-8.338 (11.856)	-20.553 (11.494)
sigma	768.32*** (144.136)	752.577*** (139.424)
Pseudo R^2	0.020	0.023
Observations	401	401

Note: *, **, *** represent significance at 10%, 5%, and 1% levels, respectively; Robust standard errors in parenthesis.

Table 5.A4 Estimation results for the effect of risk perception of conflict on the area of cropland rented-in for cultivation

	Area of cropland rented-in			
Variables	(1)		(2)	
RPI	-0.109	(0.130)		
Risk-neutral			-0.156	(0.265)
Risk-averse			-0.705	(0.445)
Age	-0.020	(0.014)	-0.021	(0.014)
Gender	0.401	(0.323)	0.449	(0.320)
Education	-0.006	(0.030)	-0.005	(0.030)
Asset index	1.781**	(0.745)	1.842**	(0.787)
Religion	-0.873*	(0.471)	-0.846*	(0.468)
Farm income	0.014*	(0.009)	0.015*	(0.009)
Off-farm income	-0.004	(0.014)	-0.004	(0.014)
Household size	0.035*	(0.020)	0.032	(0.020)
Fertiliser use	0.556	(0.319)	0.578*	(0.315)
Road quality	-0.480*	(0.282)	-0.521*	(0.285)
Land tenure	-0.406***	(0.053)	-0.401***	(0.052)
Farming experience	-0.004	(0.013)	-0.007	(0.013)
Farmers association	0.297	(0.327)	0.259	(0.326)
Extension officer visit	-0.175	(0.318)	-0.182	(0.317)
Location	-0.353	(0.381)	-0.355	(0.379)
Constant	3.398***	(0.978)	2.989***	(0.889)
sigma	2.163 ***	(0.384)	2.134***	(0.378)
Pseudo R^2	0.260		0.263	
Observations	401		401	

Note: *, **, *** represent significance at 10%, 5%, and 1% levels, respectively; Robust standard errors in parenthesis.

Table 5.A5 Estimation result for the effect of risk perception of conflict on time allocation for farm work

Variables	Income ratio (marginal effect)	
	(1)	(2)
RPI	0.043** (0.019)	
Risk-neutral		-0.001 (0.032)
Risk-averse		0.010 (0.035)
Age	-0.001 (0.002)	-0.001 (0.002)
Gender	-0.047 (0.042)	-0.062 (0.042)
Education	-0.006* (0.003)	-0.004 (0.003)
Asset index	-0.249*** (0.072)	-0.245*** (0.072)
Religion	0.125* (0.066)	0.120* (0.066)
Household size	0.004** (0.002)	0.004** (0.002)
Fertiliser use	0.100*** (0.033)	0.091*** (0.034)
Road quality	0.014 (0.033)	-0.012 (0.034)
Land tenure	-0.001 (0.007)	0.001 (0.007)
Farming experience	0.001 (0.001)	0.002 (0.001)
Farmers association	-0.002 (0.031)	0.003 (0.031)
Extension officer visit	-0.020 (0.035)	-0.019 (0.035)
Location	-0.043 (0.041)	-0.049 (0.041)
Pseudo R^2	0.027	0.023
Observations	401	401

Note: *, **, *** represent significance at 10%, 5%, and 1% levels, respectively; Robust standard errors in parenthesis.

Table 5.A6 CMP simultaneous estimation results for the effect of exposure to FH conflicts on household production decisions

Variables	Fertiliser use (Coefficient)	Fertiliser investment (Coefficient)	Rented-in Land (Coefficient)	Income ratio (Coefficient)
Exposure to FH conflicts	-0.192 (0.131)	-4.012 (2.894)	-0.023 (0.059)	-0.092 (0.085)
Age	0.008* (0.005)	0.173 (0.114)	-0.003 (0.003)	-0.002 (0.004)
Gender	-0.221** (0.092)	-4.987** (2.057)	0.165 (0.124)	-0.176 (0.115)
Education	-0.002 (0.014)	-0.060 (0.306)	-0.004 (0.006)	-0.009 (0.009)
Asset index	-0.131 (0.304)	-2.585 (6.559)	0.340* (0.184)	-0.675*** (0.208)
Religion	0.195 (0.182)	4.412 (4.085)	-0.286* (0.152)	0.319* (0.185)
Farm income	0.007* (0.004)	0.143* (0.078)	0.003* (0.002)	
Off-farm income	0.008 (0.007)	0.173 (0.156)	0.001 (0.003)	
Household size	-0.012* (0.007)	-0.267* (0.159)	-0.006 (0.003)	0.011* (0.006)
Road quality	-0.111 (0.112)	-2.385 (2.423)	-0.127* (0.075)	0.021 (0.094)
Land tenure	0.019 (0.019)	0.376 (0.421)	-0.113*** (0.02)	0.008 (0.018)
Farming experience	-0.005 (0.005)	-0.100 (0.099)	-0.001 (0.002)	0.005 (0.004)
Farmers association	0.124 (0.151)	2.555 (3.252)	0.030 (0.052)	0.034 (0.087)
Extension officer visit	0.219* (0.132)	4.716* (2.781)	-0.039 (0.057)	-0.041 (0.098)
Location	0.373*** (0.133)	8.207*** (2.994)	0.084 (0.106)	-0.170 (0.116)
Constant	-0.107 (0.364)	-1.785 (7.808)	1.591*** (0.316)	-0.282 (0.329)
Pseudo R^2	0.100	0.116	0.226	0.067
ln (σ_1)		3.072*** (0.089)		
ln (σ_2)			-0.574*** (0.209)	
ath (ω_i)		5.815** (0.973)	-0.021 (0.027)	0.018 (0.020)
ath (ε_i)			-0.023 (0.027)	0.019 (0.020)
ath (e_i)				0.019 (0.021)
Wald χ^2		376.64***		
Sample		401		

Note: Robust standard errors in parentheses. *, **, *** represent significance at 10%, 5%, and 1% levels, respectively

Table 5.A7 CMP simultaneous estimation results for the effect of number of FH conflicts on household production decisions

Variables	Fertiliser use (Marginal Effect)	Fertiliser investment (Coefficient)	Rented-in Land (Coefficient)	Income ratio (Coefficient)
Number of FH conflicts	-0.015 (0.010)	-0.295 (0.206)	-0.001 (0.003)	-0.006 (0.006)
Age	0.008 (0.005)	0.159 (0.113)	-0.003 (0.003)	-0.002 (0.004)
Gender	-0.226** (0.091)	-5.069** (2.032)	0.166 (0.122)	-0.177 (0.116)
Education	-0.005 (0.014)	-0.118 (0.315)	-0.004 (0.006)	-0.010 (0.009)
Asset index	-0.079 (0.2.98)	-1.469 (6.396)	0.347** (0.173)	-0.652*** (0.209)
Religion	0.182 (0.182)	4.098 (4.111)	-0.292* (0.155)	0.311* (0.187)
Farm income	0.007* (0.004)	0.144* (0.079)	0.003* (0.002)	
Off-farm income	0.008 (0.007)	0.168 (0.155)	0.001 (0.003)	
Household size	-0.011 (0.007)	-0.239 (0.161)	0.006 (0.003)	0.012** (0.006)
Road quality	-0.107 (0.115)	-2.286 (2.479)	-0.122 (0.079)	-0.025 (0.093)
Land tenure	0.016 (0.019)	0.313 (0.410)	-0.114*** (0.024)	0.007 (0.019)
Farming experience	-0.005 (0.005)	-0.008 (0.099)	-0.005 (0.002)	0.005 (0.004)
Farmers association	0.114 (0.152)	2.371 (3.273)	0.033 (0.053)	0.031 (0.087)
Extension officer visit	0.246* (0.126)	5.234** (2.671)	-0.038 (0.059)	-0.031 (0.098)
Location	0.476*** (0.145)	10.371*** (3.356)	0.087 (0.099)	-0.123 (0.117)
Constant	-0.165 (0.368)	-3.082 (7.8.45)	1.574*** (0.321)	-0.250 (0.324)
Pseudo R^2	0.101	0.116	0.226	0.066
ln (σ_1)		3.072*** (0.090)		
ln (σ_2)			-0.574*** (0.209)	
ath (ω_i)		5.801*** (1.878)	-0.018 (0.026)	0.018 (0.020)
ath (ε_i)			-0.021 (0.026)	0.019 (0.020)
ath (e_i)				0.019 (0.020)
Wald χ^2		391.18***		
Sample		401		

Note: Robust standard errors in parentheses. *, **, *** represent significance at 10%, 5%, and 1% levels, respectively

Chapter 6

Determinants of the Risk Perception of Farmer-Herder Conflicts: Evidence from Rural Nigeria

This chapter fulfils objective four and is based on the published journal article below:

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Chapter 6 – Statement of Authorship

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Publication Detail	Nnaji, A. (2022). Determinants of the risk perception of farmer-herder conflicts: Evidence from rural Nigeria. *International Journal of Social Economics, 49*(8), 1172-1194. https://doi.org/10.1108/IJSE-10-2021-0578	

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Contribution to Paper	Conception and design of the study; data acquisition, analysis and interpretation; drafting of the manuscript; and reviewing the manuscript critically for significant intellectual content.		
Overall percentage (%)	100%		
Certification:	This paper reports on original research conducted during the period of my Doctoral study and is not subject to any obligations or contractual agreements with a third party that would constrain its inclusion in this thesis. I am the primary author of this paper.		
Signature		Date	28/10/2022

Abstract

This study investigates how social, economic, and demographic factors affect rural households' risk perception of farmer-herder conflicts, utilizing cross-sectional data collected from 401 rural households in Nigeria. We consider two aspects of farmer-herder conflict risk perception as it relates to food production and physical insecurity. A farmer-herder conflict risk perception model is constructed and tested using exploratory factor analysis, ordinary least squares and seemingly unrelated regression equation models. Results show that in addition to economic determinants like farm size, land ownership and crop diversity, sociodemographic variables like age and number of languages spoken are significant predictors of household risk perception of farmer-herder conflict. Although gender and frequency of farmer-herder conflict have no significant effect on the risk perception of farmer-herder conflict, there is a significant moderating effect of frequency of farmer-herder conflicts on the influence of gender on the risk perception of farmer-herder conflict. The findings of this study provide insights into policies targeted at influencing the risk behaviour of rural households, which are important to aid the development of efficient risk management initiatives.

Keywords: risk perception; farmer-herder conflict; rural households; Nigeria

6.1 Introduction

An increasing number of climate disasters and the consequent scarcity of land resources have recently increased the frequency of farmer-herder (FH) resource-use conflicts in many developing countries (Brottem, 2021; CDD, 2021; Eberle et al., 2020). FH conflicts in this study represent clashes and disagreements between nomadic herders and crop farmers over limited land resources. The worsening clashes between nomadic herders and farming communities in most sub-Saharan African (SSA) countries have remained an increasing cause for concern (Krätli & Toulmin, 2020). In several countries, especially in Nigeria, rapid population growth is making the situation worse (Adeniran, 2020). The Institute for Economics and Peace report shows that fatalities resulting from FH conflicts perpetuated by the Fulani militia increased from 63 deaths in 2013 to 1224 deaths in 2014 in Nigeria, before declining by about 50 per cent in 2015 (IEP, 2016). Amnesty International estimates that a total of 3,641 fatalities from FH conflicts occurred between January 2016 and October 2018.

In Nigeria, herders with the majority of Cattle portfolio consist largely of nomadic Fulani pastoralists who customarily graze their animals in the Northern region in the rainy season and migrate southwards in the dry season (Ojo, 2020). With rising temperatures and the resulting drought and desertification (Buhaug et al., 2015), along with Boko haram insurrection (George, Adelaja, Awokuse, et al., 2021), they graze their cattle further south for longer periods. Their search for ample pasture for their animals leads to increased competition with farmers for scarce agricultural land resources (Eke, 2020). FH conflicts usually occur when herders sometimes graze their animals in farmers cropland, resulting in damaged crops and yield loss for farmers. In retaliation, farmers sometimes maim their animals and chase herders from their communities, herders fight back, and FH conflict occurs (CDD, 2021). In 2018, this type of conflict was responsible for the displacement of about 300,000 people and a third of the increase in fatalities in Nigeria (ICG, 2018). The upsurge in these FH conflicts has adverse consequences for rural livelihoods and security.

FH conflicts have been found to negatively impact agricultural output and labour (George, Adelaja, & Awokuse, 2021) and reduce farming households' food security (Nnaji, Ratna, et al., 2020a). Through

their impact on agricultural productivity and food supply, these clashes jeopardise the prospects of farmers and wider society. How rural households perceive the risk of farmer-herder conflicts has been found to negatively influence their use of productive inputs, which will have dire consequences for their productivity and income (Nnaji, Ratna, et al., 2020b). Therefore, ascertaining the factors that determine how farmers perceive the risk of FH conflicts is important to inform initiatives and strategies that help improve their productivity.

Risk perception can be defined as a psychological construct of individual subjective judgement when evaluating and describing hazards (Knuth et al., 2014; Slovic, 1987, 2000). A systematic review of farmers' perceptions of agricultural risk by Duong et al. (2019) finds that very few studies have explored the socio-economic characteristics that explain risk perceptions. This is the first study, to our knowledge, that investigates the factors that influence the risk perception of FH conflicts and thereby improves understanding of what elements influence how farmers react to the risk of FH conflicts. Risk perceptions differ depending on prior exposure to the adverse events and individual ability and preparedness to mitigate adverse consequences (Kahneman & Tversky, 1982; Knuth et al., 2014; Wang, Ye, & Shi, 2016). Furthermore, extant literature shows that awareness of farmers' risk perception is vital for making policy strategies in support of agricultural risk management and the development and facilitation of programmes targeted at rural farmers (Sulewski & Kłoczko-Gajewska, 2014).

