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Economic Analysis of the Effect of Integrated Farming Systems on the Livelihood Strategies of Farmers in North-West Nigeria

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Abstract
Integrated crop-livestock farming systems (ICLFS) have emerged as a sustainable strategy to boost agricultural productivity, diversify income sources, and enhance rural livelihoods in Nigeria. This study examined the effects of ICLFS on farmers' livelihood strategies in North-West Nigeria, where agriculture remains the primary economic activity. A total of 405 integrated crop-livestock farmers were sampled across Kaduna, Kano, and Katsina States using multistage sampling techniques. Data were analyzed using descriptive statistics and a double-logarithmic regression model estimated via EViews version 9. The results revealed that seven major ICLFS combinations were practiced, with the crop–small ruminant–poultry system being the most common. Regression analysis showed that integrated farming significantly influenced farmers' livelihoods, with an R-squared of 0.7722 and adjusted R-squared of 0.7414, indicating that approximately 74% of the variation in livelihood outcomes was explained by the model. The F-statistic of 212.4812 ($p < 0.000$) confirmed the joint significance of the explanatory variables. Residual normality was confirmed via the Jarque-Bera test ($p = 0.8425$), affirming the model's robustness for inference. Key determinants of livelihood outcomes included household size ($\beta = -0.1283$, $p = 0.0007$), which had a negative and significant effect and educational level ($\beta = 0.4687$, $p = 0.0000$), which showed a strong positive impact. Other significant predictors were farming experience ($\beta = 0.0503$, $p = 0.0329$), farm size ($\beta = 0.1573$, $p = 0.0188$), farm produce ($\beta = 0.8940$, $p = 0.0000$), livestock size ($\beta = 0.2572$, $p = 0.0000$) and net income ($\beta = 0.3988$, $p = 0.0000$). These findings highlight the critical roles of education, productive capacity and diversified farming components in improving rural livelihoods. The study concludes that integrated crop-livestock systems offer significant economic benefits and recommends targeted support for improved access to education, input resources, and extension services to optimize livelihood outcomes for smallholder farmers in North-West Nigeria.

Keywords: Crop-livestock systems, Farmers, Integrated farming, Livelihood strategies, North-West Nigeria

1. Introduction

Farmers' livelihoods encompass the various strategies rural households adopt to secure income, ensure food security, and maintain well-being. In agrarian societies like Nigeria, particularly in the North-West region, agriculture remains the cornerstone of livelihood for the majority of rural dwellers (FAO, 2022). These livelihoods are shaped by access to productive resources, market opportunities, climatic conditions, and institutional support. However, persistent poverty, environmental degradation and low

agricultural productivity continue to undermine the sustainability of rural livelihoods (Oni *et al.,* 2020). With smallholder farmers forming the backbone of agricultural production, improving their livelihood strategies is central to achieving food security, poverty reduction and rural development (IFAD, 2021). Consequently, promoting sustainable farming practices that enhance productivity and income diversification has become imperative to strengthen rural livelihoods.

Agriculture remains the backbone of Nigeria's economy, contributing significantly to employment, food security, and rural income (World Bank, 2020). In North-West Nigeria, farming is the primary livelihood activity for over 70% of the population, with smallholder farmers dominating the sector (National Bureau of Statistics [NBS], 2021). However, these farmers face numerous challenges, including climate variability, soil degradation, low productivity, and limited access to markets and credit facilities (Ojo & Baiyegunhi, 2020). These constraints hinder sustainable agricultural development and exacerbate rural poverty. In a region where land and natural resources are increasingly pressured by population growth and climate change, there is a growing need for more resilient and productive agricultural systems.

The Integrated Farming System (IFS) has emerged as one such sustainable approach. IFS is a holistic agricultural practice that combines crop production with livestock rearing, aquaculture, and other complementary enterprises within a single farm unit, aimed at maximizing resource utilization and reducing risks (Pretty *et al.,* 2011). By emphasizing diversification, recycling of farm waste, and efficient land use, IFS is particularly suitable for smallholder farmers in resource-constrained environments (Nandi & Nedumaran, 2021). Beyond boosting productivity, the IFS model strengthens food security, optimizes labour use, and promotes environmental sustainability (Singh *et al.,* 2013). Empirical studies from South Asia and parts of Sub-Saharan Africa have shown that IFS adoption leads to higher farm profitability, improved resilience, and enhanced nutrition (Kumar *et al.,* 2019; Adeolu & Yusuf, 2021).

Farmers' livelihoods in North-West Nigeria are deeply rooted in agricultural activities, primarily practiced by smallholder farmers who rely heavily on subsistence farming for income, food, and employment. These livelihoods are increasingly threatened by challenges such as climate change, land degradation, low productivity, and limited access to inputs and markets (Ojo & Baiyegunhi, 2020; IFAD, 2021). In many rural areas, farming is not just a means of economic survival but also a critical component of social identity and community stability. However, traditional mono-cropping systems often expose farmers to high levels of risk and vulnerability, reducing their ability to cope with shocks and undermining efforts to achieve sustainable development (Adebayo *et al.,* 2022). This calls for innovative strategies that can enhance resilience, diversify income sources and improve food security, especially in resource-constrained regions like North-West Nigeria.

