AGRICULTURAL INVESTMENT TECHNOLOGY PROGRAMMES AND FOOD INSECURITY AMONG SMALL HOLDER'S FARMERS IN NIGER STATE

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Abstract

Agricultural technology investment programmes are increasingly promoted as policy instruments for improving productivity, strengthening rural livelihoods, and reducing household food insecurity among smallholder farmers. However, the extent to which such programmes translate into measurable food security outcomes remains uncertain, particularly in state-level agricultural contexts. This study examined Agricultural Technology Investment Programmes and household food insecurity among smallholder farmers in Niger State, Nigeria. Anchored on the theory of change, the study adopted a mixed-methods descriptive approach. Quantitative data were collected from 474 smallholder farmers across six selected Local Government Areas using likert scale questionnaires, while qualitative data were obtained through key informant interviews with six stakeholders in Niger State Ministry of Agriculture, senior officials of Farmers Association of Nigeria, Niger State chapter and Fadama Association; and one Focus Group Discussion with agricultural extension workers. Descriptive statistics, stacked bar charts, and independent samples t-test were used to analyse the quantitative data, while qualitative data were analysed thematically using Braun and Clarke's six-phase procedure. The findings showed that ATIPs contributed to household food security-related outcomes through improved access to farm inputs, increased productivity, storage support, market linkage, income improvement, and enhanced coping capacity. However, the independent samples t-test did not establish a statistically significant difference in household food insecurity between ATIP beneficiaries and non-beneficiaries at the 0.05 level of significance. Qualitative evidence nevertheless indicated that beneficiaries were better positioned in terms of technology access, extension contact, storage capacity, dietary diversity, and resilience during lean seasons. The study concludes that ATIPs have positive but limited effects on household food insecurity in Niger State, as their expected final impact has not fully translated into statistically measurable differences between beneficiaries and non-beneficiaries. Therefore, this studyrecommends stronger implementation, timely input delivery, wider beneficiary coverage, improved storage and market support, and targeted inclusion of vulnerable smallholder farmers to enhance the food security impact of agricultural technology investments.

Keywords: Agricultural Technology Investment Programmes; household food insecurity; smallholder farmers; Niger State; Theory of Change; Nigeria.

1. Introduction

Food insecurity remains a major global development challenge and a central concern of contemporary public policy. Globally, food insecurity is driven by the interaction of poverty, conflict, climate stress, food price inflation, limited

purchasing power and weak food-system resilience. The State of Food Security and Nutrition in the World 2024 shows that hunger and food insecurity remain widespread, while the four dimensions of food security — availability, access, utilisation and stability — continue to be threatened by economic and environmental shocks (Food and Agriculture Organization of the United Nations [FAO] et al., 2024). For smallholder farming households, the problem is particularly complex because producing food does not automatically guarantee stable household access to adequate and nutritious diets (Barrett, 2010).

At the regional level, sub-Saharan Africa remains highly vulnerable to food insecurity because agricultural livelihoods depend largely on rainfall, smallholder production systems, fragile markets and limited rural infrastructure. Although agriculture remains central to employment, food supply and poverty reduction across the region, productivity is still constrained by low mechanisation, weak irrigation access, limited finance, post-harvest losses and climate variability. These constraints are especially significant for smallholder farmers, who often cultivate small plots with limited access to improved technologies, credit, storage facilities, extension services and organised markets.

In Nigeria, food insecurity persists despite the country's large agricultural population and favourable agro-ecological conditions. Recent food-security assessments projected that about 33 million Nigerians could face acute food insecurity in 2025 because of economic hardship, insecurity, climate shocks, high food prices and weak food-system resilience (World Food Programme [WFP], 2024). Studies also show that food insecurity among Nigerian farming households is shaped not only by production levels, but also by access to finance, input costs, market conditions, climate shocks, household vulnerability and coping capacity (Abdul et al., 2022; Ogheneruemu&Opeyemi, 2023).

In response to these challenges, Nigeria has adopted several agricultural policy and technology-oriented interventions aimed at improving productivity and food security. The National Agricultural Technology and Innovation Policy 2022–2027 identifies technology, innovation, climate-smart agriculture, mechanisation, finance, extension services and agribusiness development as pathways for transforming the agricultural sector (Federal Ministry of Agriculture and Rural Development [FMARD], 2022). Related interventions include the Anchor Borrowers' Programme, FADAMA and NG-CARES livelihood and input-support frameworks, e-wallet input distribution, extension support, climate-smart agriculture, post-harvest technologies, market-linkage initiatives and other state-level agricultural programmes. Current empirical studies show that agricultural finance, climate-smart practices, digital agricultural information and programme-based input support can influence productivity, income, welfare and food-security outcomes among smallholder farmers, although the strength of these effects varies by context and implementation quality (Abdul et al., 2022; Belewu et al., 2023; Gwadabe et al., 2024; Kolapo&Didunyemi, 2024; Saadu et al., 2024).

Within the study area, Niger State occupies a strategic position in Nigeria's food-security question because of its large land area, extensive arable land and strong dependence on smallholder agriculture. Official state records describe Niger State as covering about 76,469.903 square

kilometres, representing roughly 10 per cent of Nigeria's land area, with about 85 per cent of the land considered arable (Niger State Government, n.d.). This agricultural potential has informed recent state-level agricultural technology and investment interventions. In 2024, the Niger State Government launched the sales and distribution of fertiliser and other agricultural inputs, signed a Memorandum of Understanding between Niger Foods Security Systems and Logistics Limited and the Niger State Agricultural and Mechanisation Development Authority to support small and medium-holder farmers with farm equipment and inputs, and flagged off agricultural inputs and assets distribution under the N-CARES Result Area 2 scheme across the 25 Local Government Areas of the state (Niger State Government, 2024a, 2024b, 2024c). The state's strategic agricultural development plan also emphasizes mechanised farming, warehouses, processing centres, wholesale markets, value-chain improvement and the cultivation of large hectares of farmland as measures for improving productivity and food supply (Niger Foods, 2024).

