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Marko Jeločnik, Institute of Agricultural Economics, Belgrade, Serbia

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EDITORIAL OFFICE:

Volgina Street no. 15, 11060 Belgrade, Serbia

Phone/fax: +381 11 69 72 858

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CONTENT:

ANALYSIS OF RISKS AND CONSTRAINTS FACED BY CASHEW FARMERS IN OGBOMOSHO, OYO STATE, NIGERIA

Mercy Funke Salami[1], Julius Bello[2], Kehinde Kikelomo Osasona[3], Rukayat Olajumoke Ibrahim[4]

Abstract

Research has focused on cashew production, profitability, and marketing. However, the risks and constraints faced by cashew farmers have yet to receive sufficient attention. Hence, this study was conducted to examine the risks and constraints faced by cashew farmers and the management techniques adopted to curtail these challenges in Ogbomosho, Oyo state, Nigeria. The data for this study was gathered from 120 cashew farmers who were randomly selected via a two-stage sampling procedure. The study used descriptive statistics to examine the socio-economic characteristics of the respondents and to profile the risks and constraints management strategies adopted by the cashew farmers. Index ranking was used to analyze the various risks and challenges faced by cashew farmers. As major risks faced by cashew farmers were price fluctuation, theft, and adverse weather conditions, while the most pressing constraints were poor access to extension services and inadequate access to storage facilities. Enterprise diversification, off-farm income, insurance, and contractual farming arrangements were the major risk management strategies adopted by the cashew farmers. Policies that would aid the stabilization of cashew prices should be put in place. More so, extension services should be made available to cashew farmers alongside the provision of stress-tolerant cashew cultivars.

Key words: Risks, constraints, risk management, cashew production, cashew farmers.

JEL[5]: D30, Q19

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1 Mercy Funke Salami, Ph.D., Department of Agricultural Economics and Farm Management, PMB 1515, University of Ilorin, Ilorin, Kwara State, Nigeria, Phone: +234 703 047 38 09, E-mail: salami.mf@unilorin.edu.ng (corresponding author), ORCID: https://orcid.org/0000-0003-0236-0985

2 Julius Bello, B.Sc., Department of Agricultural Economics and Farm Management, PMB 1515, University of Ilorin, Ilorin, Kwara State, Nigeria, Phone: +234 813 611 99 05, E-mail: JuliusBello61@gmail.com, ORCID: https://orcid.org/0000-0002-1901-9372

3 Kehinde Kikelomo Osasona, M.Sc., Department of Agricultural Economics and Farm Management, PMB 1515, University of Ilorin, Ilorin, Nigeria, Phone: +234 806 876 68 04, E-mail: okennieegreat@gmail.com, ORCID: https://orcid.org/0000-0001-5652-4514

4 Rukayat Olajumoke Ibrahim, B.Sc., Department of Agricultural Economics and Farm Management, PMB 1515, University of Ilorin, Ilorin, Nigeria, E-mail: bintibroheemimam@gmail.com, ORCID: https://orcid.org/0009-0000-4230-6866

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Introduction

Cashew (*Anacardium occidentale*) farming is crucial to Nigeria's agricultural sector, making a significant economic contribution and supporting the livelihoods of numerous farmers (Eze et al., 2023). For many farming households, cashews have grown to be a very important agricultural product. The importance of cashews, particularly the nut, in Nigeria cannot be overstated, as their yield has a substantial impact on the nation's GDP, public revenues, and foreign trade (Oluyole et al., 2015).

Cashew is grown in several parts of Nigeria, while the Kogi, Oyo, Enugu, Osun, and Anambra are the major producing states (Agboola Adedoja et al., 2022). Aside from being the main source of revenue for many farmers, it is also a major export sector of the country. Cashew exports contribute about 8% of Nigeria's non-oil export revenue (Esan et al., 2018). This fact is further corroborated by Ogunwolu et al. (2020), who find that cashews contributed between 25 million to 35 million USD from 2010 to 2014. This fact has been rose to 342 million USD in 2017, but declined to 119 million USD in 2019. The value of cashew nuts exported from Nigeria is gradually appreciating recently, as it rose to 156 million USD in 2021 (Statista, 2023). This makes cashew nut export to be the leading agricultural export product in Nigeria, as of the second quarter of 2022 (NBS, 2022).

More so, according to Adeigbe et al. (2015), Nigeria is a leading producer of good quality cashew nuts, second only to Vietnam and closely followed by India, Cote d Ivoire, and the Philippines. Therefore, this crop needs to be given high priority, given its importance as a raw material for the local industries, as well as an export commodity (Oladejo, 2015).