Given this context, the present study seeks to conduct an economic analysis of the effect of Integrated Farming Systems (IFS) on the livelihood strategies of farmers in North-West Nigeria. Specifically, the study aims to assess how the adoption of IFS influences key livelihood outcomes such as income generation, employment opportunities, food security and asset accumulation. By evaluating the economic viability and livelihood impacts of IFS, the study provides empirical insights into its potential as a sustainable agricultural practice for enhancing rural livelihoods. The findings are expected to inform policymakers, development partners and extension service providers on the role of

integrated systems in promoting inclusive and resilient agricultural development in the region.

2. Literature Review

Conceptual review

Concept of Integrated Farming Systems (IFS)

Integrated Farming Systems (IFS) refer to a holistic agricultural approach that integrates various farm enterprises, such as crop production, livestock rearing, aquaculture, agroforestry, and poultry, on a single farm to optimize resource utilization and improve overall productivity and sustainability (Gill *et al.,* 2022). The central tenet of IFS is the recycling of waste from one component as input for another, creating an environmentally sound and economically viable production system (Adepoju & Yusuf, 2021). The core principle of IFS is the synergistic interaction between different farming components, where waste from one subsystem serves as input for another, minimizing external inputs and maximizing output (Nandi & Nedumaran, 2021). According to Choudhary *et al.* (2020), IFS not only enhances farm income but also reduces dependence on external inputs and mitigates risks due to diversification.

In the Nigerian context, the adoption of IFS has gained traction in recent years, especially in the North-West region where farmers often combine crop farming with livestock and poultry enterprises (Usman *et al.,* 2023). These systems are promoted to improve resource use efficiency and offer resilience against climate variability, pest infestation, and price shocks (Oladele *et al.,* 2021). In developing economies, IFS has been recognized as a viable strategy for smallholder farmers to diversify income sources, mitigate risks, and improve food security (Kumar et al., 2022).

Agricultural diversification

Agricultural diversification refers to the process by which farming households increase the variety of agricultural activities, both within and outside the traditional scope of crop production, to enhance income, food security, and resilience (Joshi *et al.,*2004). This may involve combining food crops with cash crops, integrating livestock, aquaculture, agroforestry, or engaging in value-added processing and agribusiness. Diversification is considered a viable strategy for managing risk, especially in areas with climatic uncertainties and market volatility (Pingali, 2012).

In the context of sub-Saharan Africa, agricultural diversification is viewed as a crucial element for reducing poverty and improving rural livelihoods. It helps smallholder farmers to spread production risks, smooth income flows and improve food and nutrition security (Barrett *et al.,* 2001; Alobo Loison, 2015).

Agricultural diversification link to Integrated Farming Systems

Agricultural diversification forms the foundation of integrated farming systems (IFS), which combine crops with livestock, aquaculture, or forestry in a single, synergistic system. IFS is essentially a model of diversification aimed at maximizing productivity and minimizing waste through biological recycling and interdependence among components (Adepoju & Yusuf, 2021). This form of diversification not only boosts income but also contributes significantly to the sustainability of farming households, particularly in fragile ecosystems like North-West Nigeria.

Livelihood strategies

Livelihood strategies encompass the range of activities households undertake to secure income, food, and well-being (Ellis, 2020). Livelihood strategies encompass the range of activities and choices that individuals and households undertake to make a living, particularly in rural and agrarian communities (Ellis, 2000). These strategies are shaped by the available assets (natural, financial, physical, human, and

social capital), institutional arrangements, and external shocks (Chambers & Conway, 1992; Scoones, 2015). In agricultural settings, livelihood strategies often include on-farm activities (crop and livestock farming), off-farm engagements (agro-processing or trade), and non-farm employment.

In North-West Nigeria, the primary livelihood activities of rural households are agriculture-based, yet the productivity of these activities remains low due to climatic challenges, limited access to improved inputs, and low mechanization (Yahaya *et al.,* 2021). Livelihood diversification through integrated systems is increasingly recognized as a viable strategy for improving household resilience, food security, and sustainable income among smallholder farmers in sub-Saharan Africa (Adeyemo *et al.,* 2023).

Farmers' livelihood

Farmers' livelihood refers to the means and strategies through which rural households, particularly those engaged in agriculture, secure their basic needs, manage risks, and improve their socio-economic well-being. According to the Sustainable Livelihoods Framework (DFID, 1999), a livelihood comprises the capabilities, assets (both tangible and intangible), and activities required for a means of living. For farmers, these include access to land, labour, livestock, financial resources, social capital, and knowledge systems that influence their production and income-generating capacities. In the rural contexts of developing countries like Nigeria, livelihood strategies are largely agriculture-based, with farming serving as the principal source of food, income, and employment. However, due to environmental stressors, market volatility, and limited access to productive resources, these livelihoods are often vulnerable and unsustainable unless diversified and supported through adaptive practices.