However, the relationship between participation in agricultural technology programmes and household food insecurity is not automatic. Technology may increase output, but food insecurity may persist where farmers face high input costs, weak purchasing power, price instability, insecurity, poor storage, post-harvest losses, limited market access or exclusion from credit and extension support. In Niger State, these concerns are particularly relevant because agricultural potential exists side by side with rural insecurity, market instability, input-access constraints and uneven programme coverage. Evidence from the state also indicates that insecurity affects farmers' food-security status, while intervention-related gains depend on effective implementation and access to complementary support such as finance, extension services, storage and market linkage (Belewu et al., 2023; Umar et al., 2024).

This creates the central research problem. Although Agricultural Technology Investment Programmes are widely promoted as instruments for productivity growth and food-security improvement, limited empirical evidence exists on the specific pathways through which participation influences household food insecurity among smallholder farmers in Niger State. Current studies such as Abdul et al. (2022), Ogheneruemu and Opeyemi (2023), Belewu et al. (2023), Gwadabe et al. (2024), Kolapo and Didunyemi (2024), and Saadu et al. (2024) have examined agricultural finance, agricultural shocks, poverty outcomes, digital technology adoption, climate-smart practices and programme effects on smallholder welfare or food security. However, most of these studies focus on national-level evidence, other states, single programmes or specific technologies, while paying less attention to multidimensional household food-insecurity indicators such as food access, dietary stability, consumption adequacy and differences between programme participants and non-participants in Niger State. This study therefore examines Agricultural Technology Investment Programmes and household food insecurity among smallholder farmers in Niger State, Nigeria.

1.2 Research Questions

I. What are the main pathways through which beneficiaries of Agricultural Technology Investment Programmes reduces household food insecurity among smallholder farmers in Niger State?

II. What difference exists in the level of household food insecurity between beneficiaries and non-beneficiaries of Agricultural Technology Investment Programmes in Niger State?

1.3 Objectives of the Study

I. To identify the main pathways through which beneficiary access to Agricultural Technology Investment Programmes reduces household food insecurity among smallholder farmers in Niger State.

II. To compare the level of household food insecurity between beneficiaries and non-beneficiaries of Agricultural Technology Investment Programmes in Niger State.

1.4 Research Hypotheses

I. **H_{01}:**Beneficiary access to Agricultural Technology Investment Programmes does not significantly reduce household food insecurity among smallholder farmers in Niger State.

II. **H_{02}:**There is no significant difference in the level of household food insecurity between beneficiaries and non-beneficiaries of Agricultural Technology Investment Programmes in Niger State.

2. Conceptual Clarification

2.1 Agriculture

Agriculture refers to the production of crops, livestock, fisheries, forestry products, and other biological resources required for food, income, raw materials, and rural livelihoods. In contemporary development thinking, agriculture is not limited to farm production; it also includes input supply, mechanisation, irrigation, storage, processing, distribution, marketing, and the institutional systems that connect farmers to technologies and markets. This broader view is important because food security depends not only on what farmers produce, but also on whether they can access inputs, finance, infrastructure, information, and profitable markets (FAO, 2022; World Bank, 2021).

In Africa and Nigeria specifically, agriculture remains central to employment, poverty reduction, and food supply. Diao, Hazell, and Thurlow (2010) argue that agriculture remains important for African development because of its strong links to rural livelihoods and poverty reduction. However, the sector is often constrained by low technology adoption, limited mechanisation, weak irrigation access, climate shocks, poor rural infrastructure, and market instability. For this study, agriculture is conceptualised as a livelihood and food-security system through which smallholder farmers convert land, labour, technology, finance, and market opportunities into food availability, income, and household welfare.

2.2 Agricultural Technology

Agricultural technology refers to the use of improved practices, tools, inputs, knowledge systems, and innovations that enhance agricultural production, efficiency, resilience, and market participation. It includes improved seed varieties, fertilisers, mechanisation, irrigation, climate-smart practices, post-harvest technologies, digital advisory tools, extension services, storage systems, and value-chain support. Nigeria's National Agricultural Technology and Innovation Policy 2022–2027 also frames technology and innovation as major

pathways for improving food security, job creation, productivity, and wealth generation in the agricultural sector (FMARD, 2022).

Empirical studies show that agricultural technology can improve smallholder welfare, but only where farmers can access and sustain its use. Awotide, Karimov, and Diagne (2016) found that technology adoption and commercialisation improved the welfare of smallholder rice farmers in rural Nigeria. Kolapo and Didunyemi (2024) found that exposure to agricultural smartphone applications influenced adoption among smallholder farmers in Southwest Nigeria, while Saadu, Ibrahim, Nazifi, and Mudashiru (2024) found that climate-smart agricultural practices improved crop yield, income, and food security among smallholder farmers in north-western Nigeria. These studies show that technology can reduce food insecurity, but its effect depends on finance, extension support, affordability, training, and market access.

In this study, agricultural technology is conceptualised as a programme-delivered bundle of biological, mechanical, digital, climate-smart, and managerial innovations provided through Agricultural Technology Investment Programmes. Its relevance is assessed not merely by availability, but by whether participation in such programmes improves productivity, farm income, food access, dietary stability, and household resilience among smallholder farmers in Niger State.

2.3 Food Insecurity

Food insecurity refers to the inability of individuals or households to obtain sufficient, safe, nutritious, and culturally acceptable food for an active and healthy life. The Food and Agriculture Organization explains food security through four major dimensions: availability, access, utilisation, and stability. Food insecurity therefore occurs not only when food is unavailable, but also when households cannot afford food, cannot consume nutritionally adequate diets, or cannot maintain access during shocks such as inflation, conflict, climate stress, or income loss (FAO, 2008; FAO et al., 2024).

This multidimensional understanding is important for smallholder farmers because food production does not automatically guarantee food security. Barrett (2010) argues that food insecurity should be understood beyond simple food availability because access, stability, and vulnerability are equally important. Recent Nigerian evidence supports this view. Abdul et al. (2022) found that agricultural financing relates positively to food security, while Ogheneruemu and Opeyemi (2023) showed that farming households in Nigeria are affected by shocks such as flooding, poor rainfall, pest invasion, input price increases, and output price decline. These findings suggest that food insecurity among farmers is shaped by both production and livelihood conditions.