Cashew remains one of the most important export crops in the Western region of Africa (Ricau, 2019). With a consistent market share of 45%, since 2015, the region has emerged as a significant player in the global cashew market (Monteiro et al., 2017). As demonstrated by the enormous increase in cashew production from 400,000 MT to approximately 1,800,000 MT between 1961 and 2016 (ACA, 2016), West Africa is dominating both the existing and emerging cashew markets. Cashew is seen as an auspicious weapon for poverty reduction in Africa, and a source of hope for many people due to its critical role in supporting the livelihoods of numerous small-scale farmers, while contributing to national income (Keller, 2010; Sanyang, Kuyateh, 2018).

However, from a sustainable agricultural perspective, the economic potential of cashews is not fully maximized. This is largely because cashew farmers are perpetually faced with lots of risks and constraints in cashew production thus impacting the productivity, marketing, and availability of cashews. Cashew farmers face various risks that could significantly impact their agricultural activities and overall farm profitability (Monteiro et al., 2017).

These risks include unpredictable weather patterns, pests and diseases, market fluctuations, price volatilities, etc. (Singla, Sagar 2012; Sarwar, Saeed, 2013; Wauters et al., 2014; Catarino et al., 2015; Ahmad et al., 2019).

Monteiro et al. (2015) reported that the effective management of risks is crucial for the sustainability and success of cashew farming operations. Risk and constraint management strategies are implemented to identify, assess, and mitigate potential risks, enhancing the farmers' ability to cope with adverse events and protect their investments.

While many researchers (Oluyole et al., 2015; Oladejo, 2015; Salau et al., 2018; Agada, Sule, 2020) have investigated cashew production, profitability, marketing, and constraints, respectively, there is yet paucity of knowledge as regards the risks facing cashew farmers and the constraint management techniques adopted by cashew farmers. Therefore, it becomes imperative to identify these challenges and management techniques that could minimize their impact on cashew production.

Understanding the risk management strategies applied by cashew farmers is crucial for developing appropriate policies, interventions, and support systems to enhance the resilience and profitability of the cashew industry. Thus, the objectives of this research are as follows:

a) To identify the socio-economic characteristics of cashew farmers in Ogbomosho, Oyo State;

b) To categorize the various risks and constraints faced by cashew farmers in Ogbomosho, Oyo State; and

c) To analyze the risk and constraints management strategies adopted by cashew farmers in Ogbomosho, Oyo State.

Methodology

Study area

The research was carried out in Ogbomosho, Oyo State, Nigeria. This region is the most predominant zone for cashew production. Ogbomosho is in the southwestern part of Nigeria. Focusing to specific geographical area, the study provides valuable insights into the risk management practices employed by cashew farmers in a high-potential cashew-growing region.

Ogbomosho is a pre-colonial urban hub and Oyo State is the second-largest metropolis in terms of both population and area. The city lies roughly 80 km from Ilorin and Osogbo, the capital cities of Kwara and Osun State respectively, and 100 km from Ibadan, the capital of Oyo State.

Data collection and sampling methods

This study relied on cross-sectional data sets from cashew farmers in Ogbomosho, Oyo State, Nigeria. Data were gathered through the carefully designed questionnaire to obtain vital information from the target population. The mode of inclusion of respondents in the study implies that they are all cashew farmers, regardless of whether they cultivate other crops or not. Nevertheless, the findings of this study focused strictly on cashew production, leaving aside other farming potentials that may be owned by the respondents. The study was conducted in the Ogbomosho metropolis, using a snow-balling technique. A total of 120 cashew farmers were interviewed. Participation in the research by respondents was entirely voluntary. Above all, it was asked for oral consent from all respondents before interviewing them. Data collection for the study was performed in period August-September 2022. As at that time, there was no access to the list of registered cashew farmers in Ogbomosho, it was impossible to use the sample size calculator. Hence, research was relied upon a random sampling, after consulting similar studies.

Analytical tools

Descriptive analysis

Performed analysis involves descriptive statistics such are frequency distribution, percentages, and means, in order to define the socio-economic characteristics of cashew farmers in the study areas, as well as to analyze the risk management strategies adopted by cashew farmers.