This study aims to examine the socio-demographic determinants of rural households' FH conflict risk perception using household-level primary data from rural Nigeria. Nigeria is an appropriate choice of study area because of the recent increase in FH conflicts in the country (CDD, 2021). The survey questionnaire collected information on FH conflict incidences, rural households' socio-demographic characteristics, and their concerns about various outcomes resulting from past occurrences of FH conflicts. Responses are used to construct a FH conflict risk perception assessment for the surveyed households, and ordinary least squares and seeming unrelated regression models are used to analyse data for the study.

This study contributes to the literature on risk perception of FH conflict in several ways**.** First, this is the first attempt in the development economics literature, to the best of my knowledge, to empirically analyse the determinants of farmers risk perception of FH conflicts. Identification of sociodemographic determinants is vital because of their influence on risk perception and consequently on agricultural production decisions and food security. Understanding the factors that influence farming households' FH conflict risk perception will improve the creation of strategies directed at managing FH conflicts and the associated risks. Second, this paper constructs sub-indices of FH conflict risk perception as it relates to food production and supply and physical insecurity and wellbeing. This enables us to determine how and to what extent social, economic, and demographic characteristics affect how rural households perceive FH conflicts for a separate set of objectives, i.e., food availability or individual wellbeing and safety. The findings will be relevant for other sub-Saharan African countries undergoing similar conflicts between farmers and pastoralists with similar socio-economic, political, and demographic identities.

The rest of the paper is organised as follows. Section 2 presents a review of related literature. Next, the conceptual framework and empirical strategy are presented in section 3. Section 4 introduces data, variable measurements, and descriptive statistics. The empirical results are presented and discussed in section 5, while the final section concludes.

6.2 Review of Literature

Risk is an objective measure of the probability of a hazardous event occurring (Slovic, Fischhoff, & Lichtenstein, 1982). In contrast, risk perception is a psychological construct and can be defined as individual subjective judgement when evaluating and describing hazards (Knuth et al., 2014; Slovic, 1987, 2000). Perception of risk differs from individual to individual and results from the personal assessment of objective risk and their inherent ability to prevent or cope with the adverse event if it occurs (Doss et al., 2008). This implies that individual risk perception of an adverse event is not only established on the probability of such event happening - for instance, the probability of an earthquake

– but also on their subjective evaluation of their vulnerability to the adverse event (Doss et al., 2008). Their subjective evaluation brings together their expectations about the probability of the event occurring with their readiness or ability to mitigate various eventualities should they even happen. On the other hand, literature on the influence of violence on risk aversiveness finds that more severe violence leads to higher levels of risk aversion (Brown et al., 2019; Jakiela & Ozier, 2019; Moya, 2018). Although a study on armed violent conflict in Turkey reveals that the extent of exposure to the armed conflict increases, individuals become more tolerant to risk (Uler, 2021).

Extant literature has found age, gender, educational level, and farming experience, farm size and off-farm work to have a significant influence on farmers' perceived source of agricultural risks (Aditto, 2011; Il Islam et al., 2021; Rizwan et al., 2020). A systematic review of farmers' perception of agricultural risks found climate change, human and market risks to be the most feared risk in the crop sector (Duong et al., 2019). The authors also found that educational attainment, age, gender, farm size, farming experience, income, and location also influenced how farmers perceive the sources of agricultural risks (Duong et al., 2019). Similarly, Lobos et al. (2018) found climate events to be the main source of perceived risk for blueberry producers in Chile. Aditto (2011) also found age, gender, education, off-farm work, farm size and location to significantly influence farmers' perceived risk from different sources of risk in Central and Northeast Thailand. In this study, the focus on the risk perception of FH conflicts is because of the recent increase in the occurrence of FH conflicts and its detrimental impact on rural livelihoods and food security (Nnaji, Ratna, et al., 2020a). Also, there has been no study examining the socio-economic factors influencing the risk perception of FH conflicts.

Exposure to an involuntary hazard has been found to increase the perceived risk of such hazards and their consequences in the future (Knuth et al., 2014). Hence, for an involuntary hazard, an individual's risk perception is most likely affected by their personal experience with that particular type of hazard and information they have about it (Knuth et al., 2014; Tversky & Kahneman, 1973). Since FH conflicts are involuntary clashes, individual risk perceptions of FH conflicts will encompass more than just the objective likelihood of such conflicts occurring. Individual risk perception also includes their prior

experience of FH conflicts, indirect exposure to the conflicts through information about prior occurrences and their personal ability to mitigate its adverse effects. Determining how farmers perceive the risk of FH conflict is important because it has been found to influence their production decisions and productivity (Nnaji, Ratna, et al., 2020b). Existing literature shows that an understanding of farmers' perceived risk of different agricultural hazards is vital for establishing efficient risk management policy initiatives (Sulewski & Kłoczko-Gajewska, 2014). Similarly, an awareness of the factors influencing the risk perception of FH conflicts is fundamental in designing instruments for agricultural policies as well as risk management mechanisms for farmers.

6.3 Conceptual Framework and Empirical Strategy

6.3.1 Conceptual Framework

The conceptual framework is inspired by the Van Raaij (1981) framework on economic behaviour and Van der Linden (2015) comprehensive climate change risk perception model (CCRPM), which suggests that climate change risk perception is a function of the cultural context, psychological processes and personal experience with the risk. The conceptual framework in Figure 6.1 illustrates the risk perception of FH conflicts to be a function of social, economic, and demographic factors, farm-level characteristics and past experience of FH conflict.

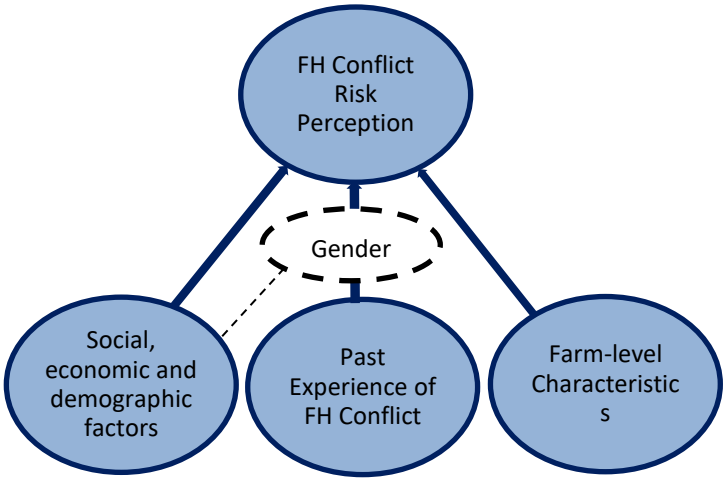

Figure 6.1 Conceptual framework of FH conflict risk perception

Most studies on the factors influencing the risk perception of adverse events like climate change, hurricanes, earthquakes etc., find socio-demographic variables to be significant predictors. Age of farmer or household head has been found to have both a positive (Il Islam et al., 2021; Ndamani & Watanabe, 2017; Rizwan et al., 2020) and negative (Lucas & Pabuayon, 2011; Peacock, Brody, & Highfield, 2005; Savage, 1993) effect of risk perception of different hazards. Education of the farmer has a positive influence on risk perception on hazards one hand (Ndamani & Watanabe, 2017; Peacock et al., 2005; Qasim et al., 2018) and a negative effect on the other hand (Lucas & Pabuayon, 2011; Rizwan et al., 2020; Savage, 1993). The conflicting results for age and education of household heads imply that both socio-economic characteristics may influence the risk perception of FH conflicts differently. Having a female household head positively influences risk perception (Savage, 1993; Van der Linden, 2015). This indicates that women have higher risk perceptions than men. In the case of FH conflicts, women have been found to be disproportionately affected by FH conflicts (CDD, 2021). Figure 6.1 explores the moderating effect of past experience of FH conflicts on the influence of gender of household head on the risk perception of FH conflicts. Income was found to increase the risk perception of hazardous events (Ndamani & Watanabe, 2017; Savage, 1993). Social factors like norms and cultures may affect individuals' feelings, thought processes, and behaviours. In a study of the United Kingdom, Van der Linden (2015) found social norms to be more strongly correlated with the risk perception of climate change compared to socio-demographic factors like gender and education.

Extant literature has found a significant relationship between individual social and political practices and climate change risk perception (Whitmarsh, 2008, 2009).

Existing studies have found farm-level characteristics influence farmers' risk perception. Farm size was found to positively influence the risk perception of farmers (Il Islam et al., 2021; Lucas & Pabuayon, 2011). The years of farming experience have also been found to positively influence farmers' risk perception of climatic issues (Il Islam et al., 2021). Studies on risk perception of adverse events agree that past individual experience or exposure to the adverse event positively influences their perceived risk of such event (Dessai & Sims, 2010; Van der Linden, 2015; van Winsen et al., 2016). Even when the objective risk is known, individuals' risk perception is still subjective because of their varying capacity to determine the probability of loss or exposure to loss due to the adverse event (Ahsan, 2011). Most existing literature has found a positive influence of the past experience of a risky event on individual subjective risk perception of that event (Qasim et al., 2018; Van der Linden, 2015). Although, a study in Sweden found men with more life experiences of risks (e.g., natural disasters, fire, and drowning) had less severe risk perceptions than other respondents (Sund, Svensson, & Andersson, 2017). This implies that personal risk experience may also reduce or increase risk perception, depending on how their risk experience changes their thought process.

6.3.2 Empirical Strategy

Ordinary least Squares (OLS) regression analysis was used to empirically determine the socio-demographic factors affecting rural households' risk perception of FH conflicts. The FH conflict risk perception indices are modelled as a function of several factors, including socio-demographic characteristics of the household and household head (e.g., age, gender, education, farming experience, and marital status), agricultural activities (crop diversification, livestock farming, type of crop cultivation), tenure security (possession of the land title to largest farmland), exposure to FH conflict and geographical location of the households.

The determinants of the risk perception of FH conflict is modelled as follows:

$$RPI_i = \sigma + \beta \boldsymbol{X_i} + \mu_i \quad (1)$$

where RPI_i is the FH conflict risk perception index of the ith household; σ is the intercept; $\boldsymbol{X_i}$ is a vector of household, household head and farm-level control variables that can influence household's risk perception of FH conflicts, and μ_i is the error term.

To probe sources of risk judgements in more detail, the study further constructs two different FH conflict risk perception indices as it concerns: (1) food production and supply, (2) household physical insecurity and wellbeing (Figure 6.2). The goal here is to investigate the influence of several socio-economic and demographic factors on how rural households' perceive FH conflicts as it relates to food production and supply on the one hand and physical insecurity and wellbeing on the other hand. Since both subindices of FH conflict risk perception can be related to a particular household but differ across multiple households depending on their socio-economic characteristics, there is a possibility of correlated error terms between the different single regressions. This may result from household-specific unobservable factors associated with the risk perception subindices. This bias can be through the non-diagonal covariance matrix as well as through the intersection of the distribution of the error terms. Following Zellner (1962) and Srivastava and Giles (2020), the study controls for correlation between the error terms in the estimation of the FH conflict risk perception subindices regression by applying a Seemingly Unrelated Regression Equation (SURE) model. In a SURE model, the regression coefficients are estimated simultaneously by applying Aitken's generalised least squares to the whole system of equations to account for correlated errors terms. It differs from the simultaneous equation in that none of the independent variables is assumed endogenous. This procedure yields asymptotically more efficient coefficients than the single-equation least squares estimators (Srivastava & Giles, 2020; Zellner, 1962). Afterwards, a Breusch-Pagan test of independence is implemented to test the hypothesis of correlated residuals.

6.4 Data, Variable Measurements, and Descriptive Statistics

6.4.1 Data

The study was carried out in Nigeria. A multistage sampling procedure was used in selecting households for the survey.[23] In the first stage, two geographical zones – food secure and food insecure, wer purposively selected based on preliminary analysis of secondary data.[24] In the second stage, one State in each zone and five Local Government Areas (LGA) in each State was purposively chosen based on a prior occurrence of FH conflict. In the third stage, two towns in each LGA, two villages in each town and about ten households in each village are randomly selected. A total of 401 households was sampled for the study.

A pilot study of 25 farming households was conducted in the study area to ensure unambiguous survey questions and response categories. Results of the pilot survey informed the refinement of the survey questionnaire. The survey was administered between May and June 2019 by locally recruited trained enumerators with prior experience in field surveys. This was done to guarantee the quality of the information collected. Data collected was related to the 2018 planting season and focused on household socio-economic characteristics, household head, farm-level characteristics, frequency of FH conflict occurrence etc. Table 6.1 presents a description and summary statistics of the key variables used in our estimation.

6.4.2 Variable Measurements

Risk perception of FH conflict

In this paper, rural households' risk perception of FH conflict is constructed. This captures rural households' perceived hazard from FH conflicts that encompasses their knowledge of the FH conflicts and their ability to cope with its consequences. The choice of risk items used to construct the farmer-herder conflict risk perception index was motivated by threats associated with this particular type of

[23] A multistage sampling procedure was done to not only ensure suitable farmer-herder conflict data is collected and to introduce randomness and variation in the sample to avoid biases, but to also overcome the limitation of time and funds to sample a large number of households in the population. As a result, the study is not representative of the Nigerian population.

