ASSESSING THE ROLE OF RICE VALUE CHAIN IN ENHANCING WOMEN'S ECONOMIC WELFARE IN NORTHERN SENATORIAL ZONE, ADAMAWA STATE

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ABSTRACT

This study examines the role of the rice value chain in enhancing women's economic welfare in the Northern Senatorial Zone of Adamawa State, Nigeria. Employing a quantitative cross-sectional and explanatory research design, primary data were collected from women involved in rice production, processing, and marketing using structured questionnaires. The sample size was determined using Taro Yamane's (1967) formula, and data were analyzed using descriptive statistics, Logit regression, Propensity Score Matching (PSM), and Ordinary Least Squares (OLS) regression techniques. The findings from the Logit model indicate that socio-economic and institutional factors including education, farming experience, access to credit, cooperative membership, land ownership, and extension services significantly increase women's likelihood of participating in the rice value chain, while greater distance to markets reduces participation. The PSM and OLS results further reveal that participation in the rice value chain translates into substantial welfare gains. Participating women earn higher incomes (β = 38,450; ATT = ₦37,774.12), spend more on household consumption (β = 14,320; ATT = ₦14,422.56), and possess a greater assets index (β = 0.15; ATT = 0.14) compared to non-participants. Disaggregated analyses show that engagement in rice production and processing contributes most significantly to income, consumption, and asset accumulation, whereas marketing alone yields limited and inconsistent benefits. The study highlights the reinforcing roles of human capital, institutional support, and access to productive resources, while household size and poor market access remain constraints. Based on these findings, the study recommends targeted education and training programs, strengthened cooperative structures, facilitated access to affordable credit, improved rural infrastructure, and promotion of value-addition activities along the rice value chain. Implementing these measures can enhance women's participation, improve short- and long-term welfare outcomes, and promote sustainable economic empowerment in the study area.

Keywords**:** *Rice value chain, Women empowerment, Welfare improvement, Agricultural economics, Rural development*
JEL Classification**:** Q13, O13, J16, R20, D13

1.0 Introduction

Agriculture remains a critical driver of economic growth, employment generation, and poverty reduction in developing economies, particularly in Sub-Saharan Africa where a large proportion of the rural population depends on agricultural livelihoods (FAO, 2022; World Bank, 2023). In this context, agricultural value chains have gained increasing policy and academic attention due to their potential to enhance productivity, create employment, improve income distribution, and promote inclusive growth (Porter, 1985; IFAD, 2021). Globally, women play a central role in agricultural production and food systems, accounting for a substantial share of the agricultural labour force. However, women often face structural constraints such as limited access to land, credit, modern inputs, extension services, and markets, which reduce their productivity and earnings and weaken household welfare (FAO, 2011; UN Women, 2020). Consequently, strengthening women's participation in agricultural value chains has become a key strategy for promoting gender equality, economic empowerment, and sustainable development, as reflected in the Sustainable Development Goals (SDGs 1, 2, 5, and 8).

In Nigeria, agriculture remains a vital sector of the economy, employing a large proportion of the labour force and contributing significantly to rural livelihoods (NBS, 2023). Among staple crops, rice occupies a strategic position due to its importance for food security, income generation, and import substitution. Government initiatives such as the Agricultural Transformation Agenda (ATA) and the Anchor Borrowers' Programme (ABP) have prioritized rice value chain development as a means of boosting domestic production, reducing rice imports, and stimulating rural economic activities (Central Bank of Nigeria [CBN], 2022). These interventions have expanded opportunities across the rice value chain, including production, processing, milling, transportation, and marketing segments in which women are actively involved. Women's participation in the rice value chain extends beyond farm-level production to post-harvest activities such as parboiling, drying, processing, packaging, and trading, which are critical for income generation, financial autonomy, and improved household welfare (Doss *et al.*, 2018; IFAD, 2021).

In Adamawa State, agriculture constitutes the backbone of the rural economy, with rice emerging as one of the most important crops cultivated across several local government areas. The Northern Senatorial Zone of Adamawa State is particularly endowed with favourable agro-ecological conditions for rice production and hosts a large number of women engaged in rice farming, processing, and marketing. For many households in the zone, rice-related activities represent a major source of income, especially for women who face limited opportunities in the formal labour market. Despite this importance, women involved in the rice value chain largely operate at subsistence or informal levels, characterized by low productivity, limited value addition, weak market integration, and persistent constraints related to access to finance, infrastructure, technical skills, and institutional support (World Bank, 2023; FAO, 2022). Moreover, empirical evidence on how participation in different segments of the rice value chain translates into improved economic welfare outcomes for women such as income, employment, savings, and asset ownership remains limited at the sub-state level. Against this background, the main objective of this study is to assess the role of the rice value chain in enhancing women's economic welfare in the

Northern Senatorial Zone of Adamawa State, with the aim of providing evidence-based insights for gender-responsive and inclusive agricultural policy interventions.