Index ranking

Following the methodology of Ndamani and Watanabe (2016), the Index ranking approach was used to measure the risks and constraints faced by cashew farmers. Responses for the ranking were rated by using a 5-point Likert-scale with the scoring order of 5, 4, 3, 2, and 1 as strongly agree, agree, neutral, disagree, and strongly disagree, respectively. In social sciences and research, the 5-point Likert-scale analysis is a commonly used survey instrument for gauging attitudes, opinions, and perceptions.

Further, the Weighted average index (WAI) analysis was performed by the next formula (Ndamani, Watanabe, 2016):

$$WAI = \frac{F5W5 + F4W4 + F3W3 + F2W2 + F1W1}{F5 + F4 + F3 + F2 + F1} \quad ...(1)$$

$$WAI = \frac{\sum FiWi}{\sum Fi} = \frac{WI}{\sum Fi} \quad ...(2)$$

Where,

F = frequency;

Wi = weight of each scale;

i = individual scale;

WI = weighted index.

Results and Discussions

The socioeconomic characteristics of cashew farmers are analyzed and include gender, age, marital status, farming experience, household size, educational status, membership of association, and access to credit facilities. The mentioned characteristics are presented in next table (Table 1.).

A majority (79.2%) of the respondents were males, contrary to 20.8% of females, meaning that cashew production in the study area is dominated by males. This is in line with the findings of Farayola et. al (2013), who revealed that 78.4% of cashew farmers in their study area are males. Larger share of males could be found in fact that male kids are usually thought to be the inheritors of farmland. In addition, a plausible explanation for this dominance could be that women are mostly active in off-farm activities such are storing and selling farm products, while men have been concentrated solely on farm activities. A vast majority of the respondents (74.1%) were above 50 years of age, while 17.5%, 6.7%, and 1.7% of the respondents were in age groups of 41-50, 30-40, and below 30, respectively.

Table 1. Socio-economic characteristics of cashew farmers in the study area

Variables	Frequency (n=120)	Percentage	Mean
Gender			
Male (1)	95	79.2	
Female (2)	25	20.8	-
Age			
Below 30	2	1.7	
31-40	8	6.7	
41-50	21	17.5	56.04167
51-60	28	23.3	
61-70	28	23.3	
71 and above	33	27.5	
Marital status			
Married	93	77.5	
Widow	26	21.7	-
Single	1	0.8	
Farming experience			
Below 20	10	8.3	
21-40	49	40.8	39.558333
41-60	45	37.5	
60 and above	16	13.3	
Household size			
Below 5	7	5.8	
5-10	46	38.5	11.933333
11-15	54	45.0	
16 and above	13	10.8	
Education level			
Primary	31	25.8	
Secondary	27	22.5	-
Tertiary	9	7.5	
No formal	53	44.2	
Membership association			
Yes	70	58.3	-
No	50	41.7	
Access to credit			
Yes	7	5.8	-
No	113	94.2	

Source: Salami et al., 2022.

Related to marital status, 77.5% of respondents belong to the group of married, 21.7% of them were widows, and 8% of respondents were single. This result shows that cashew farming is mostly dominated by married people in the study area. Modal years of farming experience is 21-40 years, meaning that the farmers are vast in the cashew business. Mentioned could affects their productivity and capability to manage risks associated with cashew farming. With regards to household size (size of family), 45% of the respondents had a household size of 11-15 people. This could help reduce the cost of hiring labor.

The distribution in terms of the education level shows that 25.8% of the cashew farmers finished primary education, 22.5% of them had secondary education, only 7.5% of them had tertiary education, and 44.2% have no formal education. Mentioned agrees with the research results of Oluyole et al. (2015), who found that 44.4% of their respondents had no formal education.

This result indicates that most of the respondents are illiterate, and this could be a limitation to the type of risk management strategies that can be adopted by the farmers. Besides, 58.3% of the respondents are members of the association, while 41.7% are not. Lastly, Table 1. shows that 94.2% of respondents had no access to credit, while only 5.8% had access to credit facilities.

On the one hand, there are identified the major risks faced by the cashew farmers, while on the other hand, there are examined the constraints that militate against their efficiency. The identified risks include pest and disease infestation, adverse weather conditions, theft, and price fluctuation. The main constraints are poor extension services and inadequate storage facilities (Table 2.).

Table 2. Risks and constraints faced by cashew farmers

Risks and Constraints	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree	WS	MS	Rank
Pest and disease infestation	31	82	6	1	0	503	4.19	4th
Adverse weather condition	61	53	6	0	0	533	4.45	3rd
Theft	86	32	2	0	0	564	4.70	2nd
Price fluctuation	94	26	0	0	0	576	4.78	1st
Poor extension services	9	53	47	11	0	420	3.50	5th
Inadequate storage facilities	2	2	14	88	14	258	2.08	6th

Source: Salami et al., 2022.