For this study, household food insecurity is conceptualised as the extent to which smallholder farming households in Niger State experience inadequate or unstable access to food despite their participation or non-participation in agricultural technology programmes. It is assessed through indicators such as food availability, food access, consumption adequacy, dietary stability, and vulnerability to economic, climatic, and security-related shocks.

2.4 Smallholder Farmers

Smallholder farmers are agricultural producers who cultivate relatively small plots of land, rely largely on family labour, use limited capital, and often have weak access to formal credit, extension services, mechanisation, irrigation, storage, and organised markets. Although the exact farm-size threshold differs by country, Lowder, Skoet, and Raney (2016) show that small and family farms remain central to global agriculture and rural livelihoods, especially in developing economies.

In Nigeria, smallholder farmers are central to domestic food production but remain exposed to poverty, market instability, climate shocks, limited infrastructure, and low technology adoption. These constraints affect their ability to benefit from agricultural policies and technology programmes. Studies on Nigerian smallholders show that welfare gains from technology adoption are stronger when farmers have access to markets, finance, extension, and institutional support (Awotide et al., 2016; Kolapo et al., 2024). For this reason, smallholders are not merely producers; they are also policy beneficiaries whose food security depends on the effectiveness of agricultural technology delivery systems.

For this study, smallholder farmers are conceptualised as farming households in Niger State cultivating relatively small plots, relying mainly on family labour, and depending substantially on agriculture for income and food supply. They are grouped into participants and non-participants of Agricultural Technology Investment Programmes in order to compare food insecurity outcomes and identify the pathways through which programme participation influences household food security.

2.2 Empirical Review

2.2.1 Pathways Linking Agricultural Technology Programmes to Food Insecurity Reduction

Empirical studies indicate that agricultural technology and institutional support can influence household food security through productivity, income, finance, extension, information and resilience pathways. Awotide et al. (2016) found that agricultural technology adoption and commercialisation improved the welfare of smallholder rice farmers in rural Nigeria. Abdul et al. (2022) also found a positive relationship between agricultural financing and food security in Nigeria, although high interest rates weakened food-security outcomes. These findings show that productivity-enhancing technologies and finance can contribute to food security where farmers have access to complementary support.

Recent evidence further shows the importance of information, climate-smart agriculture and extension support. Kolapo and Didunyemi (2024) found that exposure to agricultural smartphone applications influenced technology adoption and farm-level efficiency among smallholder farmers in Southwest Nigeria. Saadu et al. (2024) found that climate-smart agricultural practices improved crop yield, income and food security among smallholder farming households in north-western Nigeria. Waje et al. (2024) similarly showed that agricultural information provision improved technology adoption and yield among cassava producers in Ethiopia. These studies support the view that ATIPs can reduce household food insecurity through improved input access, better farm decisions, increased output, income improvement, storage, market linkage and shock resilience.

However, the pathway is not always linear. Ogheneruemu and Opeyemi (2023) found that flooding, poor rainfall, pest infestation, input price increases and output price decline worsened food security among farming households in Nigeria, while cooperative membership, credit access and assistance-based coping strategies increased the probability of being food secure. This implies that agricultural technology programmes are most effective when they are implemented alongside credit, extension, market, storage and climate-risk support.

2.2.2 Differences between Programme Participants and Non-Participants.

Studies comparing beneficiaries and non-beneficiaries of agricultural interventions show mixed but important evidence. Belewu et al. (2023) examined the Anchor Borrowers' Programme among rice farmers in Kwara and Niger States and found that poverty incidence, depth and severity were lower among beneficiaries than non-beneficiaries. Gwadabe et al. (2024) assessed the impact of the Anchor Borrowers' Programme on food security among smallholder rice farmers in Kano State and found that the programme influenced food-security outcomes among beneficiaries. These studies are relevant because they compare intervention participants with non-participants, although their focus was either poverty status or a specific crop/programme context.

Other Nigerian studies demonstrate that farming households may remain food insecure despite agricultural engagement. Ogunniyi et al. (2021) found that food security among rural maize-farming households was shaped by socio-economic and access-related factors. Arua et al. (2025) and Onyenekwe et al. (2025) also showed that food insecurity among farming households was influenced by income, farm size, household characteristics, credit access and climate-related constraints. Together, these studies suggest that differences between programme participants and non-participants depend not only on participation itself, but also on the quality of implementation, timeliness of support, access to finance, storage, markets and household-level vulnerability.

2.2.3 Gap in the Literature

The reviewed literature shows that agricultural technology, finance, extension services and institutional support can influence household food-security outcomes. However, the focus and scope of existing studies leave important gaps. For instance, Belewu, Ajao and Babatunde (2023) examined the Anchor Borrowers' Programme in Kwara and Niger States, but their emphasis was mainly on poverty status rather than multidimensional household food insecurity. Gwadabe, Saddiq, Yusuf and Oladimeji (2024) assessed the effect of the Anchor Borrowers' Programme on food security among smallholder rice farmers in Kano State, but the study was crop-specific and outside Niger State. Similarly, Saadu, Ibrahim, Nazifi and Mudashiru (2024) focused on climate-smart agricultural practices in north-western Nigeria, while Kolapo and Didunyemi (2024) examined smartphone-based agricultural information and technology adoption among smallholder farmers in Southwest Nigeria. Although these studies are relevant, they concentrated largely on specific technologies, particular crops, adoption behaviour, productivity or welfare outcomes rather than the broader pathways through which Agricultural Technology Investment Programmes influence household food insecurity.

Other studies, such as Abdul et al. (2022) and Ogheneruemu and Opeyemi (2023), provide useful evidence on agricultural finance, shocks and coping strategies in relation to food security in Nigeria. However, they were broader in scope and did not specifically examine ATIP participation among smallholder farmers in Niger State. Arua, Muomaife and Ibe (2025) as well as Onyenekwe et al. (2025), further show that farming households may remain food insecure where income, credit access, farm size and climate-related constraints are weak, but their empirical focus was not on Niger State or on participants and non-participants of Agricultural Technology Investment Programmes.