[24] Preliminary analysis of the 2015-2016 Nigerian General Household Survey (GHS) showed that the northcentral and southeast geopolitical zones are the most food secure and least food secure zones in Nigeria.

resource use conflict and validated by a pilot study of 25 rural households in the study area. The risk items go beyond just a fear of violence as a result of FH conflict. Figure 6.2 shows a pictorial representation of the construction of our FH conflict risk perception index. The study proposes that rural households' subjective risk perception of FH conflict is based on their individual knowledge of the problem and stems from their worry about its effect on their family. As shown in Figure 6.2, the study debates that rural households' risk perception of FH conflict stems from worry about the impact of FH conflict on their farm production and food supply and its effect on physical insecurity and wellbeing.

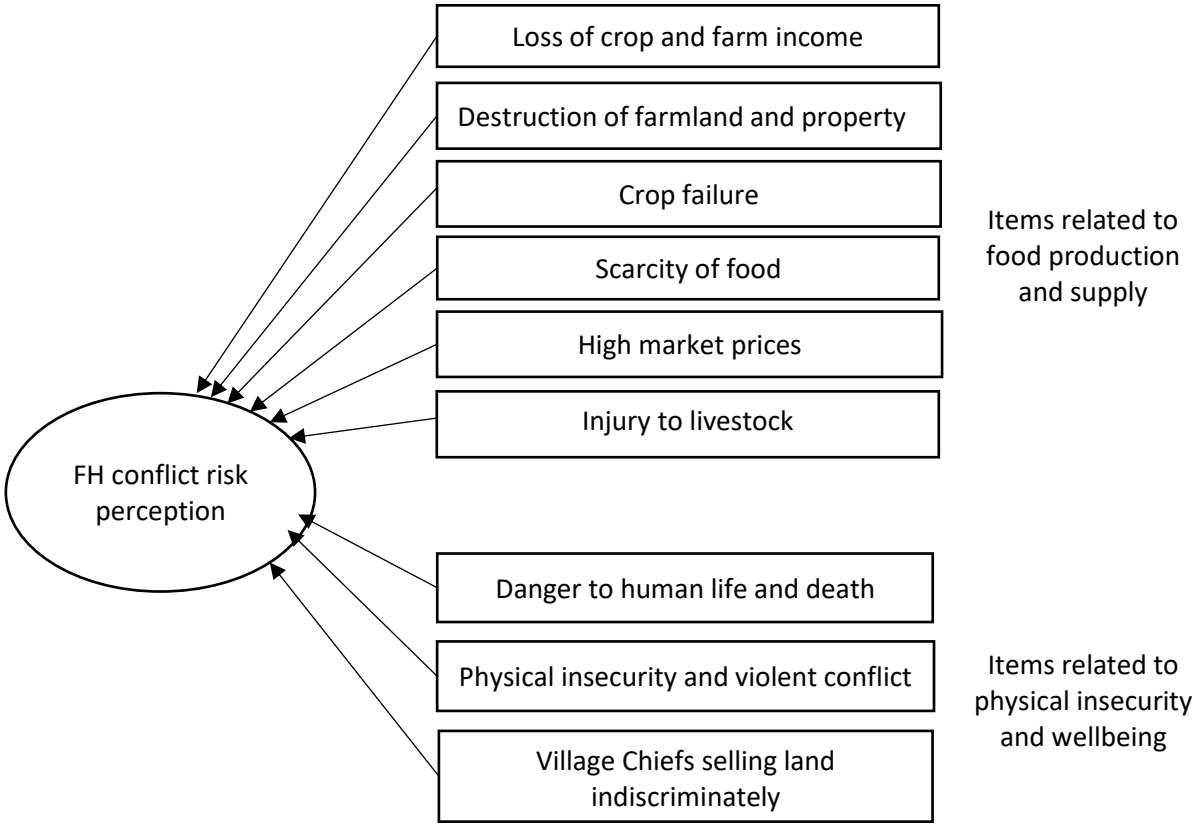

Figure 6.2 Construction of the FH conflict risk perception index and sub-indices

Household heads were asked questions on how worried they are about certain issues (high market prices, food scarcity, physical insecurity, violent clashes, possible death etc.) affecting their household as relating to previously occurred FH conflicts. Their responses are as a direct result of their personal risk aversion to farmer-herder conflicts. The rationale for this is that extant studies have found that with uncertainty as a result of violent conflict or the presence of armed actors in their communities, farmers tend to opt for sub-optimal production like subsistence farming, lower investment crop

portfolios and land use, as well as labour reallocation (Arias et al., 2019; Bozzoli & Brück, 2009; Brück et al., 2019; Gáfaro et al., 2014). This invariably leads to unfavourable consequences for their productivity and livelihoods. Nine risk questions are used to construct a holistic assessment of household FH conflict risk perception (Figure 2). The risk questions are found to be relevant and valid in the local context based on a pilot test of 25 households. The first six questions asked respondents how worried they are about the loss of crops and farm income, destruction of farmland and property, crop failure, high market prices for food, scarcity and food and injury to livestock due to FH conflicts. The remaining questions asked how worried they are about physical insecurity, violent clashes, danger to human life and the indiscriminate selling of communal land by their community head. The response categories for all questions ranged from extremely worried to not worried at all.25 Figure 3 presents the distribution of the risk items in a box plot. Figure 3 shows that majority of households are extremely concerned about the danger to human life, physical insecurity, destruction of farmland property and loss of crop income as a result of FH conflict. Most rural households in the study's sample are less worried about injury to livestock. The indiscriminate selling of communal land by Village Chiefs was the least of their worries on average.

[25] The risk items response categories are coded '5' for extremely worried to '1' or not worried at all.

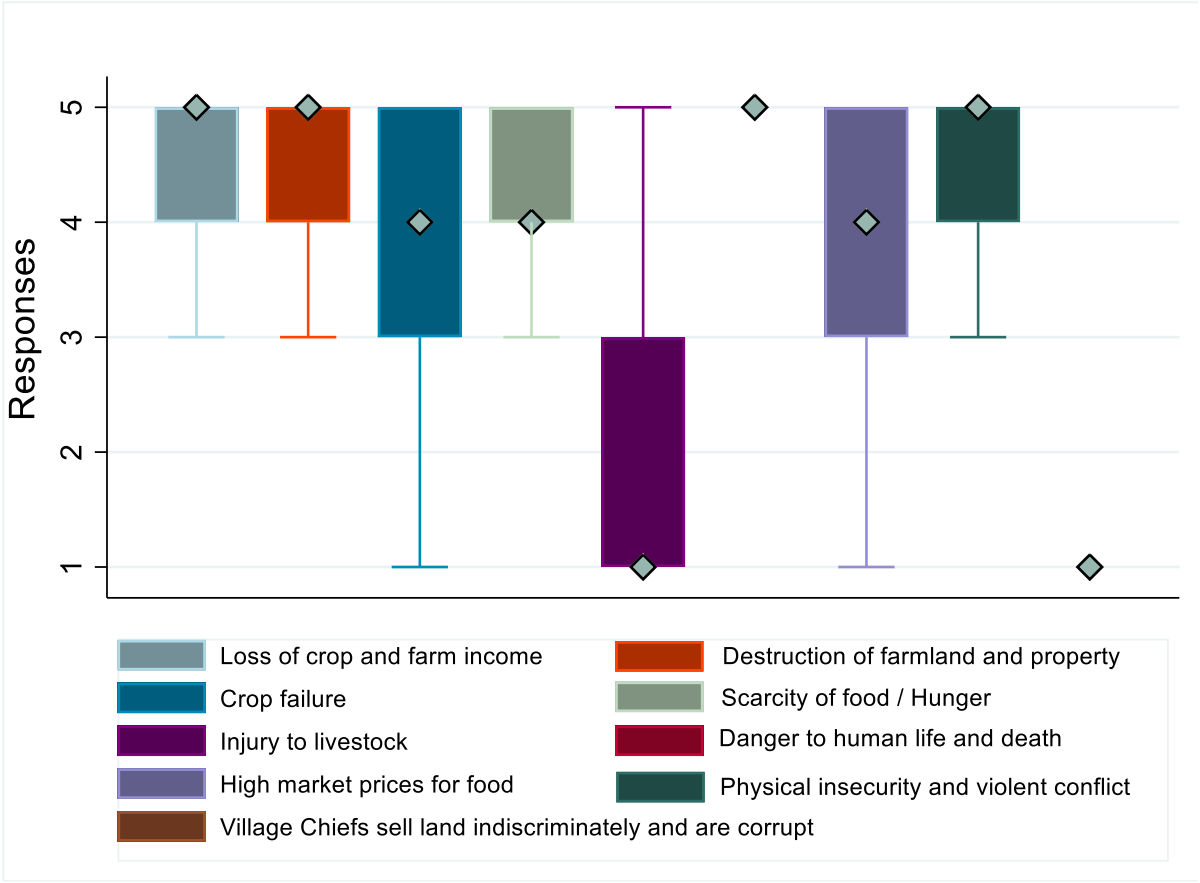

Figure 6.3 Distribution of risk items

Following Yong and Pearce (2013) and Watkins (2018), the study constructs the FH risk perception index from the nine risk items presented in figure 2 using exploratory factor analysis (EFA). EFA is used to identify and create a holistic latent index instead of using the risk items individually. The reason for this is to reduce the nine risk variables into an index, to address multicollinearity between risk variables, to determine inherent dimensions between measured risk variables and latent constructs as in the case of the FH risk perception sub-indices, and finally to evaluate the validity of constructed indices (Hooper, 2012; Watkins, 2018; Yong & Pearce, 2013). Empirical results indicate that the nine risk items are closely related.[26] The EFA has an average inter-item correlation of 0.455 with a minimum of 0.30, a maximum of 0.78 and a Cronbach alpha (α) of 0.8439.[27] To probe the major latent variables

[26] Analysis was conducted with the STATA 15 statistical package. The Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy is 0.84, above the minimum of 0.50 and indicating the variables are highly correlated (Kaiser, 1974).

[27] The Cronbach alpha is a statistic used to measure internal consistency of the set of variables included in the exploratory factor analysis. It can be described as a coefficient of reliability and used to check dimensionality and scale reliability of the index generated. See Hooper (2012)

(factors) accounting for the majority of the correlation in the EFA and further probe the source of their perceived risk, two sub-indices are constructed to capture their risk perception of FH conflict as it concerns: (1) food production and supply (α= 0.837) and (2) household physical insecurity and wellbeing (α= 0.481).

Control variables

The risk perception of natural hazards and disasters is based on individuals' innate beliefs, attitudes and judgements about the probability of occurrence and intensity of the hazard (Dzialek, 2013). Hence, we argue that similar factors will also influence the risk perception of FH conflicts. Following existing literature on the perceived risk of climate change and other hazards, the socio-demographic variables age, gender, education, dependency ratio, and marital status of household head are included to capture the impact of socio-demographic characteristics of the household head on household risk perception of FH conflicts. Farmer characteristics like age (Cohn et al., 1995; Il Islam et al., 2021; Otani et al., 1992; Rizwan et al., 2020), and education (Il Islam et al., 2021; Rizwan et al., 2020; Savage, 1993) have been found to be significant predictors of the risk perception of climate change and other disasters. Both variables have been found to have conflicting a prior expectation depending on the type of risk perception being studied. Gender of household head is also included to capture the variations in perceived risk of FH conflict by male and female farmers (Aditto, 2011; Duong et al., 2019).Women have been found to have a higher climate change risk perception (Aditto, 2011; van der Linden, 2015). A binary variable for religious affiliation of rural household is included to control for the influence of religion on the risk perception of FH conflicts. Religious beliefs have been linked as a coping strategy in times of difficulty (Nygaard et al., 2020; Yikwabs & Tade, 2021).

A set of farm-level variables like farm size, type of crop production, crop diversification (proxied by the number of crops cultivated farm household), livestock diversification (proxied by the number of livestock grown by farm household), and farming experience of the household head are also included. Farm size (Bar-Shira, Just, & Zilberman, 1997; Harrison, Lau, & Rutström, 2007; Hartog, Ferrer-i-

Carbonell, & Jonker, 2002; Il Islam et al., 2021; Lucas & Pabuayon, 2011) and farming experience (Rizwan et al., 2020) are also important predictors of risk perception and attitude.

A variable for ownership of formal title deed to their largest plot of farmland was included to capture the impact of land tenure security on household risk perception of FH conflicts. Distance from household to the closest neighbour was included to capture the effect of household settlement dispersal on their risk perception of FH conflicts. A variable for prior exposure of FH conflicts in the preceding year was included in the model to determine how the past exposure to FH conflict influences their FH conflict risk perception. A study on landslide risk perception found past experience of the event to have a positive effect on its risk perception (Qasim et al. 2018)). Hence, it's expected that prior exposure to FH conflict will be positively related to their FH conflict risk perception in the present.

6.4.3 Descriptive Statistics

Table 6.1 presents a description and summary statistics of all variables used in this study. On average, a rural household head in our sample is aged about 49 years, with 26 years of farming experience and above eight years of formal education (Table 6.1). In our sample, rural households on average cultivated about 3.86 acres of land, with about eight types of crops. About 24% of households are female-headed, with an average dependency ratio and household size of 0.40 and 9, respectively.[28] The mean distance to the closest neighbour is 320 metres and 15.41 kilometres to the nearest city. On average, FH conflicts occurred about four times in the last year. Table 6.A1 in the appendix shows the pairwise correlation matrix of all variables used in the study. No multicollinearity problems are detected.