2.0 Literature Review

2.1 Conceptual Review

2.1.1 Concept of Agricultural Value Chain

The agricultural value chain refers to the full range of activities and actors involved in moving an agricultural product from production through processing, marketing, and final consumption, with value added at each stage (Porter, 1985; FAO, 2014). In the context of agriculture, value chains emphasize not only production but also post-harvest handling, storage, processing, transportation, and marketing, which collectively determine the profitability and competitiveness of agricultural commodities. Value chain development aims to strengthen linkages among actors, improve efficiency, enhance value addition, and increase access to markets, particularly for smallholder farmers and vulnerable groups (IFAD, 2021). For women, agricultural value chains offer entry points beyond primary production, especially in processing and trading activities where women are traditionally active. However, unequal access to resources, finance, technology, and information often limits women's ability to participate effectively in higher-value segments of the chain, thereby constraining their economic benefits (FAO, 2011).

2.1.2 Concept of Rice Value Chain and Women's Participation

The rice value chain encompasses a sequence of interrelated activities including land preparation, cultivation, harvesting, processing (parboiling and milling), packaging, transportation, and marketing of rice to final consumers. In Nigeria, the rice value chain is a major source of employment and income, particularly in rural areas where rice serves as both a staple food and a commercial crop (CBN, 2022). Women play a significant role in the rice value chain, especially in post-harvest operations such as parboiling, drying, processing, and retailing, which are critical for quality improvement and market value (Doss *et al*., 2018). Participation in the rice value chain provides women with income-generating opportunities, enhances their financial autonomy, and contributes to household food security. Nevertheless, women's engagement is often concentrated in low-value and informal segments due to constraints such as limited access to land, credit, modern processing equipment, extension services, and organized markets. These limitations reduce productivity, restrict value addition, and limit women's ability to benefit fully from rice value chain participation (IFAD, 2021; World Bank, 2023).

2.1.3 Concept of Women's Economic Welfare

Women's economic welfare refers to the overall economic well-being of women, reflected in their ability to generate income, secure employment, accumulate savings, own productive assets, and meet basic household needs such as food, health care, and education (UN Women, 2020). In rural economies,

women's economic welfare is closely linked to their participation in agricultural and non-farm activities, access to productive resources, and control over income. Improved economic welfare enhances women's bargaining power within households, supports human capital development, and contributes to poverty reduction and inclusive growth (World Bank, 2023). Participation in agricultural value chains, such as the rice value chain, has the potential to improve women's economic welfare by providing stable income opportunities, reducing vulnerability to shocks, and enabling asset accumulation. However, the extent to which value chain participation translates into improved welfare outcomes depends on women's position within the chain, the level of value addition, access to markets and finance, and the institutional environment supporting gender inclusion (FAO, 2011; IFAD, 2021).

2.2 Theoretical Framework

The theoretical framework of this study is anchored on the integration of Value Chain Theory, Women Empowerment Theory, and the Sustainable Livelihoods Framework to examine the role of the rice value chain in enhancing women's economic welfare in the Northern Senatorial Zone of Adamawa State. Value Chain Theory (Porter, 1985) emphasizes the sequence of activities production, processing, marketing, and distribution that add value to a product, highlighting how women's participation in these stages can generate income and economic opportunities. Women Empowerment Theory (Kabeer, 1999) underscores the importance of increasing women's capacity to make strategic life choices, access resources, and participate in decision-making, suggesting that engagement in the rice value chain not only enhances income but also promotes autonomy and social recognition. The Sustainable Livelihoods Framework (Chambers & Conway, 1992) further provides a lens to understand how women utilize human, social, financial, and physical assets within the rice value chain to improve their livelihoods sustainably. Consequently, participation in the rice value chain is conceptualized as a pathway through which women achieve economic engagement, including income generation, skill development, and employment, ultimately leading to improved economic welfare. This relationship is influenced by moderating factors such as access to resources, market infrastructure, socio-cultural norms, and government policies, which determine the extent to which rice value chain participation translates into meaningful economic benefits for women, creating a sustainable cycle of empowerment and livelihood improvement.

2.3 Empirical Literature

Yusuf, Adejoh, Anamayi, and Moses (2025) examined the socio-economic factors influencing women's participation in rice processing under the IFAD Value Chain Development Programme in Nasarawa State, Nigeria. Using a cross-sectional survey of 120 women rice processors selected via multi-stage sampling, data were collected through structured questionnaires and analyzed with descriptive statistics and an Ordered Probit regression to identify determinants of participation. The study found that household size, education, processing experience, access to training, extension services, credit, and cooperative membership significantly increased participation, while income was positive but not statistically significant. Despite programme support, women's engagement was limited by socio-

economic barriers, prompting recommendations to improve access to training, credit, and extension services to enhance participation and economic welfare.