This gap is addressed by the present study in three ways. First, it focuses specifically on smallholder farmers in Niger State, where agricultural technology and investment interventions are expected to support productivity and food security. Second, it examines the pathways through which ATIP participation influences household food insecurity, including input access, productivity, income, storage, market linkage, extension support and coping capacity. Third, it compares household food-insecurity outcomes between ATIP participants and non-participants using both quantitative evidence from survey responses and qualitative evidence from Key Informant Interviews and Focus Group Discussion. In doing so, the study moves beyond general claims about agricultural technology and food security by providing context-specific evidence on how ATIPs operate and whether their benefits translate into measurable differences in household food insecurity among smallholder farmers in Niger State.

2.3 Theoretical Framework

This study is anchored on the Theory of Change proponed by Carol H. Weiss (1995), who advanced theory-based evaluation, and Connell and Kubisch (1998), who further developed the use of Theory of Change in programme evaluation and community-change initiatives. Weiss (1995) explains theory-based evaluation as an approach that makes explicit the assumptions linking programme activities to expected outcomes. Similarly, Connell and Kubisch (1998) argue that a Theory of Change identifies the sequence of steps through which an intervention is expected to generate results in a given context.

The theory is suitable for this study because it explains how participation in Agricultural Technology Investment Programmes is expected to produce changes in household food insecurity among smallholder farmers. It does not assume that agricultural technology automatically reduces food insecurity. Rather, it explains the logical pathway through which programme activities produce outputs, intermediate outcomes and longer-term impacts.

Applied to this study, participation in ATIPs should first improve farmers' access to agricultural technologies and support services such as improved seeds, fertiliser, mechanisation, irrigation, extension advice, climate-smart practices, storage facilities, credit and market information. These programme outputs are expected to improve productivity, reduce post-harvest losses, raise farm income, strengthen market access and increase household resilience. If these intermediate outcomes are achieved and sustained, they should contribute to reduced household food insecurity among smallholder farmers.

The theory of change also helps to explain why expected results may not be achieved. For ATIPs to reduce food insecurity, farmers must receive timely inputs, afford complementary costs, access extension guidance, reduce post-harvest losses, sell produce at reasonable prices and cope with shocks such as climate variability, insecurity, inflation and market instability. Where these assumptions fail, the pathway from programme participation to household food-security improvement may be weakened.

The framework guiding this study is therefore expressed as follows:

ATIP participation → access to agricultural technologies and support services → improved productivity, income, market access and resilience → reduced household food insecurity.

This framework aligns with the objectives of the study because it explains both the pathways through which ATIPs are expected to influence household food insecurity and the basis for comparing food-insecurity outcomes between ATIP participants and non-participants in Niger State.

3. Methodology

This study adopted a mixed-methods descriptive research design to examine Agricultural Technology Investment Programmes and household food insecurity among smallholder farmers in Niger State, Nigeria. The mixed-methods design was considered appropriate because the study required both numerical evidence from smallholder farming households and explanatory insights from agricultural officials, extension workers and farmer representatives. The quantitative strand enabled the study to measure household food-insecurity-related outcomes and compare ATIP participants and non-participants, while the qualitative strand provided contextual explanations on programme implementation, access to agricultural technologies, farmer support systems and the practical conditions shaping food-security outcomes. The design was descriptive and cross-sectional because data were collected at one point in time to describe existing conditions rather than to manipulate variables experimentally.

The study population is comprised of smallholder farming households, agricultural extension workers, officials of the Niger State Ministry of Agriculture and Rural Development, programme implementation actors and representatives of farmer-based organisations. The quantitative population consisted of registered smallholder farmers across six Local Government Areas selected from the three senatorial zones of Niger State. Kontagora and Magama were selected from Niger North, Shiroro and Chanchaga from Niger East, while Mokwa and Bida were selected from Niger South. These LGAs were selected to reflect geographical spread, agricultural activity and the presence of agricultural technology and investment-related interventions across the state. Records obtained from the Niger State Ministry of Agriculture and Rural Development and the All Farmers Association of Nigeria, Niger State Chapter, indicated that the total number of registered smallholder farmers in the selected LGAs was 5,012.

The quantitative sample size was determined using Cochran's sample size formula for proportions at 95 per cent confidence level and 5 per cent margin of error. The formula is expressed as:

$$\mathbf{n = Z^2p(1 - p) / e^2}$$

where **n** represents the required sample size, **Z** is the Z-score at 95 per cent confidence level, **p** is the estimated population proportion, and **e** is the margin of error. Using **Z = 1.96**, **p = 0.5** and **e = 0.05**, the minimum sample size was calculated as:

$$n = (1.96)^2 \times 0.5(1 - 0.5) / (0.05)^2 = 384$$

To account for anticipated non-response, incomplete responses and farmer unavailability during fieldwork, the sample was adjusted by 20 per cent using the formula:

$$nadj = n / (1 - \text{non-response rate})$$

$$nadj = 384 / (1 - 0.20) = 480$$

The final sample for the quantitative strand was therefore 480 smallholder farmers. The sample was proportionally allocated across the six LGAs using Bowley's proportional allocation formula:

$$n_i = (N_i / N) \times n$$

where n_i is the sample allocated to each LGA, N_i is the population of smallholder farmers in each LGA, **N** is the total population of registered smallholder farmers in the selected LGAs, and **n** is the total sample size. The proportional allocation and valid responses are shown in Table 3.1.