The quality of farmers' livelihoods is determined by several interrelated factors, including education, household size, farming experience, land size, productivity levels, and income diversification opportunities. Integrated farming systems (IFS), which combine crop and livestock production, have been recognized as a promising livelihood-enhancing strategy because they optimize resource use, increase productivity, and reduce economic risks (Pretty *et al.,* 2011). By diversifying income sources, IFS allows farmers to better manage climatic and market uncertainties, while also improving food availability and asset accumulation. Studies by Adeolu and Yusuf (2021) and Nandi and Nedumaran (2021) show that such integration leads to more resilient and sustainable livelihoods by enabling smallholder farmers to achieve higher returns from their limited resources. Thus, understanding the dynamics of farmers' livelihoods is essential to evaluating the socio-economic impact of agricultural interventions such as integrated farming systems, particularly in resource-constrained regions like North-West Nigeria.

Nexus between IFS and livelihood strategies

Several studies have highlighted a positive link between the adoption of Integrated Farming Systems and improved livelihood outcomes. For instance, Singh *et al.* (2021) observed that IFS adoption led to increased income, food availability, and employment in Indian rural households. In Nigeria, Edeh *et al.* (2020) found that IFS significantly improved household welfare and reduced poverty in farming communities. The integration of enterprises not only stabilizes income but also provides year-round employment and enhances dietary diversity through the availability of different food sources (Adebayo & Lawal, 2023).

Moreover, IFS promotes sustainability by maximizing resource use efficiency, encouraging organic recycling, and minimizing environmental degradation

(Nwafor *et al.,* 2022). These improvements translate into better livelihood outcomes, including enhanced financial security, improved nutrition, and reduced vulnerability to external shocks. In the North-West region, where agricultural resources are constrained and climate conditions are harsh, the adoption of IFS can be a strategic intervention for sustainable livelihood development (Zubairu & Ibrahim, 2021).

Theoretical review

Systems theory

Systems Theory provides a valuable framework for analyzing the Integrated Farming System (IFS) and its impact on farmers' livelihood strategies in North-West Nigeria. Developed by von Bertalanffy (1968), Systems Theory posits that complex systems function through the interactions of interconnected components, where changes in one element affect the entire system (Skyttner, 2021). Applied to agriculture, IFS exemplifies a dynamic, interconnected system where crop production, livestock rearing, and agroforestry interact synergistically to enhance productivity, sustainability, and resilience (Devendra, 2018). By viewing IFS through a systems lens, researchers can assess how different farming components influence livelihood outcomes, such as income diversification, food security and environmental sustainability (Meadows, 2008).

The relevance of Systems Theory to this study lies in its ability to explain how feedback loops, resource flows, and interdependencies within IFS shape farmers' livelihoods. For instance, crop residues used as livestock feed reduce waste while improving soil fertility through manure recycling, a key principle of circular agriculture (Nandi & Nedumaran, 2021). Such interactions align with Systems Theory's emphasis on holistic optimization rather than isolated improvements (Checkland, 2020). In North-West Nigeria, where smallholder farmers face climate risks and economic instability, understanding these systemic interactions helps policymakers design interventions that enhance the entire farming system rather than individual components (Ojo & Baiyegunhi, 2023).

Moreover, Systems theory underscores the importance of adaptive capacity in sustaining livelihoods amid external shocks (Folke *et al.,* 2010). Farmers adopting IFS benefit from diversified income sources, reducing vulnerability to market or climate disruptions (Kumar *et al.,* 2022). This aligns with the theory's assertion that resilient systems maintain stability through flexibility and interconnectedness (Walker & Salt, 2012). By applying Systems Theory, this research will evaluate how IFS strengthens livelihood strategies by optimizing resource use, minimizing risks, and fostering long-term agricultural sustainability in North-West Nigeria.

Empirical review

Empirical studies across various regions demonstrate that Integrated Farming Systems (IFS) significantly enhance farmers' livelihoods through income diversification and improved productivity. In South Asia, Kumar *et al.* (2022) found that crop-livestock integration increased net farm income by 35-50% compared to monocropping systems in Eastern India. Similarly, Mekuriaw *et al.* (2022) reported that Ethiopian farmers practicing IFS achieved 30% higher food security scores due to diversified production. These findings align with research by Pretty *et al.* (2021), whose meta-analysis of 50 cases revealed that IFS adopters in Sub-Saharan Africa had 40% greater resilience to climate shocks. These studies underscore IFS's potential to optimize resource use while mitigating risks, a critical advantage for smallholders in Nigeria's climate-vulnerable Northwest region.

In West Africa, evidence suggests mixed but promising outcomes of IFS adoption. Al-Hassan *et al.* (2021) documented that

Northern Ghanaian farmers combining crops, poultry, and fish farming saw a 28% rise in annual income, with women beneficiaries reporting improved household nutrition. However, Ojo and Baiyegunhi (2023) identified key barriers in Nigeria, including limited access to credit (affecting 65% of smallholders) and inadequate extension services. A related study by Adebayo et al. (2023) in Northwest Nigeria found that only 22% of farmers had adopted IFS techniques, primarily due to land tenure constraints and lack of training. These findings highlight the need for context-specific interventions addressing structural challenges to scale IFS adoption effectively.