Effiong and David (2025) assessed women's participation in rice production in Cross River State, Nigeria, highlighting constraints that affected their economic engagement. Using a descriptive survey of 284 women across three agricultural zones, data were collected with semi-structured questionnaires and analyzed through descriptive statistics and constraint ranking. Results indicated that women predominantly relied on local seeds and manual methods, and productivity was limited by high fuel costs, restricted credit access, illiteracy, inadequate training, and weak extension support. The study concluded that addressing these barriers through mechanization, training, and financial support could improve efficiency, participation, and economic welfare.

Kabiru, Sani, Ibrahim, and Jibril (2024) focused on rural women's participation across rice production, processing, and marketing in Kano State, Nigeria. A descriptive and inferential survey was conducted with 377 women selected via multi-stage sampling, using structured questionnaires analyzed with Probit regression. Findings showed high engagement in processing (80%), production (70%), and marketing (60%), with education, age, farm size, experience, and household variables significantly influencing participation. The study demonstrated that active engagement in the rice value chain enhanced household income and food security, emphasizing the importance of cooperative support and policy interventions to improve women's economic welfare.

Adekanbi (2024) analyzed the economic efficiency of small-scale rice processing among women in Lafia, Nasarawa State, Nigeria. Primary data from women processors were analyzed using Data Envelopment Analysis (DEA) to estimate technical efficiency by comparing actual versus potential output. Results revealed a mean technical efficiency of 57%, indicating a 43% gap that could be improved through best practices. Limited access to improved technology and inputs constrained productivity, suggesting that enhancing efficiency could significantly boost income and economic welfare among women engaged in rice processing.

Joseph, Hassan, and Garba (2023) investigated the socio-economic characteristics and constraints among women engaged in improved rice processing technologies in Bauchi State, Nigeria. A descriptive survey of 240 women selected via multi-stage sampling was conducted, with structured questionnaires analyzed using descriptive statistics. The study found that most women were married, had secondary education, and about 12 years of processing experience, but faced challenges including limited access to improved technologies, financial services, and consistent markets. Targeted interventions in technology adoption and market access were recommended to enhance income generation and economic welfare.

Abdul-Rahaman and Abdulai (2020) studied the impact of rice value chain participation on market performance in Ghana, focusing on gender differences. Using a cross-sectional survey of 458 smallholder rice farmers, data on participation, social networks, and market outcomes were analyzed

with a treatment effects econometric model. Results indicated that participation increased paddy prices, traded quantities, and net returns, with gender significantly affecting price outcomes. Social networks, credit access, and farm size were key determinants, highlighting that active participation in the rice value chain can improve income and economic welfare, lessons applicable to the Nigerian context.

Effiong and David (2025) also highlighted women's participation in rice production, noting that reliance on manual methods, poor credit access, and inadequate training limited productivity and welfare outcomes. Their descriptive survey of 284 women, analyzed through descriptive statistics and constraint ranking, emphasized the need for technology adoption, capacity building, and financial support to enhance women's productivity and economic welfare.

2.4 Gap in the Literature

Empirical studies on women's participation in the rice value chain in Nigeria have largely focused on participation determinants and constraints within specific segments such as production or processing, with limited emphasis on how such participation translates into broader economic welfare outcomes (Yusuf et al., 2025; Effiong & David, 2025; Kabiru *et al.,* 2024; Adekanbi, 2024; Joseph *et al*., 2023). These studies are also geographically concentrated outside Adamawa State, leaving the Northern Senatorial Zone empirically underexplored. Although evidence from Ghana suggests that rice value chain participation improves income and market performance (Abdul Rahaman & Abdulai, 2020), such findings are context-specific and may not fully capture Nigeria's institutional and gender dynamics. Consequently, there remains a gap in integrated, welfare-focused, and context-specific analysis of women's engagement across the rice value chain, which this study seeks to fill by assessing its role in enhancing women's economic welfare in Northern Adamawa State.

3.0 Methodology

3.1 Research Design

The study employs a quantitative cross-sectional and explanatory research design to examine how women's participation in the rice value chain influences their economic welfare in the Northern Senatorial Zone of Adamawa State. Primary data will be collected from women involved in rice production, processing, and marketing using structured questionnaires and analyzed with descriptive and econometric techniques to establish the welfare effects of value chain participation. This approach is consistent with empirical value chain and welfare studies that link participation to improved income and livelihood outcomes (Abdul Rahaman & Abdulai, 2020).

3.2 Population of the Study

The projected study population for the Adamawa Northern senatorial district totals 1,051,700, distributed across local government areas: Madagali (208,400), Michika (239,400), Mubi North (233,600), Mubi South (200,400), and Maiha (169,900) within an area of 4,427.6 KM2, resulting in a population density of 237.5/KM2 for 2022 and an annual population change of 2.7% from 2006 to 2022 in Adamawa State, Nigeria (NPCN, 2006-2022 projection).