Table 3.1: Population, Sample Allocation and Valid Responses by LGA

Local Government Area	Senatorial Zone	Registered Smallholder Farmers	Sample Size	Valid Responses
Kontagora	Niger North	1,168	112	111
Magama	Niger North	468	45	45
Shiroro	Niger East	229	22	22
Chanchaga	Niger East	871	83	83
Mokwa	Niger South	1,299	124	123
Bida	Niger South	977	94	90
Total		**5,012**	**480**	**474**

Source: Researcher's compilation, Filed Survey, 2026

A multi-stage sampling technique was used. First, the six LGAs were purposively selected from the three senatorial zones to ensure geographical and agricultural representation. Second, lists of registered smallholder farmers were obtained from relevant farmer associations and agricultural offices in the selected LGAs. Third, respondents were selected through simple random sampling from the available farmer lists. Beneficiary status was not used as a basis for selecting respondents; rather, it was captured in the questionnaire and later used as the grouping variable for comparative analysis. This approach allowed the study to compare ATIP participants and non-participants without predetermining group membership at the point of sampling.

Primary data were collected through structured questionnaires, Key Informant Interviews and one Focus Group Discussion. The questionnaire was administered using KoboCollect and was designed mainly on a five-point Likert scale ranging from strongly disagree to strongly agree. It captured information on respondents' demographic characteristics, ATIP participation status, access to improved seeds, fertiliser, mechanisation, irrigation, extension services, credit,

storage support, post-harvest support, market linkage and household food-insecurity-related indicators. The household food-insecurity-related indicators covered food-related worry, meal sufficiency, dietary diversity, meal skipping, income capacity to maintain a balanced diet and ability to cope with food shortages and shocks.

Six Key Informant Interviews were conducted with stakeholders who had direct knowledge of agricultural programme design, implementation and farmer support in Niger State. These included officials of the Niger State Ministry of Agriculture and Rural Development, programme implementation actors, farmer association representatives and community-level stakeholders. In addition, one Focus Group Discussion was held with six agricultural extension worker representatives, one drawn from each of the six selected LGAs. The KIIs and FGD focused on programme implementation experiences, technology access, input delivery, extension support, market linkage, storage support, farmer participation and observed differences between ATIP participants and non-participants. The qualitative component was included to provide practical explanations for the quantitative results and to clarify why programme participation may or may not translate into improved household food-security outcomes.

Secondary data were obtained from policy documents, government reports, programme records, peer-reviewed journal articles and institutional publications. These sources provided background information on agricultural technology programmes, food insecurity, smallholder farming and agricultural development interventions in Nigeria and Niger State.

The study was guided by the model:

HFI = f(ATIP, PTH, X)

Where**HFI** represents household food insecurity, **ATIP** represents participation in Agricultural Technology Investment Programmes, **PTH** represents programme pathways, and **X** represents contextual factors such as climate variability, insecurity, inflation, market instability and household characteristics. The model is consistent with the Theory of Change adopted for the study because it assumes that participation in ATIPs improves access to agricultural technologies and support services, which may then influence productivity, income, storage, market access, resilience and household food insecurity. However, the study recognises that this relationship is not automatic and may be weakened by implementation gaps and contextual constraints.

Quantitative data were analysed using IBM SPSS Statistics version 26. Frequencies, percentages and means scores were used to summarise respondents' demographic characteristics and Likert-scale responses. Stacked bar charts were used to present selected response patterns. For the hypothesis test, an independent samples t-test was used because the study compared mean household food-insecurity-related scores between two independent groups: ATIP participants and non-participants. The test was conducted at the 0.05 level of significance. The decision rule was to reject the null hypothesis where the p-value was less than 0.05 and not to reject it where the p-value was greater than 0.05.

Qualitative data from the KIIs and FGD were analysed thematically. The responses were reviewed, coded and grouped into recurring themes relating to input access, productivity, mechanisation, storage,

extension services, income, market linkage, implementation constraints and coping capacity. The qualitative findings were used to explain and triangulate the quantitative results. This integration strengthened the interpretation of the findings by showing not only whether differences existed between participants and non-participants, but also how programme pathways operated in practice and why the expected food-security outcomes may have been limited.

Ethical considerations were observed during the study. Respondents were informed about the purpose of the research, participation was voluntary, and responses were treated confidentially. The identity of respondents in the KIIs and FGD was not disclosed in the presentation of findings.

4. Result and Analysis

A total of 480 questionnaires were administered to smallholder farmers across the six selected LGAs of Niger State. Of this number, 474 questionnaires were retrieved and found suitable for analysis, representing a response rate of 98.8%.

4.1 Demographic Data of Respondents

Table 4.1: Demographic Characteristics of Respondents

Variable	Category	Frequency	Percentage (%)
Gender	Female	15	3.2
	Male	459	96.8
Age group	18-25 years	19	4.0
	26-35 years	118	24.9
	36-45 years	145	30.6
	46-55 years	148	31.2
	56 years and above	44	9.3
Marital status	Single	31	6.5
	Married	424	89.5
	Widowed	14	3.0
	Divorced/Separated	5	1.1
Highest education	No formal education	49	10.3
	Islamic/Other education	1	0.2
	Primary education	140	29.5
	Secondary education	140	29.5
	Tertiary education	144	30.4
Farming experience	Less than 5 years	17	3.6
	5-10 years	138	29.1
	11-20 years	141	29.7
	21-30 years	135	28.5
	Over 30 years	43	9.1
Farm size cultivated	Less than 1 hectare	22	4.6
	1-2 hectares	148	31.2
	3-5 hectares	216	45.6

Variable	Category	Frequency	Percentage (%)
	Above 5 hectares	88	18.6
Primary farming system	Rain-fed/seasonal farming only	178	37.6
	Fadama/irrigated farming only	99	20.9
	Mixed farming	185	39.0
	Livestock farming	12	2.5
ATIP participation status	Participant of ATIP	232	48.9
	Non-participant of ATIP	242	51.1

Source: Field Survey, 2026.