Note: WS - Weighted score; MS - Mean Score.

Price fluctuation, as revealed in Table 2., is the most challenging risk faced by cashew farmers in the study area. Price fluctuation simply refers to variability in prices over time. This is a challenge globally for the most farmers. As such, they have to rely on government intervention and income diversification to mitigate the risk of price fluctuation. Theft is ranked as the second risk facing cashew farmers. This is in line with the findings of Philips (2016), and Lawal and Uwagboe (2017) who have also identified theft as a large risk faced by cashew farmers in Oyo state. Cashew farmers are vulnerable to theft of cashew nuts by strangers because of their high nutritional and economic value.

Another risk that cashew farmers are faced with is unfavorable weather conditions. Cashew production is generally rainfed in Nigeria, hence adverse weather conditions could pose a serious production risk. Although cashews are drought-resistant, adverse weather conditions can affect the fruit and nut size which in turn would affect the level of farmers' profit. Pest and disease infestation is ranked 4th. All these risks, especially in developing countries have negative effects on farmers' livelihoods, and even a nation's food security, due to the possibility of a decline in overall crop production (Shang, Xiong, 2021).

Poor extension services and inadequate storage facilities are the primary constraints faced by the cashew farmers within the observed territory.

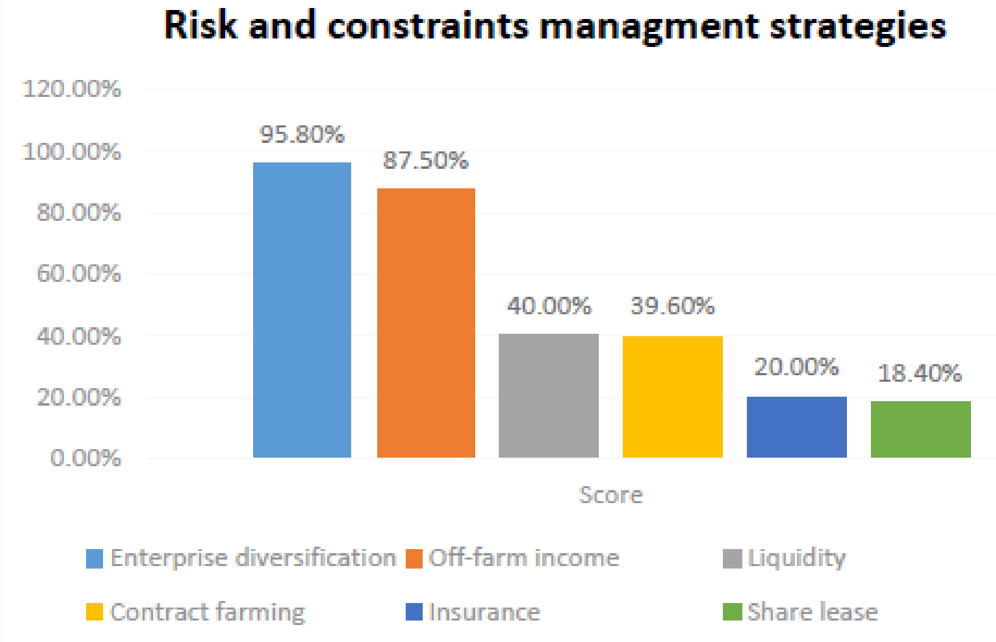
Risks and constraints management strategies adopted by cashew farmers

Figure 1. shows that 95.8% of the respondents diversified their enterprise as the major risk management strategy adopted by the cashew farmers, particularly against risks like price fluctuation, adverse weather conditions, and theft. This is in line with the result of Motin et al. (2015), who reported that 83.5% of farmers in Ghana adopted diversification as a major risk management technique in farming. A plausible explanation for this could be the unstable and sometimes unpredictable nature of farming. Thus, farmers tend to diversify into businesses with low-risk levels. Also, 87.5% of the respondents have means of earnings from off-farm income. These arise either from agriculture/non-agriculture-related activities, such as trading, weaving, fishing, and poultry farming.

Around 20% of the respondents adopted insurance as a risk management strategy against pest and disease infestation and adverse weather conditions. This is in line with *a prori* expectation. Most farmers are unwilling to take up insurance for their farm activities, due to the high costs of insurance, and the rigorous administrative procedures. Other risk management strategies adopted in the study area include liquidity (40%), contract farming (39.6%), and share lease (18.4%).