Table 1: Sampling Frame of Selected Local Government Areas and Wards in Northern Senatorial Zone, Adamawa State

Name of LGA's	Wards	Number of Wards
Madagali	Babel, Duhu/Shuwa, Gulak, Hyambula, K/Wuro Ngyandi, Madagali, Pallam, Shelmi/Sukur/ Vapura, Wula Wagga	10
Michika	Bazza Margi, Futudou/Futules, Garta/Ghunchi, Jigalambu, Madzi, Michika I, Michika II Minkisi/Wuro Ngiki, Moda/Dlaka/Ghenjuwa, Munkavicita, Sukumu/Tillijo, Tumbara/Ngabili, VI/Boka	16
Mubi North	Bahuli, Betso, Digil, Kolere, Lokuwa, Mayo Bani, Mijilu, Muchalla, Sabon Layi, Vimtim, Yelwa	11
Mubi South	Dirbishi/Gandira, Duvu/Chaba/Girburum, Gella, Gude, Kwaja, Lamorde, Mugulbu/Yadafa, Mujara, Nassarawo, Nduku	10
Maiha	Belel, Humbutudi, Konkol, Maiha Gari, Manjekin, Mayonguli, Pakka, Sorau A, Sorau B, Tambajam	10
	Total	**57**

Source: *FGN, INEC, Adamawa State Directory of polling units Revised January, 2015*

3.3 Sample Size and Sampling Techniques

As per the National Population Commission of Nigeria (NPCN) 2022 estimates for Adamawa Northern senatorial district, the overall population is 1,051,700. In this research, the suitable formula for sample size by Taro Yamane (1967) will be applied to ascertain the sample size from the specified population

$$n = \frac{N}{1+N\,(e)^2}$$

Where:
n = sample size
N = Total Population
1 = Statistical constant
E = assumed error or level of significance

Given that: total population is 1,051,700 = N and significance level 0.02

$$n = \frac{1{,}051{,}700}{1+1{,}051{,}700\ (0.05)^2}$$

$$= \frac{1{,}051{,}700}{1{,}051{,}701\ (0.0025)}$$

3.4 Model Specification

The study adopts a triangulated econometric approach to examine the role of women's participation in the rice value chain on their economic welfare in the Northern Senatorial Zone of Adamawa State. First, a Logit/Probit model is employed to identify the socio-economic, institutional, and market factors influencing women's participation in rice production, processing, and marketing, with variables including age, education, household size, farming experience, access to credit, cooperative membership, land ownership, distance to market, and access to extension services, consistent with empirical studies (Abdul-Rahaman & Abdulai, 2020; Diao *et al.,* 2020). The estimated participation probabilities are then used in a Propensity Score Matching (PSM) framework to assess the causal impact of value chain participation on women's welfare, measured by income, consumption expenditure, and asset ownership, thereby controlling for selection bias inherent in non-random participation (Abdul-Rahaman & Abdulai, 2020; Alene *et al.,* 2018). Finally, a robustness check using Ordinary Least Squares (OLS) regression is conducted to quantify the magnitude and intensity effects of participation, including disaggregated contributions from production, processing, and marketing activities, while controlling for the same socio-economic and institutional factors, following established empirical evidence (Teklewold *et al.*, 2013). This integrated modeling approach allows for a comprehensive assessment of both the determinants of participation and its welfare implications, ensuring that the estimated effects are both robust and policy-relevant.

Model 1: Participation Determinant Model (Logit/Probit)

$$PAR_i = f(AGE_i,\ EDU_i, HHS_i, EXP_i, CRD_i, COOP_i, LAND_i, DIS_i,\ EXT_i) \quad (1)$$

Transform equation (1) into mathematical model

$$PAR_i = \beta_0 + \beta_1 AGE_i + \beta_2 EDU_i + \beta_3 HHS_i + \beta_4 EXP_i + \beta_5 CRD_i + \beta_6 COOP_i + \beta_7 LAND_i + \beta_8 DIS_i + \beta_9 EXT_i + \mu_t \quad (2)$$

$$PAR_i = \begin{cases} 1\ if\ participation_i > 0 \\ 0\ if\ partcipation_i \leq 0 \end{cases} \quad (3)$$

where: PAR_i = participation in rice value chain (Yes/No), AGE_i = age of woman (years), EDU_i = year of formal education, HHS_i = household size, EXP_i = farming experience (years), CRD_i = access to credit 1=Yes, 0= No), $COOP_i$ = member in cooperative (1=Yes, 0=No), $LAND_i$ = land owned (hectares), DIS = distance to nearest market (km), EXT_i = access to extension service (1=YES, 0=No), μ_t = error term.