[28] In the 2018/2019 Nigerian Living Standard Survey (NLSS), the average share of female headed households in rural areas is 17.1% with an average dependency ratio and household size of 1.05 and 5.42 (NBS, 2020)

Table 6.1 Description and summary statistics of key variables

Variable	Description	Mean (SD)
FH conflict risk perception	Household Risk perception of FH conflict	-0.001 (0.671)
FH conflict risk perception sub-index (food production)	Subindex of risk perception of FH conflict relating to food production	-0.000 (0.753)
FH conflict risk perception sub-index (physical insecurity)	Subindex of risk perception of FH conflict relating to physical insecurity	-0.005 (0.725)
Age	Age of household head (years)	49.43 (14.46)
Gender	1 if household head is female, 0 otherwise	0.24 (0.43)
Education	Education of household head (years)	8.64 (26.83)
Religion	1 if household is Christian, 0 otherwise	0.94 (0.23)
Marital status	1 if household head is married, 0 otherwise	0.86 (0.35)
Dependency ratio	Number of household members below 18 and above 60 years	0.40 (0.23)
Household size	Number of household members (persons)	9.44 (6.82)
Language	The number of languages spoken in the household	2.20 (0.78)
Household income	Total household income (₦10,000)	30.69 (20.40)
Farming experience	Household head's years of farming	26.83 (15.25)
Farm size	Total area of cultivated farmland (acres)	3.86 (3.85)
Crop diversification	The number of crops cultivated by household	7.52 (3.15)
Livestock diversification	Types of livestock cultivated by household	1 (1.04)
Distance to city	Distance from household to closest city (km)	15.41 (9.72)
Distance to closest neighbour	Distance from household to closest neighbour (km)	0.32 (0.43)
Migration status	1 if household migrated to the community, 0 otherwise	0.12 (0.33)
Formal land title	1 if household has title deed to largest farmland, 0 otherwise	0.14 (0.35)
FH conflict exposure	1 if household is in a community that has experience FH conflict in the last five years, 0 otherwise	0.63 (0.48)
Frequency of FH conflict	Number of FH conflicts in the community in 2018 (0-28)	3.95 (6.20)
Location	1 if household is located in Northcentral zone, 0 otherwise	0.50 (0.50)

Note: ₦ is Nigerian currency (US$1 = ₦ 380), SD refers to standard deviation

Table 6.2 presents the mean differences in key variables by gender of the household head. Male-headed households are found to have a significantly higher risk perception of FH conflict than female-headed households, as well as more household members. A reason for this could be because of their

increased worry about the threat of FH conflicts on their household members. Male household heads are also significantly more educated, with a higher probability of being married than female household heads.[29] Although female-headed households were found to have a larger mean size of cultivated land, they had a lower number of crops & livestock reared as well as less income than male-headed households. This implies that even though female-headed households have larger farm sizes, it was not as productive and profitable as that of male-headed households.

Table 6.2 Mean differences in key variables by gender of household head

Variables	Male	Female	Mean Difference
FH conflict risk perception	0.11 (0.03)	-0.35 (0.08)	0.46***
Age	49.28 (0.84)	49.89 (1.43)	-0.60
Education	9.22 (0.28)	6.80 (0.59)	2.42***
Religion	0.94 (0.01)	0.96 (0.02)	-0.02
Marital status	0.95 (0.01)	0.55 (0.05)	0.41***
Dependency ratio	0.40 (0.01)	0.41 (0.03)	-0.01
Household size	10.28 (0.42)	6.84 (0.39)	3.44***
Language	2.37 (0.04)	1.67 (0.06)	0.70***
Household income	33.49 (1.16)	21.92 (1.89)	11.56***
Farming experience	27.30 (0.89)	25.34 (1.45)	1.97
Farm size	3.53 (0.21)	4.92 (0.43)	-1.39***
Crop diversification	7.74 (0.17)	6.80 (0.34)	0.94***
Livestock diversification	1.06 (0.06)	0.80 (0.08)	0.26***
Distance to city	14.09 (0.52)	19.57 (1.05)	-5.48***
Distance to closest neighbour	0.30 (0.02)	0.37 (0.05)	-0.07
Migration status	0.12 (0.02)	0.12 (0.03)	1.27
Formal land title	0.17 (0.02)	0.05 (0.02)	0.12***
FH conflict exposure	0.71 (0.03)	0.78 (0.04)	-0.07*
Frequency of FH conflict	4.75 (0.39)	1.43 (0.20)	3.31***
Location	0.65 (0.03)	0.03 (0.02)	0.62***

Note: standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1

Male-headed households are found to be located significantly closer to the nearest city, have more formal property rights as well as less FH conflict exposure than female-headed households. Variables with insignificant differences between male and female-headed households include age, religion, dependency ratio, farming experience, distance to the closet neighbour, and migration status.

[29] This is similar to statistics from the 2018/2019 NLSS where on average men have about 6.6 years of education compared to women with about 5.6 years (NBS, 2020).

6.5 Results and Discussion

Results of the OLS estimation of the determinants of the risk perception of FH conflict are presented in Table 6.3. Results for the risk perception of FH conflict relating to production and supply as well as physical insecurity and wellbeing are presented in Table 6.4. Robustness checks are carried out to check the consistency of our results.

6.5.1 Factors Influencing the Risk Perception of FH Conflicts

Table 6.3 presents three models predicting FH conflict risk perception using OLS regressions. All models in Table 6.3 passed the Ramsey Regression Equation Specification Error Test (RESET) and Link Test. The RESET test assesses the functional form of the models and checks for omitted variables, while the Link test checks for model misspecification (Ereeş, EREES, & DEMİREL, 2012; Pregibon, 1980; Wooldridge, 2015b). Results of the RESET tests fail to reject the null hypothesis that the models have no omitted variables. Similarly, results of the Link test fail to reject the assumption that the models are specified correctly. This indicates correct model specification with an absence of omitted variables. Also, all three models had a coefficient of determination higher than 40%, implying that all models in Table 6.3 are able to explain more than 40% of the variance in the risk perception of FH conflict. Model 1 in Table 6.3 includes a dummy variable that captures if the community has experienced a FH conflict in the last five years. Model 2 includes a variable capturing the frequency of FH conflict occurrence, while Model 3 contains an interaction variable that captures the mediating effect of the frequency to FH conflicts on how female-headed households FH conflict risk perception.

Results show that the coefficient for the age of household head has a negative and statistically significant effect on FH conflict risk perception for all three models. This implies that younger farmers have higher levels of FH conflicts risk perception. This is particularly true in the case of Nigeria because older farmers have been found to be less risk-averse than younger farmers (Ayinde & Obalola, 2017; Emenyonu, Eze, & Ejike, 2020; Olarinde, Manyong, & Akintola, 2010). A reason for this could be because younger farmers have less farming and conflict-resolution experience, which manifests in their increased perceived risk of FH conflicts. This finding is similar to that of Savage (1993) and Peacock

et al. (2005), studying hazard and hurricane risk perceptions, but contrary to that of Ndamani and Watanabe (2017), (Rizwan et al., 2020) and (Il Islam et al., 2021) who studied farmers climate change risk perception. The coefficient of the variable representing the number of languages spoken in the household is positive and statistically significant. This implies that the more languages spoken in a household, the higher their risk perception of FH conflicts. This could be because more linguistically diverse households may reside more in culturally varied communities and are therefore more sensitive to the threat of conflicts (Fladmoe & Steen-Johnsen, 2018; Reilly, 2017; Sahadevan, 2002).

Table 6.3 Estimation results for different models of FH conflict risk perception with and without an interaction between FH conflicts and gender

Variables	(1) FH conflict risk perception (coefficient)	(2) With frequency of FH conflict (coefficient)	(3) With conflict and gender interaction (coefficient)
Age	-0.005* (0.003)	-0.005* (0.003)	-0.006* (0.003)
Gender	-0.101 (0.097)	-0.101 (0.098)	-0.179 (0.116)
Education	0.007 (0.007)	0.006 (0.007)	0.005 (0.007)
Religion	0.007 (0.110)	0.009 (0.110)	0.025 (0.112)
Marital status	0.092 (0.120)	0.105 (0.119)	0.112 (0.120)
Dependency ratio	0.177 (0.151)	0.176 (0.151)	0.197 (0.151)
Household size	-0.004 (0.004)	-0.004 (0.004)	-0.004 (0.004)
Language	0.087** (0.042)	0.089** (0.043)	0.089** (0.043)
Household income	0.000 (0.001)	0.000 (0.001)	0.000 (0.001)
Farming experience	0.009*** (0.003)	0.009*** (0.003)	0.009*** (0.003)
Farm size	-0.017** (0.007)	-0.017** (0.007)	-0.016*** (0.007)
Crop diversification	0.034*** (0.010)	0.034*** (0.010)	0.032*** (0.010)
Livestock diversification	0.065** (0.025)	0.066** (0.025)	0.067** (0.026)
Distance to city	0.001 (0.003)	0.001 (0.003)	0.001 (0.003)
Distance to closest neighbour	0.313*** (0.062)	0.312*** (0.062)	0.321*** (0.063)
Migration status	-0.260*** (0.098)	-0.261*** (0.098)	-0.256*** (0.098)
Formal land title	-0.420*** (0.083)	-0.421*** (0.084)	-0.414*** (0.084)
FH conflict exposure	0.384*** (0.080)	0.392*** (0.093)	0.374*** (0.092)
Frequency of FH conflicts		-0.001 (0.004)	-0.002 (0.005)
FH conflict and gender interaction			0.056* (0.033)
Location	0.438*** (0.071)	0.442*** (0.075)	0.445*** (0.075)
Constant	-1.115*** (0.274)	-1.117*** (0.274)	-1.133*** (0.275)
Observations	401	401	401
R-squared	0.428	0.428	0.434
RESET test	0.68 [0.565]	0.64 [0.593]	0.57 [0.638]
Link test	-0.138 [0.202]	-0.131 [0.228]	-0.116 [0.265]

Note: Robust standard errors in parentheses; P-value in square brackets; *** p<0.01, ** p<0.05, * p<0.1

The farming experience variable has a positive and statistically significant coefficient for all three models. This finding suggests that the greater number of years the household head has spent in farming, the higher their risk perception of FH conflicts. The increased farming knowledge and awareness about FH conflicts may make farmers wearier about FH conflicts and how they may affect their households.

The coefficient of the farm size variable is negative and statistically significant. This suggests that the more farmland the household has under cultivation, the lower their risk perception of FH conflicts. A potential reason may be that households with more land under cultivation have reduced fear of losing their entire crop yield due to FH conflicts or may be wealthy enough to have protection over their farmland. It could also mean that households who perceive lower risk of farmer-herder conflicts are more willing to expand their area of farmland put under cultivation. This finding disagrees with Lucas and Pabuayon (2011), who studied the risk perceptions of rain-fed lowland rice farmers in Ilocos Norte, Philippines. Similarly, the finding contradicts the result of Il Islam et al. (2021), who studied farmers risk perception and attitudes associated with environmental and climate issues in Bangladesh. The coefficient of the variables representing crop and livestock diversification is positive and statistically significant for all three models. This indicates that rural households with a higher number of crops and livestock portfolios have higher FH conflict risk perception. This finding disagrees with that of Rockmore (2020), who found farmers reduce their crop and livestock portfolios as the risk of violence and insecurity increases. A reason for this may be that rural households with a higher risk perception of FH conflict may diversify their crop and livestock holdings as a risk management strategy. This might be a way for them to still be able to meet the nutritional needs of their household in the possible event of a FH conflict since local food markets may not function properly or food prices may soar.

The distance to the closest neighbour variable has a positive and statistically significant impact on FH conflict risk perception for all three models. This implies that living in a community with low settlement density increases rural households' risk perception of FH conflicts. A reason for this finding may be that households living more remotely may be more vulnerable to violent attacks during a FH conflict

because of a lack of immediate help from nearby neighbours in the event of a FH conflict. This finding agrees with that of Adeyemi et al. (2021), who found that in Nigeria, population density is associated with a reduced rate of crime. Conversely, for all three models, the coefficient for the variable capturing household's possession of a formal title to their largest farmland is negative and statistically significant. This suggests that tenure security, in the form of the possession of a formal title to land, reduces rural households' FH conflict risk perception because of the secure tenure and formal claim to their farmland. Other studies have found increased tenure security to improve rural households' prospects for food security, improvement in farming practices, as well as increased investment in productive inputs (Abdulai et al., 2011; Ghebru & Holden, 2013; Kousar & Abdulai, 2016).

For all models in Table 6.3, the coefficient of the FH conflict exposure variable is positive and statistically significant. This indicates that households in communities that have experienced FH conflicts at least once in the last five years have a higher risk perception of FH conflicts. This finding agrees with that of Qasim et al. (2018), who found that past experience of landslides increases landslide risk perception. Furthermore, the location variable has a positive and statistically significant effect on the risk perception of FH conflicts. This shows that households living in the North Central geopolitical zone have a higher risk perception of FH conflict than those living in the Southeast. This may be explained by the fact that the northcentral geopolitical zone is mainly agrarian, producing the majority of the food consumed in the country and has more FH conflicts. Other socio-demographic and economic characteristics like gender, education level, religion, marital status, dependency ratio, household size and income had no statistically significant impact on the risk perception of FH conflict. This implies that these characteristics are not important predictors of how rural households perceive the risk of FH conflicts. The finding of an insignificant effect of the religion of households on their risk perception of FH conflict is surprising considering the ethnic and religious difference between most nomadic herders and farming communities in Nigeria.