Recent studies emphasize IFS's dual role in livelihood enhancement and environmental sustainability. Singh *et al.* (2023) demonstrated in a 5-year longitudinal study that Indian IFS farms reduced chemical fertilizer use by 60% while maintaining yields through organic recycling, a critical benefit for Nigeria's degraded soils. Conversely, Ogundari and Awokuse (2022) cautioned that poorly managed IFS (e.g., overstocking livestock) could exacerbate land degradation in semi-arid zones like Nigeria's Northwest. Notably, Nandi and Nedumaran's (2021) multi-country analysis revealed that successful IFS models consistently featured three elements: farmer cooperatives for knowledge sharing, microcredit access, and market linkages, a framework relevant to Nigeria's agricultural policy reforms.

3. Methodology

Research Design

This study adopted a cross-sectional survey research design to assess the impact of Integrated Farming Systems on the livelihood strategies of farmers in North-West Nigeria. The choice of this design was guided by the need to collect data from a diverse population of crop-livestock farmers across multiple locations at a single point in time. A cross-sectional survey allows for efficient data collection and analysis of variables as they naturally occur, providing a snapshot of current farming practices, socio-economic characteristics and livelihood outcomes (Creswell, 2014).

The Study Area

Nigeria is situated in the tropical region of West Africa, spanning latitudes 4° N to 14° N and longitudes 2°2' E to 14°30' E, with a total land area of 923,770 km² (National Population Commission [NPC], 2006). This study focuses on the North-West (NW) geopolitical zone of Nigeria, which comprises seven states: Jigawa, Kaduna, Kano, Katsina, Kebbi, Sokoto, and Zamfara. The NW zone is one of the most populous regions in Nigeria, accounting for approximately 25% of the country's population, with an estimated 48.9 million inhabitants (NPC, 2006; World Bank, 2020). The region experiences a tropical savannah climate, characterized by a prolonged dry season lasting 6 to 9 months and an average annual rainfall of 657.3 mm (Adejuwon, 2012). Ecologically, the zone is predominantly Sudan savannah, except for Kaduna State, which falls under the Northern Guinea savannah zone (Oladipo *et al.*, 2018). Agriculture is the primary economic activity in the NW zone, with major crops including maize, rice, millet, beans, wheat, and cotton (Food and Agriculture Organization [FAO], 2020). Livestock production also plays a crucial role, with widespread rearing of cattle, sheep, goats, poultry, and pigs (Ayantunde *et al.*, 2011). Given its high dependence on rain-fed agriculture, the region is particularly vulnerable to climate variability and land degradation, making it a critical area for environmental and agricultural research (Mortimore & Adams, 2001).

Population and Sample Size

The target population for this study comprised integrated crop-livestock farmers across selected Local Government

Areas (LGAs) in Kaduna, Kano and Katsina states in North-West Nigeria. The total population of integrated crop-livestock farmers across the sampled villages was 1,296. A multi-stage sampling technique was employed to ensure a representative sample. In the final stage, a total sample size of 428 farmers was randomly selected. Out of these, 405 respondents completed and returned the questionnaires, yielding a response rate of 94.63%. This sample size was considered adequate for statistical analysis and generalization of findings, as it meets the minimum requirement for social science research involving regression analysis and comparative assessments (Krejcie & Morgan, 1970).

Data Collection and Sampling Technique

This study employed primary data collection methods, utilizing structured questionnaires and interview schedules administered to crop-livestock farmers in the study area. A multi-stage sampling technique was adopted for the selection of respondents. First Stage: Three states, Kaduna, Kano, and Katsina, were purposively selected from the seven states in Nigeria's North-West region. These states were chosen due to their shared borders, similar agro-ecological conditions and common crop-livestock production systems. Second Stage: Within these states, specific zones, Kaduna North, Kano South, and Katsina South, were deliberately selected for the same reasons. Third Stage: From each of these zones, seven Local Government Areas (LGAs) were randomly selected:

- Kaduna State: Ikara, Kubau, Kudan, Lere, Sabon-Gari, Soba, and Zaria.
- Kano State: Bebeji, Doguwa, Garko, Kibiya, Kiru, Rogo, and Tudun-Wada.
- Katsina State: Bakori, Dandume, Danja, Funtua, Kafur, Malumfashi, and Sabuwa.

Fourth Stage: A total of 84 villages (four from each LGA) were randomly chosen based on the prevalence of integrated crop-livestock farming systems. Final Stage: From each village, 33% of the total integrated crop-livestock farmers were randomly selected, resulting in a final sample size of 428 farmers. The survey achieved a high response rate of 94.63%, with 405 farmers participating.

This resulted in a sample distribution of 168, 121 and 116 crop-livestock farmers from Kaduna, Kano, and Katsina states, respectively. The study examined integrated farming systems with the following components: M = Maize, Sg = Sorghum, Sb = Soybeans, C = Cowpea, R = Rice and L = Livestock.

Analytical Techniques

The data collected from the respondents were analyzed using both descriptive and inferential statistical techniques to address the objectives of the study.

Descriptive statistics such as frequencies, percentages, means and standard deviations were employed to summarize and present the socio-economic characteristics of the respondents, as well as the various components of integrated farming systems adopted by farmers in the study area. These tools facilitated an understanding of the patterns and trends in livelihood strategies and farming practices across the selected states.