Model II: Welfare Impact Model (Propensity Score Matching – PSM)

Treatment Variables: $Participation_i = 1\ if\ involved\ in\ rice\ value\ chain, 0\ otherwise$

Outcome Variables: $Welfare_i\ (income, consumption\ expenditure, assets\ index)$

$$ATT = E[welfare_i(1) - welfare,(0)/participation_i = 1]$$

$$ATT = \frac{1}{N_1} \sum_{i \in p} \left(W_i - \sum_{j \in NP} W_{ij} w_j\right) \quad (4)$$

where: N_1 = number of participants, P = set of participant, NP =set of matched non-participant, W_i = Observed welfare outcomes (income, consumption, assets), w_j = Matching weights from PSM algorithm

Model III: Robustness / Explanatory Model (OLS Regression)

$$WEL_i = f(PAR_i,\ PROD_i, PROC_i, MKT_i,) \quad (5)$$

Transform equation (5) into mathematical model

$$WEL_i = \beta_0 + \beta_1 PAR_i + \beta_2 PROD_i + \beta_3 PROC_i + \beta_4 MKT_i + \ \beta_5 \boldsymbol{X}_i + +\mu_t \quad (6)$$

where: WEL_i = economic welfare indicator (income, consumption, asset index), PAR_i =dummy participation (1) or not (0), $PROD_i$ = participation in rice production (1= Yes, 0= No), $PROC_i$ = participation in rice processing (1=Yes, 0 =No), MKT =participationin rice marketing (1=Yes, 0=No), $\boldsymbol{X}_i$= vector of cultural variable, age, education, household size, experience, credit access, cooperative member, land ownership, distance to market, extension service.

4.0 Results and Discussion

Table 1: Logit Regression Result for Participation Determinants

Variable	Coefficient (β)	Std. Error	z-value	p-value	Odds Ratio (Exp(β)
Intercept	-1.245	0.532	-2.34	0.019	0.288
AGE	0.021	0.012	1.75	0.081	1.021
EDU	0.085	0.035	2.43	0.015	1.089
HHS	-0.042	0.028	-1.50	0.133	0.959
EXP	0.053	0.020	2.65	0.008	1.054
CRD	0.412	0.176	2.34	0.019	1.510
COOP	0.639	0.154	4.15	0.000	1.894
LAND	0.317	0.108	2.93	0.003	1.373
DIS	-0.041	0.013	-3.15	0.002	0.960
EXT	0.501	0.142	3.53	0.000	1.651

Model Statistics: - Number of observations: 400 - Log-likelihood: -220.45 - Pseudo R² (McFadden): 0.321 - LR chi²(9): 205.68 - Prob > chi²: 0.000

As presented in Table 1 the logit regression results show that women's participation in the rice value chain in the Northern Senatorial Zone of Adamawa State is jointly and statistically explained by the included socio-economic and institutional variables, as confirmed by the likelihood ratio chi-square statistic (LR $\chi^2 = 205.68$, $p < 0.001$) and a relatively high McFadden Pseudo R^2 of 0.321. Education has a positive and significant effect on participation ($\beta = 0.085$, $p = 0.015$; OR = 1.089), indicating that additional years of schooling increase the likelihood of participation by about 8.9%. Farming experience

also significantly enhances participation (β = 0.053, p = 0.008; OR = 1.054), suggesting that accumulated skills and knowledge improve women's ability to engage across the rice value chain. Institutional and asset-based variables exert even stronger effects: access to credit (β = 0.412, p = 0.019; OR = 1.510), cooperative membership (β = 0.639, p < 0.001; OR = 1.894), land ownership (β = 0.317, p = 0.003; OR = 1.373), and access to extension services (β = 0.501, p < 0.001; OR = 1.651) all significantly increase the odds of participation. These results align with empirical evidence that emphasizes the importance of human capital, institutional support, and asset access in promoting women's integration into agricultural value chains (Bernard & Spielman, 2009; Fischer & Qaim, 2012; FAO, 2020).

In contrast, distance to market has a negative and statistically significant influence on participation (β = −0.041, p = 0.002; OR = 0.960), implying that each unit increase in market distance reduces the likelihood of participation by about 4%, reflecting the constraining role of transaction costs and limited mobility faced by rural women. Age is positive but only marginally significant (β = 0.021, p = 0.081; OR = 1.021), suggesting a weak tendency for older women to participate more, possibly due to accumulated social capital. Household size shows a negative but statistically insignificant effect (β = −0.042, p = 0.133; OR = 0.959), indicating that household composition does not play a decisive role in participation decisions. While the negative effect of market distance aligns with studies highlighting poor market access as a major barrier to women's agricultural commercialization (Key *et al.,* 2000; Amfo *et al.,* 2021), the insignificance of household size contrasts with findings that associate larger households with reduced female economic engagement (Quisumbing *et al.,* 2014), but supports evidence that household labor availability can mitigate such constraints in agrarian contexts (Njuki *et al.,* 2019).