A variable for the frequency of FH conflicts was included (Model 2, Table 6.2), but the results show no statistically significant effect of the frequency of FH conflict occurrence on rural households' risk

perception of FH conflict. In Model 3, Table 6.3, an interaction term between gender of household head and frequency of FH conflict was included. This is to capture the moderating effect of the frequency of FH conflict occurrences on the impact of gender of household head on FH conflict risk perception. Extant literature show women to be disproportionately affected by FH conflicts (CDD, 2021). Results show that the coefficient of the interaction term is positive and statistically significant. This finding indicates that an extra occurrence of FH conflict increases female-headed households' risk perception of FH conflict by 0.058 units compared to male-headed households.

6.5.2 FH Conflict Risk Perception as a Two-Dimensional Construct

To further investigate differences in risk perception as well as the source of their perceived risk in more detail, the nine risk perception items are split to capture different dimensions of their perceived risk. Two sub-indices are constructed to capture rural households' risk perception of FH conflict as it concerns: (1) food production and supply and (2) physical insecurity and wellbeing. Table 6.4 presents results of the SURE models with the two sub-indices capturing FH conflict risk perception as it relates to food production and supply (Model 1) and physical insecurity and wellbeing (Model 2) as outcome variables.

Table 6.4 Estimation results for models of FH conflict risk perception relating to food production and physical insecurity and wellbeing

Variables	(1) Food production and supply (coefficient)	(2) Physical insecurity and wellbeing (coefficient)
Age	-0.007* (0.003)	-0.003 (0.003)
Gender	-0.107 (0.097)	-0.093 (0.098)
Education	0.002 (0.007)	0.016** (0.007)
Religion	0.007 (0.141)	0.048 (0.142)
Marital status	0.138 (0.104)	-0.013 (0.105)
Dependency ratio	0.236 (0.137)	0.055 (0.137)
Household size	-0.001 (0.005)	-0.011** (0.005)
Language	0.099** (0.047)	0.063 (0.048)
Household income	-0.002 (0.002)	0.004** (0.002)
Farming experience	0.009*** (0.003)	0.010*** (0.003)
Farm size	-0.014 (0.009)	-0.025** (0.011)
Crop diversification	0.037*** (0.011)	0.028** (0.012)
Livestock diversification	0.047 (0.033)	0.104*** (0.033)
Distance to city	-0.002 (0.004)	0.008** (0.004)
Distance to closest neighbour	0.355*** (0.0799)	0.232*** (0.080)
Migration status	-0.309*** (0.100)	-0.153 (0.101)
Formal land title	-0.472*** (0.091)	-0.317*** (0.091)
FH conflict exposure	0.524*** (0.075)	0.090 (0.076)
Location	0.396*** (0.097)	0.539*** (0.098)
Constant	-1.110*** (0.305)	-1.151*** (0.307)
Observations	401	401
R-squared	0.397	0.340

Note: Robust standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1
Breusch-Pagan test of independence: χ^2 = 75.440, P-value = 0.0000

The results for model 1, Table 6.4 show that the variables age, number of languages spoken in the household, farming experience, crop diversification, distance to closest neighbour, formal land title, migration status and FH conflict exposure and location are significant predictors of FH conflict risk perception relating to food production and supply. Specifically, the findings imply that households in the North Central zone, with younger heads and more years of farming experience, have a higher risk perception of conflict relating to food production and supply. In addition, households that have experienced FH conflicts in the past, living farther away from their closest neighbour, with a higher number of languages spoken and crops cultivated, have a greater risk perception of conflict relating to food production and supply. On the other hand, possession of the formal title to farmland and migrating into the community reduced FH conflict risk perception relating to food production and supply.

The results for model 2 (column 3, Table 6.4) show that the variables education, household size, household income, farming experience, farm size, crop and livestock diversification, distance to the city, distance to closest neighbour, formal land title and location are significant predictors of FH conflict risk perception relating to physical insecurity and wellbeing. Explicitly, results imply that households with educated household heads, more income, and live remotely from the city and their closet neighbour have a higher risk perception of FH conflict concerning physical insecurity. This implies that the farther away from their neighbour and a city a household lives, the higher the fear of adverse effects of a FH conflict. A reason for this may be the lack of security personnel in remote areas where the household is located. In contrast, possession of a formal title to farmland, a higher area of cultivated farmland and the number of household members lower their risk perception of FH conflict regarding physical insecurity and wellbeing. An explanation for this is that there is more confidence in their ability to protect their property and dependents in the event of a FH conflict with larger household sizes. These findings are similar to those of Legesse and Drake (2005), who found that livelihood diversification and family size reduced smallholder farmers' risk perception of land scarcity and high crop prices in Ethiopia. The FH conflict exposure variable is an insignificant predictor for the risk perception of FH conflict regarding physical insecurity and wellbeing.

Compared to the overall FH conflict risk perception model (Table 6.3), results of the determinants of the sub-indices of FH conflict risk perception (Models 1 and 2 in Table 6.4) show that while education, household size, income and distance to the closest city are exclusively important predictors of FH conflict risk perception concerning physical insecurity and wellbeing. On the other hand, the age of household head, language diversity, migration status and FH conflict exposure are important predictors of FH conflict risk perception concerning food production and supply.

To check the robustness of the main results, sensitivity analysis is carried out by including controls for household local government areas. This is to capture location-based fixed effects for lower levels of geographical disaggregation. The results of the robustness checks are presented in Tables 6.A2 and 6.A3 in the appendix. Apart from the age of household head variable becoming insignificant, the results

show no change in the direction and significance of the estimated coefficients in the analysis and therefore confirm our main results.

6.6 Conclusion

This paper explores the determinants of the risk perception of FH conflicts using data from 401 rural households in Nigeria. Results provide evidence of the significant influence of household and household head social, economic, and demographic characteristics on the risk perception of FH conflicts. Results also differentiate between the risk perception of FH conflicts concerning food production and supply and physical insecurity and wellbeing and highlight their important predictors. Although this study provides a vital understanding of what affects FH conflict risk perceptions, further research is needed to understand how climate and time-varying variables influence the risk perception of FH conflicts. This can be done by using longitudinal data to control for time and climate effects.

Findings recommend the enactment of initiatives that facilitate procurement of formal titles to land resources and encourage a gradual shift to more sustainable herding systems. Sustainable livestock production systems referred to here encompass efficient livestock production and optimal use of finite productive resources amidst a reduced likelihood of environmental degradation. The aforementioned, implemented with the enforcement of land property rights, will most probably reduce the occurrence of FH conflicts which will, in turn, have a negative effect on the risk perception of FH conflicts. Studies have shown that how farmers respond to risk is an important factor in determining their agricultural production choices. Hence, strategies that improve farmers' capacity to cope with FH conflict risks should be facilitated.

Findings have implications for governmental and non-governmental agents who wish to influence the risk behaviour of rural households to FH conflicts using targeted interventions, for instance, increasing tenure security through the provision of formal title to owned land. Guided by their local context, findings will aid policymakers in countries facing similar conflicts understand the thought process of

rural dwellers on their perceived risk of FH conflict. Additionally, it will improve understanding of how they may respond to policy changes regarding the perceived risk of FH conflict and aid the development of efficient risk management initiatives.

A key limitation of the study is the lack of nationally representative panel data for analysis. Future research should collect nationally representative panel data in order to facilitate the investigation of time-invariant factors influencing the risk perception of FH conflicts.

Appendix 6.0

Table 6.A1 Pairwise correlation matrix of all variables

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)
(1) RPI	1.000														
(2) Age	-0.040	1.000													
	(0.426)														
(3) Gender	-0.297*	0.018	1.000												
	(0.000)	(0.721)													
(4) education	0.102	-0.443*	-0.200*	1.000											
	(0.042)	(0.000)	(0.000)												
(5) Religion	0.008	-0.216*	0.039	0.186*	1.000										
	(0.867)	(0.000)	(0.434)	(0.000)											
(6) Marital status	0.197*	-0.154*	-0.496*	0.265*	0.051	1.000									
	(0.000)	(0.002)	(0.000)	(0.000)	(0.308)										
(7) Dependency ratio	0.044	-0.052	0.025	-0.011	-0.016	0.123	1.000								
	(0.381)	(0.299)	(0.619)	(0.828)	(0.753)	(0.014)									
(8) Household size	0.180*	0.117	-0.216*	-0.016	-0.066	0.191*	-0.123	1.000							
	(0.000)	(0.019)	(0.000)	(0.754)	(0.188)	(0.000)	(0.014)								
(9) Language diversity	0.267*	-0.062	-0.385*	0.262*	-0.047	0.252*	-0.095	0.318*	1.000						
	(0.000)	(0.218)	(0.000)	(0.000)	(0.347)	(0.000)	(0.057)	(0.000)							
(10) Household income	0.114	0.025	-0.243*	0.157*	-0.079	0.118	-0.028	0.182*	0.153*	1.000					
	(0.022)	(0.623)	(0.000)	(0.002)	(0.116)	(0.019)	(0.577)	(0.000)	(0.002)						
(11) Farming experience	0.159*	0.714*	-0.055	-0.442*	-0.151*	-0.089	-0.042	0.185*	0.029	0.116	1.000				
	(0.001)	(0.000)	(0.269)	(0.000)	(0.002)	(0.076)	(0.401)	(0.000)	(0.561)	(0.021)					
(12) Farm size	-0.072	0.087	0.155*	-0.110	-0.138*	-0.039	-0.018	0.078	-0.022	0.125	0.103	1.000			
	(0.152)	(0.082)	(0.002)	(0.028)	(0.005)	(0.438)	(0.715)	(0.118)	(0.660)	(0.012)	(0.039)				
(13) Crop diversification	0.263*	0.113	-0.128	-0.006	-0.035	0.058	0.044	0.179*	0.114	0.208*	0.191*	0.229*	1.000		
	(0.000)	(0.024)	(0.010)	(0.900)	(0.491)	(0.243)	(0.385)	(0.000)	(0.023)	(0.000)	(0.000)	(0.000)			
(14) Livestock	0.202*	0.044	-0.106	0.049	0.041	0.075	0.000	0.139*	0.123	0.278*	0.180*	0.108	0.346*	1.000	

diversification															
	(0.000)	(0.375)	(0.034)	(0.324)	(0.411)	(0.135)	(0.996)	(0.005)	(0.014)	(0.000)	(0.000)	(0.030)	(0.000)		
(15) Distance to city	-0.092	0.040	0.242*	-0.167*	-0.187*	-0.204*	0.014	-0.185*	-0.303*	-0.048	-0.068	0.219*	-0.064	0.031	1.000
	(0.067)	(0.421)	(0.000)	(0.001)	(0.000)	(0.000)	(0.784)	(0.000)	(0.000)	(0.339)	(0.177)	(0.000)	(0.204)	(0.539)	
(16) Distance to closest neighbour	0.104	-0.058	0.069	-0.073	-0.194*	-0.023*	0.017	-0.026	-0.021	-0.018	-0.136*	0.108	-0.206*	-0.183*	0.317*
	(0.038)	(0.247)	(0.168)	(0.143)	(0.000)	(0.648)	(0.740)	(0.607)	(0.673)	(0.726)	(0.006)	(0.031)	(0.000)	(0.000)	(0.000)
(17) Migration status	-0.227*	-0.113	0.007	0.121	0.025	-0.023	0.064	-0.192*	-0.065	0.068	-0.199*	-0.073	-0.187*	-0.044	-0.000
	(0.000)	(0.024)	(0.889)	(0.016)	(0.619)	(0.645)	(0.201)	(0.000)	(0.194)	(0.175)	(0.000)	(0.160)	(0.000)	(0.377)	(0.998)
(18) Formal land title	-0.127	-0.090	-0.144*	-0.127	-0.127	0.072	0.068	0.084	-0.016	0.077	0.137*	0.046	-0.077	0.062	-0.123
	(0.011)	(0.071)	(0.004)	(0.011)	(0.011)	(0.148)	(0.171)	(0.094)	(0.744)	(0.122)	(0.006)	(0.353)	(0.122)	(0.215)	(0.013)
(19) FH conflict exposure	0.224*	-0.025	0.067	0.224*	0.224*	0.012	0.116	-0.122	0.029	-0.083	-0.148*	0.020	-0.051	0.092	0.285*
	(0.000)	(0.615)	(0.179)	(0.000)	(0.000)	(0.808)	(0.020)	(0.015)	(0.560)	(0.099)	(0.003)	(0.696)	(0.312)	(0.067)	(0.000)
(20) Frequency of FH conflict	0.310*	-0.125	-0.229*	0.310*	0.310*	0.023	0.090	0.136*	-0.050	0.235*	0.275*	0.099	0.024	0.218*	-0.145*
	(0.000)	(0.012)	(0.000)	(0.000)	(0.000)	(0.647)	(0.073)	(0.006)	(0.318)	(0.000)	(0.000)	(0.049)	(0.626)	(0.000)	(0.004)
(21) Location	0.401*	-0.176*	-0.529*	0.401*	0.203*	0.074	0.339*	-0.084	0.413*	0.476*	0.059	0.075	-0.185*	0.067	-0.506*
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.137)	(0.000)	(0.094)	(0.000)	(0.000)	(0.236)	(0.135)	(0.000)	(0.181)	(0.000)

Note: * p<0.05

Table 6.A1 Continued

Variables	(16)	(17)	(18)	(19)	(20)	(21)
(17) Distance to closest neighbour	1.000					
(18) Migration status	0.055	1.000				
	(0.270)					
(19) Formal land title	-0.154*	-0.038	1.000			
	(0.002)	(0.451)				
(20) FH conflict exposure	0.063	0.018	0.018	1.000		
	(0.211)	(0.726)	(0.726)			
(21) Frequency of FH conflict	-0.072	-0.135*	0.069	0.387*	1.000	
	(0.153)	(0.007)	(0.170)	(0.000)		
(22) Location	-0.150*	-0.214*	0.174*	-0.181*	0.368*	1.000
	(0.003)	(0.000)	(0.000)	(0.000)	(0.000)	

Chapter 7

General Conclusion and Policy Implications

7.1 Introduction

The unequal access to productive resources like land in most developing countries, as well as the recent increase in the frequency of occurrence of farmer-herder (FH) conflicts, motivated the need to examine the effect of gendered land access on the food security status of the household, and the direct and indirect effects of FH conflicts on rural household livelihoods. This thesis contributes to the extant literature by investigating the joint influence of access to land and gender on household food security and the multifaceted effect of FH conflicts on rural households' production decisions and food security in Nigeria. First, the joint influence of gender and land access on household food security status is determined. Second, the differential impact of the incidence and severity of FH conflicts on rural households' food insecurity is investigated. Third, a theoretical model of farmer-herder resource use conflict is developed, and the hypotheses derived tested, which posits that the risk perception of FH conflict will influence rural households' productive input use, participation in the land rental market, and their time allocation for farm work. Finally, the social-economic and cultural determinants of rural households' risk perception of FH conflict is examined.