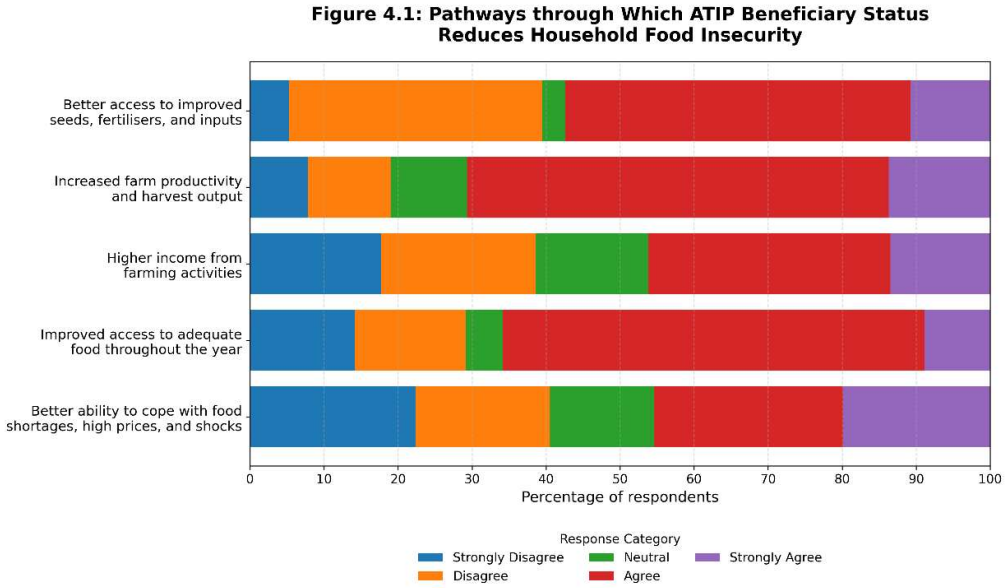
Table 4.1 shows that the respondents were predominantly male, married, and within the economically active age range of 36–55 years. Most respondents had at least primary education, while a large proportion had more than ten years of farming experience, suggesting that the responses were drawn from farmers with practical knowledge of agricultural conditions in the study area. The data also show that most respondents cultivated between 1 and 5 hectares and practised either rain-fed or mixed farming. Importantly, 232 respondents, representing 48.9%, were participants of Agricultural Technology Investment Programmes, while 242 respondents, representing 51.1%, were non-participants. This near-balanced distribution provides a suitable basis for comparing household food insecurity outcomes between ATIP participants and non-participants.

4.2 Likert-Scale Questionnaire Items

Objective One: Pathways through which ATIP Participation Reduces Household Food Insecurity

Figure 4.1 presents respondents' views on the main pathways through which participation in Agricultural Technology Investment Programmes reduces household food insecurity among smallholder farmers in Niger State.

Figure 4.1: Pathways through which ATIP participation reduces household food insecurity
Source: Field Survey, 2026.



Source: Field Survey, 2026.

The findings show that respondents generally agreed that participation in Agricultural Technology Investment Programmes contributes to household food insecurity reduction through several pathways. The strongest pathway was increased farm productivity and harvest output, with 70.7% of respondents agreeing or strongly agreeing and a mean score of 3.58. This was followed by improved household access to adequate food throughout the year, with 65.8% agreement and a mean score of 3.31. Access to improved seeds, fertilisers, and modern farm inputs also recorded a positive response, with 57.4% agreement and a mean score of 3.23. However, the responses were weaker on income improvement and coping with food shortages, high food prices, and climate-related shocks, with mean scores of 3.03 each. The grand mean of 3.24 indicates that respondents generally agreed that ATIP participation reduces household food insecurity, although the strength of the effect differs across the identified pathways.

The Key Informant Interviews supported the quantitative findings by identifying productivity improvement, input access, mechanisation, storage, income stabilisation, market linkage, and climate resilience as the major pathways through which ATIPs influence food security. Officials explained that improved seeds, mechanisation, fertiliser support, storage technologies, advisory services, and market information help farmers increase output, reduce post-harvest losses, and maintain food access during lean seasons. One official noted that mechanised agricultural tools enabled some farmers to expand cultivation from about 2–3 hectares to 5 hectares and above, while others emphasised the role of e-vouchers, subsidised inputs, digital advisory services, off-taker linkages, and storage technologies in improving food availability and household resilience.

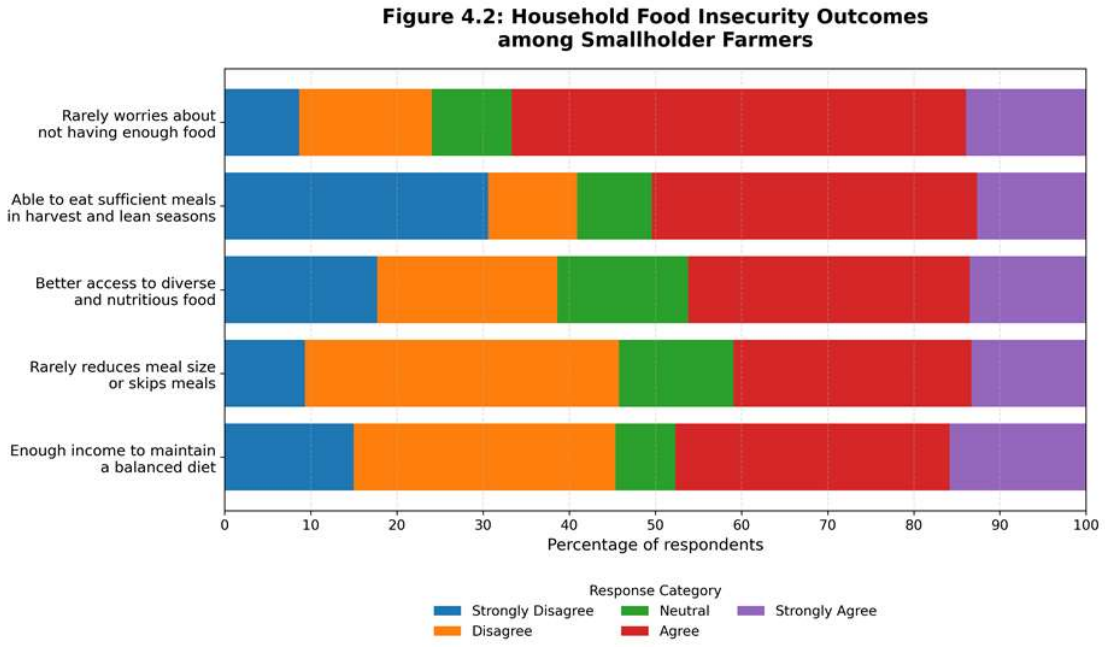
The Focus Group Discussion with agricultural extension workers also confirmed these pathways. Participants identified increased yield per hectare, reduced post-harvest losses, improved lean-season food access, diversified household diets, and increased cash income as the main ways through which ATIPs reduce food insecurity. They explained that farmers who adopted improved seeds, used fertiliser correctly, accessed hermetic storage bags, and participated in mechanisation support were better able to store food, sell produce at better prices, and maintain household consumption during the hungry season.