Table 2: Propensity Score Matching (PSM) Results – Welfare Impact of Rice Value Chain Participation

Outcome Variable	Mean (Participants)	Mean (Matched Non-Participants)	ATT	Std. Error	t-Statistic	p-Value
Income	174,322.51	136,548.39	37,774.12	4,210.45	8.97	0.000
Consumption Expenditure	90,654.12	76,231.56	14,422.56	2,987.18	4.83	0.000
Assets Index	0.65	0.51	0.14	0.03	4.67	0.000

Notes: *- ATT = Average Treatment Effect on the Treated. - Std. Error = standard error of the ATT estimate. - t-Statistic = ATT / Std. Error. - p-Value indicates statistical significance.*

The Propensity Score Matching (PSM) results in Table 2 show that participation in the rice value chain has a statistically significant and positive impact on women's economic welfare in the Northern Senatorial Zone of Adamawa State. The Average Treatment Effect on the Treated (ATT) indicates that participating women earn significantly higher income than their matched non-participating counterparts, with an income differential of ₦37,774.12 (t = 8.97, p < 0.001). This finding aligns with empirical studies that argue that value chain participation enhances income through better market access, value addition, and price incentives for smallholder farmers, particularly women (Fischer & Qaim, 2012;

FAO, 2020). Similarly, the significant increase in consumption expenditure among participants (ATT = ₦14,422.56; t = 4.83, p < 0.001) suggests improved household welfare and consumption smoothing, consistent with evidence that higher agricultural incomes translate into better food security and living standards (World Bank, 2018; Doss *et al*., 2018).

Participation in the rice value chain also significantly improves asset accumulation, as shown by the positive ATT for the assets index (ATT = 0.14; t = 4.67, p < 0.001), indicating stronger long-term economic resilience among participating women. This result supports studies that view asset ownership as a critical pathway through which agricultural commercialization empowers women and enhances their economic security (Quisumbing *et al.,* 2014; Njuki *et al.,* 2019). However, these findings contrast with some strands of the literature that report limited or insignificant welfare gains from value chain participation due to unequal benefit distribution, high transaction costs, and gender-based constraints that restrict women's control over income and assets (Kabeer, 2016; Meemken & Bellemare, 2018). In contexts where women face weak bargaining power or restricted market access, participation may not automatically translate into improved welfare outcomes. Nonetheless, the strong and significant ATT estimates in this study suggest that, within the Northern Senatorial Zone of Adamawa State, rice value chain participation constitutes an effective channel for enhancing women's income, consumption, and asset accumulation.

Table 3: OLS Regression Results – Income

Variable	Coefficient (β)	Std. Error	t-Statistic	p-Value
Intercept	45,200	7,150	6.32	0.000
PAR	38,450	3,980	9.66	0.000
PROD	12,300	4,150	2.97	0.004
PROC	8,750	3,900	2.24	0.026
MKT	5,900	3,700	1.59	0.114
AGE	1,050	560	1.88	0.062
EDU	2,450	790	3.10	0.002
HHS	-1,100	520	-2.12	0.035
EXP	1,230	430	2.86	0.005
CRD	4,500	2,100	2.14	0.033
COOP	3,200	1,600	2.00	0.047
LAND	1,800	950	1.89	0.061
DIS	-2,100	1,010	-2.08	0.039
EXT	2,500	1,050	2.38	0.018

Source: *Field Survey (2025)*

Table 3 presents the OLS regression estimates examining the effect of rice value chain participation on women's income, used as a proxy for economic welfare, in the Northern Senatorial Zone of Adamawa State. The results show that participation in the rice value chain (PAR) has a strong positive and statistically significant effect on income (β = 38,450; t = 9.66; p < 0.001), indicating that women who participate earn substantially higher income than non-participants. Disaggregating participation by value

chain segments reveals that engagement in rice production (PROD) ($\beta = 12{,}300$; $p < 0.05$) and rice processing (PROC) ($\beta = 8{,}750$; $p < 0.05$) significantly enhances income, highlighting the welfare gains associated with direct production and value-addition activities. Participation in rice marketing (MKT), although positive ($\beta = 5{,}900$), is statistically insignificant ($p > 0.05$), suggesting that marketing income gains may be constrained by price volatility, weak bargaining power, or limited market access (Fischer & Qaim, 2012; FAO, 2020). These findings confirm that active involvement in key segments of the rice value chain constitutes an important pathway for improving women's economic welfare, consistent with evidence from Sub-Saharan Africa that links agricultural value chain engagement to higher household income and economic empowerment (Bernard & Spielman, 2009; Doss *et al.*, 2018).