7.2 Summary of Results

The results in Chapter 3 reveal that in Nigeria, increased access to arable land reduces the likelihood of households being food insecure. In addition, male-headed households are more likely to be food secure than female-headed households. The findings of the non-linear interaction between gender of household head and area of land accessed show that a one-acre increase in arable land reduced the probability of female-headed households being food insecure by about 16% on average when compared to male-headed households. However, the results also show that increased access to arable land does not improve the food security prospects for some female-headed households in Nigeria.

In Chapter 4, a positive and statistically significant impact of the incidence and severity of FH conflict on rural household food insecurity is found in rural Nigeria. An additional incidence of FH conflict increased rural household food insecurity by 0.07 HFIAS units and 1.97 CSI units. Similarly, it is found that a unit increase in the severity of FH conflicts increases rural households' food insecurity by 2.04 HFIAS units and 5.41 CSI units. The occurrence and severity of FH conflicts may raise household food insecurity through reduced food availability or diminished income resulting from the destruction of farm property, crop failure, and consequent crop yield loss. The results suggest that although both the incidence and severity of FH conflict have a statistically significant positive impact on rural households' food insecurity, the latter's impact is higher. Furthermore, household size, crop diversification, road quality to farmland, household asset index, and land tenure have significant negative impacts on food insecurity, while having a formal title to farmland positively influences food insecurity.

Chapter 5 finds that the risk perception of FH conflict has a negative and statistically significant effect on rural households' decision to use fertilisers. Similarly, rural households' risk perception of FH conflicts has a significant negative effect on their investment in fertilisers. This negative impact on productive input use, in this case, fertiliser, may invariably have adverse consequences for productivity and subsequent income. The results also reveal a statistically significant positive effect of the risk perception of FH conflict on rural households' time allocation for farm work. This suggests that rural households commit more time to farm work because of the perceived negative consequences of FH conflicts. Furthermore, the results show no significant impact of the risk perception of FH conflict on the area of cropland rural households' rent-in for cultivation. However, by splitting households into groups based on their perception of FH conflicts, our results show that risk-averse households rent in less cropland than risk-loving households.

Several social, economic, and demographic factors that influence rural households' risk perception of FH conflicts are discussed in Chapter 6. Specifically, the age of household head, farm size, migration status, and having formal title to cropland have a significant negative influence on the risk perception of FH conflicts. On the other hand, the farming experience of household head, household crop and

livestock diversity, number of languages spoken, distance from household to closest neighbour, households being in the north-central region, and the occurrence of a FH conflict in the community in the last five years, have a significant positive influence on the risk perception of FH conflicts. Furthermore, splitting the FH conflict risk perception index into two sub-indices relating to food production and supply and physical insecurity, reveals that age of household head, household language diversity, and exposure to FH conflict, are significant predictors of FH conflict risk perception regarding food production and supply. In contrast, household size, income, education of household head, farm size, and distance from household to the closest city are significant factors influencing FH conflict risk perception regarding physical insecurity and wellbeing.

7.3 Policy and Governance

For an ethnic and culturally diverse country like Nigeria, the successful implementation of policies presents major challenges. There have been numerous agricultural policies focused on advancing food security, including those focused on land and gender issues. However, while the implementation of some of these policies was partly successful, some were abandoned, and others simply failed. Before discussing the policy implications of this study, it is important to place the work within the context of the wider policy situation in Nigeria. Therefore, in this section, some of the core policies to address food security, land access and gender equality are discussed and the possible barriers to implementation are reviewed.

One of the major policies to improve the nutritional status of every Nigerian especially children, women and the elderly, were identified under the National Plan of Action on Food and Nutrition which was established in 2004. Its specific goal was to establish an operable system for coordinating the food and nutrition activities of all sectors and stakeholders as well as promoting habits that diminish malnutrition levels in the country. Evaluation of this policy between 2013 and 2016, exposed its non-performance and failure to achieve the set goals for food and nutrition security.

Currently, Nigeria is executing a National Multisectoral Plan of Action for Food and Nutrition (NMPFAN) between 2021 and 2025 aimed at attaining optimal nutrition for every Nigerian especially the most vulnerable including children, women and internally displaced people. The NMPFAN policy seeks to scale up cost-effective and high-impact nutrition interventions like enhancing infant and young child feeding, in order to improve the deteriorating nutrition situation in the country as well as meet post-SDG targets. All tiers of government in Nigeria are to finance the cost of implementing the NMPFAN policy within their budgets. The policy is also being supported by development partners and the private sector by building partnerships and scaling up nutrition interventions. Although the policy is only part way through, a barrier to its successful implementation may include a lack of coordination and synergy among key stakeholders and implementers.

In the agricultural sector, the Agricultural Transformation Agenda (ATA) policy was implemented over the period between 2011 and 2015. The ATA policy had multiple objectives, including promotion of agribusiness; reduction of post-harvest losses; improving efficiency across the agricultural value chain; development of rural infrastructure and; enhanced access to financial services and markets by smallholder farmers. If successful, the ATA would have also greatly improved food security. Unfortunately, the ATA had significant shortcomings, and as a result, the Agriculture Promotion Policy (APP) was developed and implemented between 2016 – 2020 to drive the growth and development of Nigeria's agriculture sector over the period. The overarching objectives of the APP are food security, economic diversification and job creation, as well as input substitution. The APP sought to address some of the shortcomings in the ATA like insufficient input supply and smallholder credit access, post-harvest losses etc. Although the APP made progress in some objectives like reducing unemployment in the agricultural sector, improving smallholder access to certified seeds, training more women, and increasing the volume of agricultural exports, there were still gaps in reaching the set objectives. Some of the gaps identified are the empowerment of women and youths in the agricultural sector, postharvest losses, import substitution and foreign exchange earnings amongst others. Recently, the federal ministry of agriculture launched the National Agricultural Technology, and Innovation Policy (NATIP) which is being implemented between 2022 and 2027.

For land administration policies, the cultural biases within the framework in which these decisions are made also determine how successful they are. For example, in the case of farmer-herder conflicts over land resources, the Nigerian government has made prior policy attempts to resolve the issue. The Nigeria Land use act of 1978 abolished the existing land tenure systems in both Northern and Southern Nigeria and replaced them with a uniform land administration system whereby land is under the control of the Governor for use and for the benefit of natives of the region. With the increased occurrence of FH conflicts, some state governments banned open grazing in order to curtail the onset of conflicts. This policy decision failed to resolve the issue of FH conflicts and may have increased tension between farmers and herders.[30]

The Federal government then proposed the enactment of Rural Grazing Areas (RUGA) settlements to be piloted in 12 states in the country. This policy process was suspended because of the fear of ethnic domination among key stakeholders and firm opposition by some state governments in the Southern region in their bid to protect the land for their natives. The RUGA policy, formulated amid overwhelming ethnic prejudice, failed because of a failure to have an inclusive policy process that enables collective efforts to address the devastating consequences of FH conflict. Following the failure of the RUGA settlements, the federal government initiated a National Livestock Transformation Plan (NLTP) which proposes the establishment of ranches across interested states. This is with the goal of reducing open grazing and subsequently decreasing the incidences of FH conflicts. As of mid-2021, only a fifth of the 20 states that agreed to the NLTP were ready for its implementation. This lack of trust and coordination among different governmental stakeholders further worsens the likelihood of resolving the burden of FH conflicts sustainably. Another contributory factor to the government's failure in addressing FH conflicts is the ethnic and religious biases of both farmers and herders. Most herders are Muslim and from the Fulani tribe, while most farmers are Christian and of diverse ethnicities. This imposes another layer of distrust among all concerned parties and may further buttress wariness and cynicism in enacting adequate policies to resolve these types of conflicts.

[30] See Yikwabs et al (2020)

Although examining the ethnic and religious bias involved in FH conflicts was beyond the scope of the research questions, it is important to note its influence on the implementation of the above-mentioned policies.[31]

Within this wider policy context, this thesis has provided evidence of the devastating effects of FH conflicts and the impact of gendered access to land on food security. The complex-policy making failures described above bring to light the difficulty that may be experienced by the Nigerian government in its bid to enact the right policies. These impediments include the federal government's inability to implement any land policies without the express permission of state governors. State governors, on the other hand, may be averse to certain land policies, for example, RUGA, because of differing ethnic and political interests. Also, mistrust of the government and failed institutional processes due to vested interests by key public and private stakeholders may disrupt the execution and performance of suggested policies. All of these may prevent the implementation of suggested policy processes that potentially prevent and alleviate the burden of FH conflicts.

One of the major policies to address gender equality is the Nigerian National Gender Policy (NGP) in Agriculture aiming to promote the adoption of gender-sensitive and gender-responsive strategies in the agricultural sector that ensure women and men have equal access to productive resources for improved agricultural productivity.[32] The NGP recognizes barriers to the advancement of the Nigerian agricultural sector due to the exclusion of female smallholder farmers in terms of accessing productive resources and strategic participation in key decision-making processes. For example, court land arbitrations are expensive and time-consuming with negotiations usually in favour of men over women due to deeply entrenched systemic cultural biases. Also, the NGP acknowledges that the rate of implementation of already existing policies to bridge the gender gap is poor. Hence, this policy provides

[31] See Ogu (2022) and Yamusa (2022) for a discussion on ethnic and religious bias influencing to FH conflicts.
[32] Gender-responsive policies refer to policies that incorporate gender and inclusion to improve targeted interventions while gender-transformative policies do not just incorporate gender and inclusion interventions, but also inform structural changes in norms and power relations that ultimately result in sustained improvements leading to gender equality.

a logical plan for the implementation of plans and programmes that will ensure the unbiased and equitable contribution of all farmers to the food and agricultural system.

The NGP proposes to address gender bias in the agricultural sector through mainstreaming gender equity in agricultural extension and coaching agricultural workers to pinpoint and address gender issues in the agricultural sector. The policy also seeks to empower female smallholder farmers by building their financial management skills and setting up a monitoring and evaluation framework to assess differential impacts of ongoing projects and interventions on men and women. Impediments to the successful implementation of the national gender policy are the inadequate documenting of policy processes, lack of programmes or initiatives that directly address the structural power relations, social norms, gender biases and inequalities in ownership and access to resources.[33]

7.4 Policy Implications

The previous section has outlined the broader policy environment in which this thesis is situated. Against this background, this section discusses the policy implications for each research objective. These policy implications are assessed within a nexus approach. In this case, the nexus of climate change, water and food security, energy and social justice embodied in the sustainable development goals (SDGs), are useful in understanding connections, linkages and trade-offs between governmental and non-governmental sectors.[34] This approach recognises that sustainably improving food security is hinged on complex trade-offs between food, water, energy and the environment. It goes beyond just increasing food production in isolation of other processes which may result from it. Interventions must be carried out within a framework that captures the intricacies of the effect of policies, strong institutions, health services, market infrastructures and resilience capacity.

The findings in Chapter 3 of this thesis show that although male-headed households are more food secure than female-headed households, with a one-acre increase in access to arable land, female-

[33] See Amadi (2017).
[34] See Grafton et al. (2016) and Lui et al (2018) for discussions on nexus approaches to global challenges of sustainable development.

headed households are less likely to be food insecure. This has implications for policies that seek to improve the food security of rural dwellers. First, it emphasizes the importance of gender equity in access to arable land to ensure food security. Also, the finding provides evidence that can help inform policy initiatives around issues of gendered access to land in support of the fifth SDG for gender equality and the empowerment of marginalized women. For instance, findings from this chapter can influence the review of the 2019 NGP being conducted by Nigeria's Federal Ministry of Agriculture and Rural Development (FMARD).