Taking the quantitative, KII, and FGD evidence together, the study finds that Agricultural Technology Investment Programmes reduce household food insecurity mainly through productivity improvement, better access to inputs, storage support, market linkage, income improvement, and improved resilience to shocks. However, the relatively weaker responses on income improvement and coping capacity suggest that while ATIPs have positive effects, the benefits are not yet strong or evenly experienced across all farmers. The researcher's verdict is that ATIP participation contributes positively to household food insecurity reduction among smallholder farmers in Niger State, but its effectiveness depends on the extent to which farmers receive timely inputs, mechanisation support, storage facilities, extension services, and reliable market access.

Objective Two: Household Food Insecurity among ATIP Participants and Non-Participants

Figure 4.2 presents respondents' views on household food insecurity outcomes among smallholder farmers in Niger State. The items examined food-related worry, meal sufficiency, dietary diversity, meal skipping, and income capacity to maintain a balanced diet.

Figure 4.2: Household Food Insecurity Outcomes among Smallholder Farmers



Source: Field Survey, 2026.

The findings show mixed but generally positive responses on household food insecurity outcomes. The strongest result was recorded on food-related worry, where 66.7% of respondents agreed or strongly agreed that their households rarely worried about not having enough food, with a mean score of 3.48. Respondents also showed moderate agreement that their households had better access to diverse and nutritious food, with a mean score of 3.03, and that household income was sufficient to support a balanced diet, with a mean score of 3.03. However, the results were weaker on meal sufficiency across both harvest and lean seasons, with a mean score of 2.92, and on reduction in meal skipping, with a mean score of 2.99. The grand mean of 3.09 indicates a mild positive household food security outcome, although the evidence suggests that food insecurity has not been fully eliminated, particularly during lean seasons.

The Key Informant Interviews supported the quantitative findings by showing that participants of Agricultural Technology Investment Programmes generally experienced better food security outcomes than non-participants. Informants reported that participants had fewer months of food deficit, better household dietary diversity, more frequent extension contact, improved access to storage technologies, and stronger market linkages. They further explained that participants were better able to store grains, reduce distress sales, cultivate larger farm sizes through mechanisation, and maintain food stocks for longer periods. However, the KIIs also noted that some differences between participants and non-participants may be influenced by initial access to capital, group membership, awareness, and ability to meet upfront costs.

The Focus Group Discussion with agricultural extension workers further confirmed observable differences between participants and non-participants across the study areas. Extension workers reported that participating farmers generally recorded higher productivity, lower post-harvest losses, better dietary diversity, higher farm income, and lower reliance on severe coping strategies such as meal skipping, borrowing grain at high interest, migration for food-related labour, and reduction in food variety. They also observed that female participants in vegetable production, small livestock, and processing components appeared more food secure than non-participant women, especially during the lean season.

Taking the quantitative, KII, and FGD evidence together, the study finds that ATIP participants appear to be relatively better positioned than non-participants in terms of food access, dietary diversity, income stability, storage capacity, and coping ability. However, the relatively low mean scores on meal sufficiency and meal skipping indicate that household food insecurity remains a concern, especially during the hungry season. The researcher's verdict is that participation in Agricultural Technology Investment Programmes is associated with improved household food security outcomes, but the improvement is moderate and depends on timely input delivery, storage support, extension services, market access, and the ability of farmers to participate effectively in programmeactivity

4.3 Test of Hypotheses

The two hypotheses were tested using independent samples t-test with ATIP beneficiary status as the grouping variable. The decision rule was to reject the null hypothesis where $p < 0.05$ and not reject it where $p > 0.05$.

Hypothesis	Group	Mean	SD	t-value	p-value/Decision
H01	Beneficiaries	3.05	1.37	-1.59	0.112; Not rejected
	Non-beneficiaries	3.13	1.30		
H02	Beneficiaries	3.05	1.37	-1.59	0.112; Not rejected
	Non-beneficiaries	3.13	1.30		

Source: Field Survey, 2026.

The t-test produced a p-value of 0.112, which is greater than 0.05. Therefore, both null hypotheses were not rejected. This implies that the quantitative comparison did not establish a statistically significant difference in household food insecurity between ATIP beneficiaries and non-beneficiaries. The result should be interpreted as evidence of mild programme contribution rather than conclusive statistical proof of impact.

4.4Discussion of Findings

The findings on Objective One show that Agricultural Technology Investment Programmes contribute to household food-insecurity reduction mainly through improved access to farm inputs, increased productivity, storage support, market linkage, income improvement and resilience to shocks. The descriptive result, with a grand mean of 3.24, indicates that respondents generally agreed that ATIP benefits support food-security-related outcomes among smallholder farmers in Niger State. This finding aligns with Saadu et al. (2024), who found that climate-smart agricultural practices improved yield, income and food security among smallholder farmers. It also supports Kolapo and Didunyemi (2024), whose study linked agricultural information and technology exposure to improved productivity outcomes, and Abdul et al. (2022), who emphasised the role of agricultural financing in strengthening food security.