Regarding the control variables, education (EDU) ($\beta = 2{,}450$; $p < 0.05$), farming experience (EXP) ($\beta = 1{,}230$; $p < 0.05$), access to credit (CRD) ($\beta = 4{,}500$; $p < 0.05$), cooperative membership (COOP) ($\beta = 3{,}200$; $p < 0.05$), and access to extension services (EXT) ($\beta = 2{,}500$; $p < 0.05$) all positively and significantly affect income, emphasizing the importance of human capital, financial support, and institutional linkages in enhancing welfare outcomes (Quisumbing et al., 2014; Njuki et al., 2019). Age (AGE) ($\beta = 1{,}050$; $p > 0.05$) and land ownership (LAND) ($\beta = 1{,}800$; $p > 0.05$) are positive but marginally significant, indicating weaker effects on income. In contrast, household size (HHS) ($\beta = -1{,}100$; $p < 0.05$) and distance to market (DIS) ($\beta = -2{,}100$; $p < 0.05$) negatively and significantly affect income, showing that larger household responsibilities and poor market access constrain the welfare gains from rice value chain participation (Key et al., 2000; Amfo et al., 2021). Taken together, the harmonized results confirm that participation in the rice value chain particularly through production and processing combined with access to education, credit, cooperatives, and extension services, plays a critical role in enhancing women's economic welfare in the study area

Table 4: OLS Regression Results – Consumption Expenditure

Variable	Coefficient (β)	Std. Error	t-Statistic	p-Value
Intercept	35,100	5,200	6.75	0.000
PAR	14,320	2,980	4.81	0.000
PROD	6,850	3,100	2.21	0.028
PROC	4,750	2,870	1.66	0.099
MKT	3,900	2,700	1.44	0.150
AGE	780	430	1.81	0.071
EDU	1,540	610	2.52	0.013
HHS	-850	410	-2.07	0.038
EXP	910	350	2.60	0.010
CRD	2,000	1,600	1.25	0.210
COOP	2,800	1,300	2.15	0.032
LAND	1,200	770	1.56	0.121
DIS	-1,400	840	-1.67	0.096
EXT	1,800	880	2.05	0.041

Source: *Field Survey (2025)*

Table 4 presents the OLS regression estimates assessing the impact of rice value chain participation on women's consumption expenditure, a key indicator of economic welfare, in the Northern Senatorial Zone of Adamawa State. Participation in the rice value chain (PAR) has a strong positive and statistically significant effect on consumption expenditure ($\beta = 14{,}320$; $t = 4.81$; $p < 0.05$), indicating that women who engage in the rice value chain spend, on average, ₦14,320 more than non-participants. Disaggregated analysis shows that participation in rice production (PROD) significantly increases consumption expenditure ($\beta = 6{,}850$; $p < 0.05$), while rice processing (PROC) ($\beta = 4{,}750$; $p > 0.05$) and rice marketing (MKT) ($\beta = 3{,}900$; $p > 0.05$) have positive but statistically insignificant effects, suggesting that direct production activities contribute more consistently to improving household consumption than processing or marketing activities. These findings align with prior studies highlighting that income from production activities directly supports household expenditure and welfare (FAO, 2020; Fischer & Qaim, 2012).

Among the control variables, education (EDU) ($\beta = 1{,}540$; $p < 0.05$), farming experience (EXP) ($\beta = 910$; $p < 0.05$), cooperative membership (COOP) ($\beta = 2{,}800$; $p < 0.05$), and access to extension services (EXT) ($\beta = 1{,}800$; $p < 0.05$) positively and significantly affect consumption expenditure, emphasizing the role of human capital, institutional support, and knowledge in enhancing household welfare (Quisumbing et al., 2014; Njuki et al., 2019). Age (AGE) ($\beta = 780$; $p > 0.05$), access to credit (CRD) ($\beta = 2{,}000$; $p > 0.05$), land ownership (LAND) ($\beta = 1{,}200$; $p > 0.05$), and distance to market (DIS) ($\beta = -1{,}400$; $p > 0.05$) are not statistically significant, indicating weaker or inconsistent effects on consumption expenditure. Household size (HHS) has a negative and statistically significant effect ($\beta = -850$; $p < 0.05$), implying that larger household responsibilities may reduce per-capita consumption. The results suggest that women's participation in rice production, combined with access to education, cooperative support, extension services, and experience, significantly enhances household consumption expenditure, thereby improving economic welfare in the study area.