As noted in the previous section the NGP in agriculture aims to foster the implementation of gender-responsive and gender-transformative plans and programmes in the agricultural sector towards ensuring the equal control of, and access to, productive resources for men and women. Findings from this thesis emphasize the need for gender-transformative approaches to bridge gender gaps as well as in distributing productive resources to reduce food insecurity among Nigerian households. For multi-national organisations such as the Food and Agricultural Organisation (FAO) or World Food Programme (WFP), the research findings will help streamline already existing programmes and facilitate new ones that not only bridge the gap of gendered access to productive resources but encourage equity in access to these resources in order to enhance household food security at all levels.

An immediate response could be for the government to enact specific policies to facilitate and provide direct cash transfers or food crop subsidies to female-headed households to alleviate their food insecurity, especially during the lean season or episodes of drought. Nevertheless, direct cash transfers and crop subsidies will only alleviate the immediate needs of women and not address the root cause of the problem. In addition, the government can facilitate an inclusive framework, bringing together all key stakeholders to develop more gender-transformative policies that go beyond identifying the gender gaps to addressing the structural power relations, social norms and inequalities that foster these gaps. Also, agricultural project development at all levels should involve all stakeholders, including rural men and women. This is to ensure the relevance of interventions as well as enhance the probability of its success.

In Chapter 4, the result of the positive impact of incidence and severity of FH conflict on rural household food insecurity highlights the detrimental effects of the ongoing FH conflicts. This finding emphasizes the importance of policy initiatives to support rural households adversely affected by FH conflicts. For instance, policies that facilitate urgent safety nets like food aid to affected households or conflict resolution and rehabilitation for both herders and farmers in affected communities. Additionally, there is a need to establish policies that may prevent the onset of FH conflicts by addressing the root causes of these conflicts. For example, facilitating initiatives that encourage more sustainable herding practices like ranching and intensive crop farming. This is most likely to help in curbing the probability of FH conflicts in the future. This is important because the adverse effects of climate change are continually placing increased pressure on available arable land resources.

Results in Chapter 5 of the negative effect of the risk perception of FH conflict on the decision to use fertilisers, subsequent investment in fertilisers, and the area of cropland rented-in for cultivation suggests that FH conflict risk perception may have adverse consequences for agricultural productivity. Given that use of productive inputs use has been found to improve farm productivity and yield, the negative effect of FH conflict on fertiliser use may invariably have a detrimental impact on rural households' production and output. Thus, this finding provides empirical evidence of the damaging psychological effect of FH conflicts. The finding supports the argument that strategies targeted at improving rural farmers' productivity and efficiency, especially in conflict regions, should include improving their perception of security and safety. This can be done by enhancing the rule of law by increasing both the presence of security personnel and their effectiveness in FH conflict-affected communities and developing rural infrastructure like access roads. In addition, although challenging, the facilitation of an efficient conflict-resolution mechanism between farmers and herders that may include police personnel, the community heads and the neighbourhood watch may not only reduce the likelihood of FH conflict occurrence but also build trust and increase the perceived security of farming communities. These will facilitate the reduction of the perceived risks associated with FH conflicts. Currently, Nigeria is unable to meet domestic food demand for its growing population; thus, there is an urgent need for policies that will help boost food production.

The social, economic, and demographic factors that influence how rural households perceive the risk of FH conflicts have significant implications. Findings in Chapter 6 suggest that the facilitation of strategies that improve the procurement of formal titles to farmland may reduce how rural households perceive the risk of FH conflicts. For example, improving the security of land tenure through the facilitation of formal titles to cropland will help reduce how rural households perceive the risk of FH conflicts. Given that findings in Chapter 5 show that rural households' risk perception of FH conflicts significantly influences their production input use decisions, initiatives that reduce how adversely FH conflicts are perceived should be established. This result has implications for governmental and development agents keen on influencing the risk attitude of rural farmers and understanding how they respond to policy changes regarding FH conflicts.

Findings of the determinants of the risk perception of FH conflicts will also facilitate understanding of what factors influence how rural dwellers behave, especially with the threat of FH conflicts. Subsequently, this will inform the development of strategies that seek to influence rural households' risk attitudes to FH conflicts and improve risk management strategies. Also, findings in chapter 6 will help develop future studies where we can have more nuanced investigations with an interdisciplinary lens to help influence how farmers perceive the risk of FH conflicts. Engagement and coordination among key stakeholders and different tiers of government to identify potential trade-offs of different policy options will further increase the chances of arriving at a feasible solution to the vicious cycle of FH conflicts.

7.5 Limitations and Future Research

This thesis is not without limitations. A major limitation of the thesis is the lack of nationally representative data for analysis. Data from the third wave of the Nigerian general household survey was used in Chapter 3, but the number of observations was reduced to 1096 households after selecting key variables. Also, the analysis in Chapter 3 does not capture intra-household gender differences. This

is a shortcoming because women in male- and female-headed households may encounter different challenges in accessing land resources.

A second limitation is that the study does not capture herders in the survey data. Apart from the study's primary data research design being solely focused on rural farming households, the possibility of reaching out to nomadic herders was extremely limited. Inclusion of herders was not possible not only because of funding and time restraints, but also because of the risk factors. Hence, the research questions focused on rural farming households.

Another limitation of the thesis arises from the use of cross-sectional data due to a lack of micro-level longitudinal data on FH conflicts. Examining the seasonality effects of the risk perception of FH conflicts will be beneficial for future research. Longitudinal data will be more effective in capturing unobserved heterogeneities that also affect FH conflicts, for example, time-varying seasonality effects and climate conditions. This will give more insight into the long-term effects of FH conflict. Further studies investigating how past FH conflict shocks affect current risk perceptions will be important to improve understanding of the dynamics of FH conflicts.

Despite the inevitable limitations, the analytical chapters in this thesis make novel contributions by providing new insights into the influence of gendered access to land on food security; examining the direct and indirect effect of FH conflicts on rural households' livelihoods and food security; and exploring the social, economic, and demographic determinants of the risk perception of FH conflicts.

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Appendix A

Data Collection Questionnaire

Primary Data Questionnaire

Access to Land, Gender, and Conflict: Implications for Food Security of Rural Households in Nigeria

Questionnaire

Instructions

- Please interview the household head. If it is not possible, then interview the most important member of the household.
- First introduce yourself and explain thoroughly the purpose of the survey.
- Please stick to the units in which figures and values are asked.
- Please use codes where provided.
- Please fill out all the details as correctly as possible.
- Please note that the information will be kept secret and will not be disclosed to anyone.
- Please have household head read and sign the consent form. Where this is not possible, please explain to them that participation is absolutely voluntary and their consent can be withdrawn any time before 5th August 2019 by calling the lead researcher, Amaka Nnaji on +2347038146361 or +64225384550. Also, the results of this project will be used for publications in journals and conferences with the understanding that their anonymity will be guaranteed.
- Tick the box if verbal consent has been received ☐

Time interview commenced: _____ GPS coordinates: _____

Household No.: _____Date: _____

LGA/State: _____Town: _____

Village: _____ Name of Respondent: _____

Distance from village to the nearest city: _____ (km) Phone no:_____

A/ General information on the household head

Please write down the basic information about the Household head.

[A1] Age? (years) _____

[A2] Gender? (1=Male, 0=Female) _____

[A3] Educational level of household head? (1=no formal education, 2=primary education, 3=secondary education, 4=vocational education, 5=university degree)

[A31] Number of years you spent schooling? (years) _____

[A4] Marital status? (1= Unmarried, 2= Married, 3= Widow/Widower, 4=Divorced, 5=Separated) _____

[A5] Religion? (1=None, 2=Muslim, 3=Christian, 4=Traditionalist,

[A51]=others specify (_____)

[A6] Main occupation? (1= Crop farming, 2= livestock farming, 3= Trading,

4 = Civil service, 5= Artisan, **[A61]** =others specify (_____))

[A7] Secondary occupation? ((1= Crop farming, 2= livestock farming, 3= Trading,

4 = Civil service, 5= Artisan, **[A61]** =others specify (_____))

[A8] Did you participate in off-farm work in 2018? (1=Yes, 0=No) _____

[A81]Time taken between household and place of off-farm work by usual transport?(minutes)

Did any of the following participate in off farm work in 2018? (1=Yes, 0=No). If yes, how many?

[A82] Your neighbour		**[A83]** Your close friends		**[A84]** Your relatives	
(1=Yes, 0=No)	How many?	(1=Yes, 0=No)	How many?	(1=Yes, 0=No)	How many?

[A85] Do you think it is easy to find off-farm work locally? (1=Yes, 0=No) _____

[A9] Did your household migrate to the community? (1=Yes, 0=No) _____

[A10] Farming experience of household head? (years) _____

[A11] Are you a member of any Farmer's association/cooperative? (1=Yes, 0=No) _____

Are any of the following members of a Farmer's association/cooperative? (1=Yes, 0=No)

[A111] Your neighbour	**[A112]** Your closest friend	**[A113]** Your relative

[A12] What ethnic group do you belong to? _____ (0=if you prefer not to say)

[A13] What languages are spoken in your household? _____

B/ Household level information

Please use given codes for the following household level information.

[B1] Household family type? (1=Nuclear, 0=Extended) _____

[B2] Number of household members? _____

[B21] No. of household members aged less than 15 years _____

[B22] No. of household members aged 65 years and above _____

[B3] Time taken from household to the largest farm plot by usual transport? (minutes)

[B4] Time taken from household to the closest source of inputs by usual transport? (minutes)

[B5] Time taken from household to the closest output market by usual transport? (minutes)

[B6] Does household have access to electricity? (1=Yes, 0=No)

[B7] House wall material? (1=Cemented 2= Wooden, 3= Earthen,

[B71=others specify (_____))

[B8] In general, how much was your total household income in 2018? (₦)_____

[B81] Total Farm income? (₦)_____

[**B82]** Total Production Costs? (₦)_____

[B83] Total Off-farm income? (₦) _____

[B84] Total Farm Gross Revenue? (₦)_____

[B85] Did you receive money or food/non-food items any of your family or friends living outside your community? (1=Yes, 0=No)

[B851] If yes above, what form did you receive assistance from your family or friends living outside your community? (1=Cash, 2=non-cash, 3=both)

[B852] If yes above, how much did you receive? (₦) _____

[B9] Does household head have access to credit? (1=Yes, 0=No)

[B91] What type of credit? 1= Formal credit, 2= Informal credit (e.g. Esusu), 3= Traditional money lender, 4 =NGO or governmental credit, **[B911]** =others specify (_____)

[B92] Time taken from household to closest source of credit by usual transport? (minutes)

[B10] Does the household own a Tractor/ Farm Machinery (e.g. ploughs or planters)? _____ (1=Yes, 0=No). **[B101]** A Car? _____ (1=Yes, 0=No). **[B102]** A mobile phone? _____ (1=Yes, 0=No). **[B103]** A Motorbike? _____ (1=Yes, 0=No). **[B104]** Refrigerator? _____ (1=Yes, 0=No). **[B105]** Radio? _____ (1=Yes, 0=No). **[B106]** A TV? _____ (1=Yes, 0=No). **[B107]** A Computer_____ (1=Yes, 0=No). **[B108]** Animal Cart? _____ (1=Yes, 0=No).

[B11] How do you perceive the road condition from your village to your largest plot of farmland? (1=Good, 0=Not good) _____

[B111] How do you perceive the road condition from your village to the closest source of input? (1=Good, 0=Not good) _____

[B112] How do you perceive the road condition from your village to the closest output market? (1=Good, 0=Not good) _____

C/ Household Farm-level characteristics

[C1] How many farmland parcels does your household have access to? _____

[C2] What is the predominant soil type in your farmland? (1=Clay, 2=Loam, 3=Clay loam, 4=Sandy loam, 5=Silt loam, **[C21]** others specify (_____)

[C3] Do you think your farmland is fertile? (1=fertile, 0=otherwise) _____

[C4] Fertiliser use? (1 = Organic (e.g. farmyard manure), 2 = Chemical (e.g. NPK, Urea), 3 = both Organic and Chemical, 4 = none) _____

[C41] Amount of money spent on organic fertilisers in 2018? (₦) _____

[C42] Amount of money spent on chemical fertilisers in 2018? (₦) _____

[C5] Irrigation source? (1=Only Rain, 2=Canal, 3=Tube well, 4=Canal+ Tube well, 5=Small dam, 6=Dug wells, 7=Turbines, **[C51]**=others specify (_____)

[C6] Do you use improved seeds? (1=Yes, 0=No) _____

[C61] Amount of money spent on improved seeds in 2018? (₦) _____

[C7] Do you use pesticides? (1=Yes, 0=No) _____

[C71] Amount of money spent on pesticides in 2018? (₦) _____

[C8] Type of cultivation? (1=Commercial, 2=Subsistence, 3= Both) _____

[C81] What percentage of household output is sold in the market? _____

[C9] Type of cropping? _____ (1=Perennial, 2=Seasonal, 3=Both)

[C10] Type of crops grown? _____ (1=Cash crop, 2=Food crop, 3=Both)

[C11] Please indicate the crops your household produces in the table below

Type of crop	(1=Yes, 0=No)	**Type of crop**	(1=Yes, 0=No)	**Type of crop**	(1=Yes, 0=No)
[C111] Cassava		**[C117]** Cashew		**[C1113]** Corn	
[C112] Yams		**[C118]** Cocoa		**[C1114]** Sorghum	
[C113] Soybeans		**[C119]** Palm fruit		**[C1115]** Groundnuts	
[C114] Beans		**[C1110]** Rice		**[C1116]** Potato	
[C115] Vegetables		**[C1111]** Fruits		**[C1117]**Plantain/Banana	
[C116] Millet		**[C1112]**Sugarcane		**[C1118]** Melon	
[C119] Others					