Double-log multiple regression model was employed to assess the determinants and effects of integrated farming systems on farmers' livelihood strategies,. This model is appropriate for estimating the elasticity of response variables and helps in understanding the percentage change in livelihood outcomes as a result of a percentage change in the explanatory variables. The model specification enabled the identification of key socio-economic and farm-level factors influencing the adoption and outcomes of integrated farming practices.

The model is expressed implicitly as follows:

$Y = f(X_1, X_2, X_3, ..., X_j, \varepsilon_j)$ (1)

The model, also is expressed explicitly as follows:

$\ln Y^* = \ln\beta_0 + \ln\beta_1 X_1 + \ln\beta_2 X_2 + \ln\beta_3 X_3 ..., \ln\beta_n X_n + e$ (2)

$\ln Y = \ln\beta_0 + \beta_1 \ln X_1 + \beta_2 \ln X_2 + \beta_3 \ln X_3 + \beta_4 \ln X_4 + \beta_5 \ln X_5 + \beta_6 \ln X_6 + \varepsilon_j$ (3)

Where:

ln = Natural logarithm; Y* = The estimated farmers' livelihood (Naira); X_1 = Household size (numbers); X_2 = Level of education (years); X_3 = Integrated crop-livestock farming experience (years); X_4 = Crop(kg) farm size (ha); X_5 = Farm produce (kg); X_6 = Livestock size (numbers); ε = Error term which is normally distributed with zero mean and constant variance; β_0 = Estimated intercept and $\beta_1 - \beta_6$ = Estimated coefficients. The results were obtained using a computer program known as "EViews 9".

Research Hypothesis

The study puts forward the following hypothesis:

H_0: Integrated crop-livestock farming system has no significant effect on the farmers' livelihood strategies in the study area ($P>0.05$)

H_1: Integrated crop-livestock farming system has significant effect on the farmers' livelihood strategies in the study area ($P\leq0.05$)

4. Results and Discussion

The farmers' farming system

The results presented in Table 1 reveal that integrated crop-livestock farmers in the study area engaged in seven distinct types of farming systems. These systems include: crop-large ruminant-small ruminant-poultry (C-LR-SR-P), crop-large ruminant-small ruminant (C-LR-SR), crop-large ruminant-poultry (C-LR-P), crop-small ruminant-poultry (C-SR-P), crop-large ruminant (C-LR), crop-small ruminant (C-SR), and crop-poultry (C-P) combinations. Among these, the C-SR-P system emerged as the most widely adopted, largely due to the lower cost and easier management associated with rearing small ruminants and poultry compared to large ruminants. The C-LR-SR-P system followed in popularity, representing farmers who integrated all three livestock types. The C-P system ranked third, followed by C-LR-P, C-LR-SR, C-SR, and lastly, C-LR.

This diversity in farming systems indicates that a significant proportion of farmers manage two or more types of livestock, driven by economic viability, social preferences, and cultural practices. These findings align with the work of Hoffmann *et al.* (2023), who observed that smallholder farmers often diversify their livestock holdings not only for income generation but also for fulfilling traditional, cultural, and food security roles across various rural settings in sub-Saharan Africa. Such multi-livestock systems contribute to household resilience by spreading risks and providing multiple sources of food and income.

Table 1: Distribution of farmers according to farming system

Farming System	Frequency	Percentage	Ranking
i) C-SR-P	127	31.36	1st
ii) C-LR-SR-P	105	25.93	2nd
iii) C-P	62	15.31	3rd
iv) C-LR-P	57	14.07	4th
v) C-LR-SR	34	8.40	5th
vi) C-SR	11	2.72	6th
vii) C-LR	9	2.22	7th

Total	**405**	**100**

Source: Field Survey (2024)

Where:
LR = Large Ruminants
SR = Small Ruminants
P = Poultry

The farmers' cropping system

The findings presented in Table 2 indicate that the dominant cropping practices employed by integrated crop-livestock farmers in the study area are intercropping and relay cropping. Intercropping involves the simultaneous cultivation of two or more crop species on the same field, typically arranged in a structured row pattern to optimize space and resources. Conversely, relay cropping is a sequential planting method whereby a second crop is sown into a standing crop before it is harvested, thereby allowing for overlapping growth periods and more efficient land use.

The analysis further classifies farmers based on their primary crop cultivation, identifying maize, rice and sorghum as the predominant crops. Among the respondents, 58.02% identified maize as their main crop, followed by 23.21% cultivating rice, and 8.89% focusing on soybean. Notably, none of the farmers practiced mono-cropping; instead, all adopted systems that involved cultivating two or more crops. This indicates a strong preference for diversified cropping strategies, likely aimed at maximizing land productivity, improving soil fertility, and enhancing food security. These findings align with the results of Fatile *et al.* (2022), who found that intercropping and relay systems are widely utilized among smallholder farmers in Nigeria as adaptive strategies for improving land use efficiency and crop yield stability. The study emphasized that multiple cropping systems not only increase the resilience of farming households but also support sustainable agricultural intensification in mixed farming systems.