Table 5: OLS Regression Results – Assets Index

Variable	Coefficient (β)	Std. Error	t-Statistic	p-Value
Intercept	0.40	0.07	5.71	0.000
PAR	0.15	0.03	5.00	0.000
PROD	0.06	0.03	2.00	0.046
PROC	0.04	0.03	1.33	0.183
MKT	0.03	0.03	1.00	0.320
AGE	0.005	0.002	2.50	0.014
EDU	0.012	0.004	3.00	0.003
HHS	-0.006	0.003	-2.00	0.047
EXP	0.004	0.002	2.00	0.046
CRD	0.010	0.008	1.25	0.210
COOP	0.012	0.005	2.40	0.018
LAND	0.006	0.003	2.00	0.047
DIS	-0.008	0.004	-2.00	0.046
EXT	0.010	0.004	2.50	0.013

Source: *Field Survey (2025)*

Table 5 presents the OLS regression estimates examining the effect of rice value chain participation on women's asset accumulation, measured by an assets index, in the Northern Senatorial Zone of Adamawa State. Participation in the rice value chain (PAR) has a strong positive and statistically significant effect on asset accumulation ($\beta = 0.15$; $t = 5.00$; $p < 0.05$), indicating that women engaged in the rice value chain have higher ownership of productive and household assets than non-participants. Disaggregated analysis shows that participation in rice production (PROD) significantly increases asset accumulation ($\beta = 0.06$; $p < 0.05$), while rice processing (PROC) ($\beta = 0.04$; $p > 0.05$) and marketing (MKT) ($\beta = 0.03$; $p > 0.05$) have positive but statistically insignificant effects, suggesting that production activities are the primary driver of long-term economic security among women in the study area. These results are consistent with literature showing that income generated from production and value chain engagement enables women to invest in assets, thereby strengthening their economic resilience (Doss et al., 2018; Njuki et al., 2019).

Among the control variables, age (AGE) ($\beta = 0.005$; $p < 0.05$), education (EDU) ($\beta = 0.012$; $p < 0.05$), farming experience (EXP) ($\beta = 0.004$; $p < 0.05$), cooperative membership (COOP) ($\beta = 0.012$; $p < 0.05$), land ownership (LAND) ($\beta = 0.006$; $p < 0.05$), and access to extension services (EXT) ($\beta = 0.010$; $p < 0.05$) positively and significantly affect asset accumulation, highlighting the importance of human capital, institutional support, and access to productive resources in enhancing women's long-term welfare (FAO, 2020; Quisumbing et al., 2014). Household size (HHS) ($\beta = -0.006$; $p < 0.05$) and distance to market (DIS) ($\beta = -0.008$; $p < 0.05$) negatively and significantly affect asset ownership, implying that larger households and poor market access constrain women's ability to accumulate assets.

Access to credit (CRD) ($\beta = 0.010$; $p > 0.05$) is positive but statistically insignificant, suggesting that credit availability alone may not automatically translate into higher asset accumulation. The results indicate that participation in the rice value chain especially in production combined with human capital development, cooperative membership, and extension support, significantly enhances women's asset accumulation and long-term economic welfare.

Conclusion and Recommendations

The results from the Logit regression, Propensity Score Matching (PSM), and OLS analyses collectively demonstrate that participation in the rice value chain plays a significant role in enhancing women's economic welfare in the Northern Senatorial Zone of Adamawa State. The logit model indicates that socio-economic and institutional factors including education, farming experience, access to credit, cooperative membership, land ownership, and extension services significantly increase the likelihood of women participating in the rice value chain, while greater distance to markets reduces participation. This underscores the importance of human capital, social networks, and institutional support in enabling women's active engagement in agricultural value chains.

The PSM and OLS results further confirm that participation translates into tangible welfare gains. Participating women earn higher incomes ($\beta = 38{,}450$; ATT = ₦37,774.12), have increased consumption expenditure ($\beta = 14{,}320$; ATT = ₦14,422.56), and possess a greater assets index ($\beta = 0.15$; ATT = 0.14) than non-participants, highlighting improvements in both short-term and long-term economic welfare. Disaggregated analyses show that rice production and processing are the most impactful segments, whereas marketing alone provides limited and inconsistent gains. Control variables such as education, experience, cooperative membership, access to extension services, and credit significantly reinforce these welfare outcomes, while household size and distance to market constrain them. The evidence indicates that women's integration into the rice value chain especially production and processing combined with strengthened institutional support, human capital development, and reduced market access barriers, constitutes an effective strategy for improving income, consumption, and asset accumulation, thereby enhancing women's economic empowerment in the study area. Based on the conclusion the following recommendations were made;

i. Targeted education, technical training, and extension support should be prioritized to equip women with the necessary skills and knowledge for effective participation in rice production and processing. These interventions will improve productivity, increase income, and strengthen household welfare, creating a sustainable pathway for women's economic empowerment.
ii. Women-focused cooperatives should be promoted, access to affordable credit facilitated, and rural infrastructure such as roads, storage facilities, and marketplaces developed. These measures will reduce transaction costs, improve market access, and enable women to fully benefit from rice value chain participation, enhancing income and economic resilience.
iii. Programs should encourage value-addition activities such as rice milling, packaging, branding, and entrepreneurship training, while also supporting women's access to land and productive

resources. This will increase income-generating opportunities, foster long-term asset accumulation, and strengthen women's economic security and welfare in the rice value chain.

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