[C12] Is your household engaged in livestock farming? (1=Yes, 0=No) _____

[C121] If yes, what are the types of livestock kept? (1= Poultry, 2=sheep & goat, _____

3=Cattle, 4=Pigs, 5=Rabbit, 6=Snail, 7=Grasscutter [**C122]** =others specify (_____))

[C13] Do you have visits from extension agents? (1=Yes, 0=No) _____

[C131]Time taken from household to closest extension agent office by usual transport? (mins)

_____

Do any of the following have access to extension agents? (1=Yes, 0=No)

[A132] Neighbour's farm	**[A133]** closest friend's farm	**[A134]** Relative's farm

[C14] What type of farming system do you practice? (1= Crop rotation, 2=Mixed Farming,

3=Agroforestry, 4=Nomadic pastoralism, 5=Monocropping, 6=shifting cultivation)

D/ Access to Land

[D1] Tenancy Status of cultivated land? (2=Owner and tenant, 1=Owner, 0=Tenant) _____

[D2] If tenant, then what form does the tenancy take? (1=Fixed rent,

2=Sharecropping, 3=both) _____

[D3] What is the total area of farmland you own? (acres) _____

[D31] What area of your farmland is cultivated? (acres) _____

[D32] What area of your farmland is not cultivated? (acres) _____

[D4] What area of land did you rent from someone else for cultivation? (acres) _____

[D41] What area of land did you rent out to other farmers? (acres) _____

[D5] If you are involved in sharecropping, what area of land was sharecropped? (acres)_____

[D6] If you practiced irrigation, what area of your farmland is irrigated? (acres) _____

[D61] What area of your farmland is not irrigated? (acres) _____

[D7] If you rented land for cultivation, how much rent did you pay in 2018 (₦)_____

[D71] If you rented your land to someone else, how much were you paid in 2018? (₦)_____

[D8] Is household located in the same village as your farmland? (1=Yes, 0=No) _____

E/ Tenure Security Index

[E1] Do you have title certification to your land? (1=Yes, 0=No) _____

Breadth of Property rights		
		1=Yes, 0=No
[E21]	Right to use open access grazing	
[E22]	Right to gather natural resources (thatch and firewood) on land?	
[E23]	Right to gather perennial produce (oil palm, cocoa breadfruit etc.) on land?	
[E24]	Right to use the land during the planting season?	
[E25]	Right to use this land throughout the year?	
[E26]	Right to choose what crops to grow?	
[E27]	Right to bequeath this land?	
[E28]	Right to fence off the land?	
[E29]	Right to exclude other people's livestock from grazing on the land	
[E210]	Right to make permanent improvements on the land? (e.g. establish irrigation, building etc.)	
[E211]	Right to lease out your land?	
[E212]	Right to sell land?	

Assurance of property rights

Do you have:

[E31] Land map/Blueprint for your farmland? (1=Yes, 0=No) _____

[E32] Informal registration? (1=Yes, 0=No) _____

[E33] Formal land title? (1=Yes, 0=No) _____

F/ Resource-use Conflict (farmer-herdsmen conflict)

Incidence and severity of conflict

[F1] Has there ever been any farmer-herdsmen conflict in your community in the last 5 years?
1=Yes, 0=No _____

If yes, did the conflict lead to any of the following?

[F21] Injury to household member 1=Yes, 0=No	**[F22] Death of household member** 1=Yes, 0=No	**[F23] Death of neighbour, friend/relative** 1=Yes, 0=No	**[F24] Loss of yield** 1=Yes, 0=No	**[F25] Destruction of farmland & property** 1=Yes, 0=No	**[F26] Scarcity of food** 1=Yes, 0=No	**[F27] Injuries to livestock** 1=Yes, 0=No

[F3] Number of farmer-herdsmen conflicts in your community in 2018?

As a result of farmer-herdsmen conflict in the last year, have you/your household:

[F41] Changed farmland use? (1=Yes, 0=No) _____

[F42] Changed type of crop cultivated? (1=Yes, 0=No) _____

[F43] Changed to off-farm work? (1=Yes, 0=No) _____

[F44] Changed from perennial to seasonal cropping? (1=Yes, 0=No) _____

[F45] Changed from commercial to subsistence farming? (1=Yes, 0=No) _____

[F46] Others please specify? _____

Risk perception of Conflict

[F5] Are you aware of any farmer-herdsmen clash in your community or neighbouring community? (1=Yes, 0=No) _____

All respondents are to answer the following questions

[F6] Considering farmer-herdsmen conflicts, I have a made a list of concerns people may have about possible conflict and would like you to indicate which of these you are afraid could affect your household. Responses (1=not worried, 2=slightly worried, 3=moderately worried, 4=very worried, 5=extremely worried)

	Risks	**Response**				
		1	2	3	4	5
[F61]	Loss of crop and farm income					
[F62]	Destruction of farmland and property					
[F63]	Crop failure					
[F64]	Scarcity of food / Hunger					
[F65]	Injury to livestock					
[F66]	Danger to human life and death					
[F67]	High market prices for food					
[F68]	Physical insecurity and violent conflict					
[F69]	Village Chiefs sell land indiscriminately and are corrupt					
[F610]	Others ( )					

[F7] Of those you indicated some level of concern, please rank the risks from greatest worry to least:

	Risks	**Rank**
[F71]	Loss of crop and farm income	
[F72]	Destruction of farmland and property	
[F73]	Crop failure	
[F74]	Scarcity of food / Hunger	
[F75]	Injury to livestock	
[F76]	Danger to human life and death	
[F77]	High market prices for food	
[F78]	Physical insecurity and violent conflict	
[F79]	Village Chiefs sell land indiscriminately and are corrupt	
[F710]	Others ( )	

[F8] Instrumental Variables for Farmer-Herder conflict

[F81] Distance from household to nearest police station? (km) _____

[F811]Time taken to travel from household to closest police station by usual transport?(mins)

[F82] Availability of local vigilante service? (1=Yes, 0=No) _____

[F83] Private means of protecting household (e.g. personal vigilante service)? (1=Yes, 0=No)

[F84] Distance between household and nearest neighbour? (km) _____

[F841] Time taken from household to nearest neighbour by usual transport? (minutes) _____

[F9] What role do you think the government can play in preventing or mitigating farmer-herdsmen conflicts?

……

……

G/ Food Security

[G1] How many months in 2018 was it difficult for you to feed your household? _____

[G2] Household Food Insecurity Access Scale (HFIAS)

	In the past 30 days, how often did this happen…	**0. Never** **1. Rarely (once or twice in the past 30 days)** **2. Sometimes (three to ten times in the**
[G21]	Did you worry that your household would not have enough food due to a lack of resources?	
[G22]	Were you or any household member not able to eat the kinds of foods you preferred because of a lack of resources?	
[G23]	Did you or any household member have to eat a limited variety of foods due to a lack of resources?	
[G24]	Did you or any household member have to eat some foods that you really did not want to eat because of a lack of resources to	
[G25]	Did you or any household member eat a SMALLER MEAL than you felt you needed because there was not enough food?	
[G26]	Did you or any household member eat FEWER MEALS in a day because there was not enough food?	
[G27]	Was there ever no food at all in your household because there were no resources to get more?	
[G28]	Did you or any household member go to sleep at night hungry because there was not enough food?	
[G29]	Did you or any household member go a whole day without eating because there was not enough food?	

[G3] Coping Strategy Index (CSI)

If there have been times in the past 30 days when you did not have enough food or enough money to buy food, has your household had to:		**How often have you had to do this in the past 30 days?** 0. Never 1. Hardly at all (<1 time/week) 2. Once in a while (1-2 times/week) 3. Pretty often (3-6 times/week) 4. Always (every day)
[G31]	Rely on less preferred or less expensive food?	
[G32]	Borrow food, or rely on help from a relative?	
[G33]	Purchase food on credit?	
[G34]	Gather wild foods, "famine foods", hunt, or harvest immature crops?	
[G35]	Consume seed stock that will be needed for next season	
[G36]	Send household members to eat elsewhere?	
[G37]	Send household members to beg?	
[G38]	Limit portion size at mealtimes?	
[G39]	Restrict consumption by adults in order for small children to eat?	
[G310]	Reduce number of meals eaten in a day?	
[G311]	Skip entire days without eating?	

Time interview concluded: _____

Appendix B

Human Ethics Approval

Research Management Office

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PO Box 85084, Lincoln University
Lincoln 7647, Christchurch
New Zealand
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29 March 2019

Application No: 2019-11

Title: Access to Land, Gender and Conflict: Implications for food security of rural households in Nigeria

Applicant: A Nnaji

The Lincoln University Human Ethics Committee has reviewed the above noted application.
Thank you for your response to the questions which were forwarded to you on the Committee's behalf.

I am satisfied on the Committee's behalf that the issues of concern have been satisfactorily addressed. I am pleased to give final approval to your project.

Please note that this approval is valid for three years from today's date at which time you will need to reapply for renewal.

Once your field work has finished can you please advise the Human Ethics Secretary, Alison Hind, and confirm that you have complied with the terms of the ethical approval.

May I, on behalf of the Committee, wish you success in your research.

Yours sincerely

Grant Tavinor
Chair, Human Ethics Committee

PLEASE NOTE: The Human Ethics Committee has an audit process in place for applications. Please see 7.3 of the Human Ethics Committee Operating Procedures (ACHE) in the Lincoln University Policies and Procedures Manual for more information.

Appendix C

Empirical Results Summary Table

Summary of Results

Chapter 3: Gendered Access to Land and Household Food Insecurity: Evidence from Nigeria		
Dependent Variable	Significant Independent Variables	Sig
Food insecurity	Farm size	-
	Gender	+
	Gender*Land	-
	Education	-
	Farm income	-
	Fertilizer use	-
	Soil quality	-

Chapter 4: Farmer-herder conflicts and food insecurity: Evidence from rural Nigeria						
Dependent Variables	Significant Independent Variables	Sig	Significant Independent Variables	Sig		Sig
Incidence of FH conflict	*First stage*		*HFIAS*		*CSI*	
	Age	-	Incidence of FHC	+	Incidence of FHC	+
	Gender	-	Asset index	-	Formal land title	+
			Incidence of FH			
	Household size	+	Formal land title	+	Household size	-
	Crop diversification	+	Household size	-	Crop diversification	-
	Road quality	-	Crop diversification	-	Land tenure	-
	Land tenure	+	Land tenure	-		
	Time to police station	+				
Severity of FH conflict	*First stage*		*HFIAS*		*CSI*	
	Farm size	-	Severity of FH conflict	+	Severity of FH conflict	+
	Household size	-	Asset index	-	Formal land title	+
	Crop diversification	+	Formal land title	+	Crop diversification	-
	Road quality	+	Crop diversification	-	Land tenure	-
	Distance to police	+	Road quality	-		
			Land tenure	-		

Chapter 5: Risk Perception, Farmer-Herder Conflicts, and Production Decisions: Evidence from Nigeria

Fertilizer use	*Sig*	*Fertilizer investment*	*sig*	*Rented-in Land*	*sig*	*Income ratio*	*sig*
RPI	-	RPI	-	Asset index	+	RPI	+
Gender	-	Gender	-	Religion	-		
Farm income	+	Farm income	+	Farm income	+	Asset index	-
Household size	-	Household size	-	Road quality	-	Religion	+
Extension visits	+	Extension visits	+	Land tenure	-	Household size	+
Location	+	Location	+				

Fertilizer use		*Fertilizer investment*	*sig*	*Rented-in Land*	*sig*	*Income ratio*	sig
Risk-averse	-	Risk-averse	-	Risk-averse	-	Gender	-
Gender	-	Gender	-	Asset index	+	Asset index	-
Farm income	+	Farm income	+	Religion	-	Household size	+
Household size	-	Household size	-	Farm income	+		
Extension visits	+	Extension visits	+	Road quality	-		
Location	+	Location	+	Land tenure	-		

Chapter 6: Determinants of the Risk Perception of Farmer-Herder Conflicts: Evidence from Rural Nigeria

Dependent Variable	Model 1		Model 2 (With the frequency of FH conflict)		Model 3 (With conflict and gender interaction)	
Risk perception of FHC	Age	-	Age	-	Age	-
	Language	+	Language	+	Language	+
	Farming experience	+	Farming experience	+	Farming experience	+
	Farm size	-	Farm size	-	Farm size	-
	Crop diversification	+	Crop diversification	+	Crop diversification	+
	Livestock diversification	+	Livestock diversification	+	Livestock diversification	+
	Distance to closest neighbour	+	Distance to closest neighbour	+	Distance to closest neighbour	+
	Migration status	-	Migration status	-	Migration status	-
	Formal land title	-	Formal land title	-	Formal land title	-
	FH conflict exposure	+	FH conflict exposure	+	FH conflict exposure	+
					Frequency of FHC * Gender	+
	Location	+	Location	+	Location	+

Dependent Variable	Food production and supply	Sig	Physical insecurity and wellbeing	Sig
Risk perception of FHC	Age	-	Education	+
	Language	+	Household size	-
	Farming experience	+	Household income	+
	Crop diversification	+	Farming experience	+
	Distance to closest neighbour	+	Farm size	-
	Migration status	-	Crop diversification	+
	Formal land title	-	Livestock diversification	+
	FH conflict exposure	+	Distance to city	+
	Location	+	Distance to closest neighbour	+
			Formal land title	-
			Location	+