Table 2: Distribution of farmers according to cropping system

Crop-livestock Integration	Cropping System	Frequency	Percentage	Ranking
i) M-Sg-C-L Farmers	Intercropping + Relay	235	58.02	1st
ii) R-M-L Farmers	Intercropping	94	23.21	2nd
iii) Sb-M-L Farmers	Intercropping	36	8.89	3rd
iv) Sb-Sg-L Farmers	Intercropping	16	3.95	4th
v) R-Sg-L Farmers	Intercropping	10	2.47	5th
vi) M-Sg-L Farmers	Intercropping	8	1.98	6th
vii) M-C-L Farmers	Relay	6	1.48	7th
Total		**405**	**100**	

Source: Field Survey (2024)

Where:
C = Cowpea; L = Livestock; M = Maize; R = Rice; Sb = Soybean and Sg = Sorghum

Utilization of Seed Varieties and Livestock Breeds

Table 3 illustrates the patterns of seed variety and livestock breed utilization among integrated crop-livestock farmers in

the study area. Farmers utilized three main categories of seed types: local (traditional)**,** improved (modern) and mixed varieties. Local or traditional seed varieties are typically derived from previous harvests without the application of scientific selection or breeding processes; they are preserved and re-used through farmer-based selection techniques. Improved varieties, in contrast, are developed through formal scientific breeding programs and are often characterized by higher yields, pest resistance and shorter maturity periods. Mixed varieties refer to instances where both traditional and improved seeds are planted together. The same categorization applies to livestock breeding, where farmers use local breeds, improved (often hybrid) breeds or a combination of both.

Table 3: Distribution of farmers according to varieties of seed used and livestock breed

Variable	**Local Variety (Freq)**	**Percentage**	**Improved Variety (Freq)**	**Percentage**	**Mixed Variety (Freq)**	**Percentage**	**Total Frequency**	**Total Percentage (100%)**
i) Maize	212	55.94	156	41.16	11	2.90	379	100
ii) Cowpea	198	82.16	35	14.52	8	3.32	241	100
iii) Rice	92	88.46	12	11.54	0	0.0	104	100
iv) Sorghum	149	55.39	103	38.29	17	6.32	269	100
v) Soybean	21	40.38	31	59.62	0	0.0	52	100
	Local Breed (Freq)	**Percentage**	**Hybrid (Freq)**	**Percentage**	**Mixed Breed (Freq)**	**Percentage**	**Total Frequency**	**Total Percentage (100%)**
vi) Large rum.	51	79.69	6	9.38	7	10.94	64	100
vii) Small rum.	204	73.12	27	9.68	48	17.20	279	100
viii) Poultry	11	10.68	73	70.87	19	18.45	103	100

Source: Field Survey (2024)

NB: Inter and relay cropping systems were adopted during the planting and some of the farmers raised more than one category of the livestock

The data reveals that 55.94% of maize farmers relied on local seeds, 41.16% adopted improved varieties and only 2.90% used mixed seeds. For cowpea cultivation, the dominance of local varieties was more pronounced, with 82.16% using traditional seeds, 14.52% utilizing improved seeds and 3.32% employing mixed types. A similar pattern was observed among rice and sorghum farmers, with 88.46% and 55.39%, respectively, using local varieties. Improved seed usage among rice and sorghum farmers stood at 11.54% and 38.29%, respectively, while 6.32% of

sorghum farmers employed mixed seeds. Interestingly, in soybean production, a majority of farmers (59.62%) adopted improved varieties, while 40.38% used local seeds. These findings suggest a widespread reliance on traditional seed varieties across most crops, which may partly explain the sub-optimal productivity levels observed among farmers in the study area.

This result is consistent with the findings of Tufa, Alemu, and Alemayehu (2022), who reported that low adoption rates of improved crop varieties in smallholder farming systems in sub-Saharan Africa are strongly linked to limited access to quality inputs, insufficient extension services and entrenched preferences for traditional varieties. Their study emphasized that greater adoption of improved seed and livestock breeds could significantly enhance agricultural productivity resilience, and food security in mixed farming contexts.

The findings further reveal a parallel trend in livestock production practices among integrated crop-livestock farmers in the study area. A significant proportion of farmers raising large ruminants, approximately 79.69%, depended on indigenous (local) breeds, while only 9.38% adopted hybrid breeds and 10.94% used a combination of both. Similarly, for small ruminants such as goats and sheep, 73.12% of the respondents reared local breeds, 9.68% kept hybrid breeds, and 17.20% reared a mix of both. In contrast, poultry production demonstrated a distinct pattern: 70.87% of poultry farmers predominantly raised hybrid birds, 18.45% used mixed breeds, while only 10.68% relied solely on local poultry breeds. These results suggest that while the use of improved and hybrid breeds is still relatively limited in large and small ruminant production, there is a greater preference for improved breeds in poultry farming. This may be attributed to the faster growth rates, higher productivity, and better disease resistance of hybrid poultry, which make them more economically viable for smallholder farmers compared to local birds.

This observation aligns with the findings of Akinola *et al.* (2021), who reported that hybrid poultry breeds are increasingly being adopted among smallholder farmers in Nigeria due to their commercial benefits, whereas traditional preferences and limited access to improved breeding stock constrain the widespread adoption of hybrid breeds in ruminant production. The study emphasized the need for policy and extension support to promote breed improvement and access to productive livestock genetics, particularly among mixed-farming communities.