The qualitative evidence from the Key Informant Interviews and Focus Group Discussion further strengthens this finding. The KIIs showed that ATIP beneficiaries were more likely to access improved seeds, fertiliser, mechanisation services, extension advice, storage support and market information. Similarly, the FGD with agricultural extension worker representatives indicated that farmers who received programme support were better positioned to increase output, reduce post-harvest losses, improve food storage and maintain household consumption during lean seasons. This confirms that ATIPs operate through identifiable change pathways consistent with the Theory of Change: programme participation improves access to agricultural technologies and support services, which then influences productivity, income, food access and resilience.

However, the test of hypotheses shows that these positive pathways have not translated into a statistically significant difference in household food-insecurity outcomes between beneficiaries and non-beneficiaries. The independent samples t-test produced a p-value of 0.112, which is greater than the 0.05 level of significance. Therefore, the null hypotheses were not rejected. This means that, although the

descriptive and qualitative findings suggest that ATIPs contribute positively to food-security-related outcomes, the quantitative comparison did not provide sufficient statistical evidence to conclude that beneficiaries differ significantly from non-beneficiaries in household food insecurity. This result suggests that the programme effect exists mainly as a mild or intermediate contribution rather than as a strong measurable impact.

The findings on Objective Two further show that ATIP beneficiaries were perceived by officials, extension workers and farmer representatives to be better positioned in terms of access to inputs, extension contact, storage capacity, market linkage, dietary diversity and coping ability. The KII evidence revealed that beneficiaries generally had more direct contact with agricultural support systems, while the FGD participants observed that programme-supported farmers were better able to reduce losses, store produce and avoid severe coping strategies such as distress sales, meal reduction and borrowing food during the lean season. These qualitative findings are important because they explain how ATIP participation may improve the practical conditions of beneficiaries, even where the statistical test does not show a significant difference.

The non-significant t-test result may be explained by several factors. First, ATIP coverage may not have been wide or intensive enough to produce a strong difference across all beneficiary households. Second, implementation gaps such as delayed input delivery, inadequate extension coverage, limited storage facilities and weak market access may have reduced the strength of programme outcomes. Third, broader contextual pressures such as food inflation, insecurity, climate shocks and market instability may have affected both beneficiaries and non-beneficiaries, thereby narrowing the measurable difference between the two groups. Fourth, some non-beneficiaries may have accessed alternative sources of support through cooperatives, personal finance, informal credit, private input dealers or other government and donor programmes.

This finding partly agrees with Ogheneruemu and Opeyemi (2023), who observed that farming households may remain food insecure despite agricultural engagement where shocks, weak coping capacity and limited access to productive support persist. It also moderates the position of Belewu et al. (2023), who found stronger welfare differences between beneficiaries and non-beneficiaries of agricultural intervention. In the context of the present study, the result implies that participation in ATIPs is useful but not sufficient on its own to guarantee a statistically significant reduction in household food insecurity.

From the perspective of the Theory of Change, the findings suggest that ATIPs are generating positive intermediate outcomes, especially in relation to input access, productivity, storage, extension support and market linkage. However, the final outcome of significantly reduced household food insecurity has not been fully achieved. The expected pathway from programme participation to improved food security appears to be weakened by uneven programme access, implementation constraints and wider economic, climatic and security-related pressures. Therefore, the study finds that ATIPs have positive but limited effects on household food insecurity among smallholder farmers in Niger State.

5.1 Conclusion

This study examined Agricultural Technology Investment Programmes and household food insecurity among smallholder farmers in Niger State, Nigeria. The findings show that ATIPs contribute to food-security-related outcomes through improved access to inputs, productivity support, storage, market linkage, income support and coping capacity. Evidence from the Key Informant Interviews and Focus Group Discussion also showed that beneficiaries were better positioned in terms of access to agricultural support services, extension contact, storage options and market information.

However, the independent samples t-test did not establish a statistically significant difference in household food insecurity between ATIP beneficiaries and non-beneficiaries. This means that, although ATIPs appear to generate positive intermediate outcomes, the quantitative evidence does not confirm a strong measurable difference in household food-insecurity outcomes between the two groups. The study therefore concludes that ATIPs have positive but limited effects on household food insecurity among smallholder farmers in Niger State.

In line with the Theory of Change, the findings suggest that the expected pathway from programme participation to reduced household food insecurity is functioning, but not strongly enough to produce a statistically significant final outcome. The effectiveness of ATIPs therefore depends on stronger implementation, wider coverage, timely input delivery, improved targeting, affordable participation, storage support, market linkage and greater inclusion of vulnerable farming households.

5.2 Recommendations

First, in line with the first objective, the Niger State Ministry of Agriculture and Rural Development, in collaboration with NAMDA, AFAN, extension service units and relevant development partners, should strengthen the main pathways through which Agricultural Technology Investment Programmes influence household food-security outcomes. Since the findings showed that ATIPs contribute through input access, productivity improvement, storage support, market linkage, income support and coping capacity, programme implementation should prioritise timely delivery of improved seeds, fertilisers, mechanisation services, irrigation support, storage technologies and extension advisory services before and during the production season. Proper farmer registration, early input distribution, regular extension visits, monitoring of technology use and post-harvest support should also be strengthened so that the positive intermediate outcomes identified in the study can translate more clearly into improved household food access, reduced post-harvest losses, stable income and stronger resilience among smallholder farmers.

Second, in line with the second objective, the Niger State Government, through the Ministry of Agriculture and Rural Development, AFAN, microfinance institutions, cooperatives and local government agricultural offices, should expand ATIP coverage to non-beneficiaries and vulnerable smallholder farmers. The findings showed that beneficiaries were generally better positioned in terms of access to inputs, extension contact, storage capacity, market linkage and coping ability, but the hypothesis test did not establish a statistically significant difference between beneficiaries and non-

beneficiaries. This suggests that programme coverage and intensity are not yet strong enough to produce a measurable food-security gap. Therefore, the action plan should include community sensitisation, subsidised participation windows, group-based credit, storage-equipment loans, market-linkage support and targeted inclusion of women, poorer farmers and farmers in insecurity-affected communities. This will reduce uneven access to ATIP benefits and improve the likelihood that future interventions will produce statistically measurable improvements in household food insecurity among smallholder farmers in Niger State.

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