Effects of integrated crop-livestock farming system on farmers' livelihood strategies

The double logarithmic regression model was estimated using the statistical software package EViews version 9. As presented in Table 4, the R-squared and adjusted R-squared values were 0.722 and 0.7414, respectively. This indicates that approximately 74% of the variation in the dependent variable, farmers' livelihood, was collectively explained by the independent variables included in the model. The F-statistic value of 212.4812, which is significant at the 1% level ($p < 0.000$), confirms that the explanatory variables had a statistically significant joint effect on farmers' livelihood in the study area. Furthermore, the Jarque-Bera test was used to assess the normality of the residuals. With a probability value of 0.8425 ($p > 0.05$), the result suggests that the residuals were normally distributed, indicating the model's suitability for inference.

Table 4: Effect of integrated crop-livestock farming system on farmers' livelihood

Variable	Coefficient	Standard error	T-statistic	P-values
Constant	10.7273	0.1484	72.2867	0.0000
Household size	-0.1283***	0.0380	-3.3731	0.0007
Educational level	0.4687***	0.0316	14.8254	0.0000
Farming experience	0.0503**	0.0236	2.1338	0.0329
Farm size	0.1573**	0.0667	2.3487	0.0188
Farm produce	0.8940***	0.0482	18.5604	0.0000
Livestock size	0.2572***	0.0613	4.1977	0.0000
Diagnostic Statistics:				
Number of observation	405			
R-squared	0.7722			
Adjusted R-squared	0.7414			
Log-likelihood	9.351			
Jarque-Bera	0.1382			
Prob(Jarque-Bera)	0.8425			
F-statistic	212.4812			
Prob(F-statistic)	0.0000			

Source: Field Survey (2024)

Note: *** and ** denote significant at 1% and 5%, respectively.

Household size (X_1): The regression outcome revealed that household size had a negative and statistically significant impact on farmers' livelihood, with a coefficient of -0.1283 and a t-value of -3.3731 at the 1% significance level. This aligns with theoretical expectations, indicating that a 1% increase in household size results in a 0.1283% decline in livelihood outcomes, assuming other factors remain constant. The implication is that larger household sizes may impose higher consumption burdens on farming households, thereby reducing the income available for reinvestment in productive agricultural activities. This finding is consistent with a research by Edeh, Nwachukwu and Nwosu (2023), who reported that an increase in household size significantly constrained economic well-being among smallholder farmers in Nigeria, due to increased dependency ratios and pressure on limited farm income.

Educational level (X_2): The regression analysis demonstrated that educational attainment had a positive and statistically significant influence on the livelihood of farmers, with a coefficient of 0.4687 and a t-value of 14.8254 at the 1% significance level. This suggests that a 1% increase in the educational level of farmers corresponds to a 0.4687% improvement in their livelihood outcomes, holding all other variables constant. This finding implies that farmers with higher education levels are better equipped to access and apply modern farming practices, optimize resource use, and enhance productivity and income. A study by Yusuf, Adebayo and Jibowo (2023) corroborates this result, showing that education significantly contributes to increased agricultural efficiency and income generation among rural households in Nigeria.

Farming experience (X_3): The regression outcome indicates that farming experience had a positive coefficient of 0.0503 and was statistically significant (t = 2.1338) at the 5% probability level. This implies that a 1% increase in farming experience led to a 0.0503% improvement in farmers' livelihood, assuming other factors remain constant. The implication is that farmers with more years of experience in integrated crop-livestock systems are likely to possess better knowledge of effective production practices, resource management, and market dynamics. This accumulated expertise contributes to greater productivity and income, ultimately enhancing livelihood. These findings are consistent with those of Okon, Udoh, and Oboh (2023), who found that farming experience significantly improved the productivity and income levels of smallholder farmers in mixed farming systems in Nigeria.

Farm size (X_4): the regression result reveals that farm size had a positive coefficient of 0.1573 and was statistically significant (t = 2.3487) at the 5% level of probability. This indicates that a 1% increase in farm size was associated with a 0.1573% improvement in farmers' livelihood, holding all other variables constant. The implication is that farmers with larger farm size are more likely to achieve higher output volumes, which in turn boosts income and enhances their livelihood status. This aligns with the findings of Yusuf *et al.* (2023), who observed that farm size had a significant positive impact on income levels and livelihood outcomes among rural farming households in Nigeria.

Farm produce (X_5): the regression analysis shows that farm produce had a positive coefficient of 0.8940 and was statistically significant (t = 18.5604) at the 1% probability level. This means that a 1% increase in farm produce resulted in a 0.8940% improvement in farmers' livelihood, holding all other factors constant. In essence, farmers who were able to harvest larger quantities of produce generated higher incomes, which subsequently enhanced their livelihood. This is consistent with the findings of Adebayo *et al.* (2022), who found that an increase in crop yield positively influenced income generation and livelihood improvement among smallholder farmers in Nigeria.

Livestock size (X_6): the coefficient for livestock size was found to be positive (0.2572) and statistically significant (t = 4.1977) at the 1% probability level in the study area. This suggests that a 1% increase in livestock size resulted in a 0.0270% improvement in farmers' livelihood. Essentially, farmers with larger herds of livestock were able to generate higher income compared to those with fewer animals. This finding aligns with the work of Ibrahim *et al.* (2021), who demonstrated that livestock ownership significantly contributed to income diversification and enhanced livelihood outcomes for pastoral farmers in the Northern Nigeria region.

Net income (X_7): the coefficient for net income was positive (0.3988) and statistically significant (t = 11.6756) at the 1% probability level. This indicates that a 1% increase in net income resulted in a 0.3988% improvement in farmers' livelihood. In other words, farmers with higher net incomes were more likely to diversify into additional income-generating activities, thus improving their overall livelihood. This finding supports the conclusions of Girei *et al.* (2018), who found that farmers with higher net incomes were able to invest more in diversification strategies, which contributed positively to their livelihood outcomes in the context of small-scale farming in Nasarawa State, Nigeria.

Test of research hypothesis

The null hypothesis of the study was tested using the results of the multiple regression analysis. From the results, household size had a negative and significant effect (β = -

0.1283, $p < 0.01$), suggesting that an increase in household size adversely affects farmers' livelihood outcomes, likely due to increased consumption pressure. Educational level showed a positive and highly significant relationship ($\beta = 0.4687$, $p < 0.01$), indicating that more educated farmers are better positioned to enhance their livelihood through knowledge-based decisions and adoption of modern practices. Farming experience had a positive and significant effect ($\beta = 0.0503$, $p < 0.05$), implying that more experienced farmers tend to have better resource management skills and adaptive capacity, thus improving livelihood outcomes. The regression results also revealed a positive and significant relationship ($\beta = 0.1573$, $p < 0.05$), suggesting that larger farm sizes contribute to higher agricultural productivity and income, thereby enhancing livelihoods. Farm produce exerted a strong positive and highly significant influence ($\beta = 0.8940$, $p < 0.01$), indicating that increased crop output leads to higher income and improved livelihood strategies. Livestock size had a positive and highly significant impact ($\beta = 0.2572$, $p < 0.01$), reflecting that farmers with more livestock enjoy better income diversification and food security. Net income showed a positive and highly significant relationship ($\beta = 0.3988$, $p < 0.01$), confirming that higher earnings enable farmers to invest in productive activities and improve living conditions. The overall model was statistically significant ($F = 212.4812$, $p < 0.000$) with an adjusted R-squared of 0.7414, indicating that approximately 74% of the variation in farmers' livelihood strategies was jointly explained by the independent variables. Based on these results, the null hypothesis (H_0) is rejected while the alternative (H_1) is accepted. Therefore, it is concluded that integrated crop-livestock farming system has a significant effect on the livelihood strategies of farmers in the study area.

5. Conclusion and Recommendations

This study examined the economic effect of the Integrated Crop-Livestock Farming System (IFS) on the livelihood strategies of farmers in North-West Nigeria. Drawing on empirical evidence from multiple regression analysis, the findings demonstrate that IFS significantly enhances farmers' livelihoods across several dimensions. The model produced an R^2 value of 0.7722 and an adjusted R^2 of 0.7414, indicating that approximately 74% of the variation in farmers' livelihood strategies can be explained by the key components of the IFS included in the model. The overall model was statistically significant at $p < 0.01$ ($F = 212.4812$), confirming the robustness of the estimated relationships. Specifically, the results revealed that farm produce ($\beta = 0.8940$, $p < 0.01$), net income ($\beta = 0.3988$, $p < 0.01$), livestock size ($\beta = 0.2572$, $p < 0.01$), and educational level ($\beta = 0.4687$, $p < 0.01$) had strong positive and significant effects on farmers' livelihood strategies. These findings imply that productivity enhancement, income diversification, and access to education are pivotal in improving rural livelihoods. Moreover, variables such as farming experience ($\beta = 0.0503$, $p < 0.05$) and farm size ($\beta = 0.1573$, $p < 0.05$) also contributed significantly, highlighting the importance of accumulated knowledge and land access in optimizing integrated farming outcomes. Conversely, household size had a negative effect ($\beta = -0.1283$, $p < 0.01$), suggesting that larger households may exert pressure on available resources, thereby constraining livelihood improvements. In conclusion, the study provides compelling evidence that Integrated Crop-Livestock Farming Systems significantly improve the livelihood strategies of farmers in North-West Nigeria.

Recommendations

1) Farmers should be encouraged through awareness campaigns and

demonstration farms to adopt integrated farming practices, as they enhance productivity, income diversification and resilience.

2) Government and NGOs should organize regular training programs focused on modern farming techniques, efficient resource management and business skills to improve farmers' productivity and profitability.

3) Efforts should be made by the government and other stakeholders to supply farmers with high-yield, disease-resistant crop varieties and improved livestock breeds to boost output and income.

4) Financial institutions should design affordable loan schemes tailored for integrated farmers, enabling them to invest in farm expansion, technology adoption and improved inputs.

5) Improving rural infrastructure such as roads, storage facilities and markets will help farmers reduce post-harvest losses, access markets easily and fetch better prices for their products.

6) Farmers should be supported to diversify their income sources by integrating crop-livestock systems with other rural enterprises (e.g., agro-processing, aquaculture) to build resilience against economic shocks.

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