Sufficient liquidity enables farmers to make investments in security measures to safeguard their harvested crops and cashew orchards. This could entail putting in place surveillance systems, hiring security guards, or taking other anti-theft precautions. When farmers have enough money, they can react quickly to theft situations, and take prompt action to protect their assets.

Figure 1. Risk and constraints management strategies adopted by cashew farmers



Source: Salami et al., 2022.

More so, farmers can quickly invest in pest and disease management techniques when they have enough financial assets. This entails investing in disease-resistant cultivars, buying high-quality insecticides, and employing qualified workers to carry out pest management procedures. Prompt investments can shield the cashew crop and production overall against infestations or lessen their effects.

Conclusion and Recommendations

To conclude, price fluctuation, theft, adverse weather conditions, and pests and diseases are the major risks faced by cashew farmers in Ogbomosho. Their major constraints are inadequate access to extension services and inadequate storage facilities. Enterprise diversification, off-farm income, insurance, and liquidity remain the major risk management strategies adopted by cashew farmers. This research has thus contributed to the existing knowledge on risk management strategies in cashew farming, particularly in the context of Ogbomosho, Oyo State, Nigeria. The research results will assist policymakers, agricultural organizations, and farmers in developing targeted interventions and support mechanisms to strengthen risk management, practices and improve the overall resilience of cashew farming systems in Nigeria.

Future research can analyze the dynamics of technology adoption among cashew farmers through the gender lens. The following recommendations are hereby suggested based on the study findings:

1. Implementation of a price support program for the protection of farmers against price fluctuations;
2. To safeguard farmers against huge losses that can occur during the production process, farmers should be urged to obtain insurance coverage;
3. Planting materials that are tolerant to drought, and resistant to pests and diseases should be also made available to farmers.

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SOCIOECONOMIC FACTORS INFLUENCING RURAL WOMEN ACCESSIBILITY TO EMPOWERMENT PROGRAMS IN KOGI STATE, NIGERIA

Ajoke Oluwatoyin Kayode[1], Sijuwade Adebukola Adebayo[2], Stella Ojone Adejoh[3], Adeseye Oluwasikemi Awoyemi[4]

Abstract

The goal of empowerment programs is to promote initiatives aimed at uplifting society's impoverished and disenfranchised citizens, who are typically women and youth. This paper, therefore, examined the socioeconomic features influencing rural women accessibility to empowerment programs in Kogi state, Nigeria. The research is specifically looking at socioeconomic characteristics of respondents, ascertaining the level of effectiveness of empowerment programs on agricultural activities, describe the level of accessibility to empowerment programs and identifying the constraints of empowerment programs. Random and snow ball sampling methods have been combined to gather information from 125 respondents. Descriptive statistics and multiple linear regression were used to analyze data. Average farm size was 2.82 ha, with annual income of 466,000 NGN. Empowerment programs such as Kogi APPEAL and Farmer moni were mostly accessible among women farmers. Marital status, household size, education were significant factors in accessing empowerment programs among women in Kogi state. Therefore, it is recommended that policies and programs that address women farmers' access to empowerment programs assets should be more inclusive.

Key words: Women, empowerment, rural women, effects, programs.

JEL[5]: Q10, Q18

1 Ajoke Oluwatoyin Kayode, Ph.D., Department of Agricultural Extension and Rural Development, University of Ilorin, PMB 1515, Ilorin, Nigeria, Phone: +234 806 730 93 97, E-mail: kayode.ao@unilorin.edu.ng, ORCID: https://orcid.org/0000-0002-9437-1552

2 Sijuwade Adebukola Adebayo, Ph.D., Department of Agricultural Extension and Rural Development, University of Ilorin, PMB 1515, Ilorin, Nigeria, Phone: +234 816 517 43 09, E-mail: adebayo.sa@unilorin.edu.ng, ORCID: https://orcid.org/0000-0001-9842-2137

3 Stella Ojone Adejoh, Ph.D., Department of Agricultural Economics and Extension, Federal University Lafia, Nasarawa, Nigeria, Phone: +234 803 597 25 30, E-mail: stelloken@yahoo.com, ORCID: https://orcid.org/0000-0002-3692-020X

4 Adeseye Oluwasikemi Awoyemi, Ph.D., Department of Agricultural Extension and Rural Development, University of Ilorin, PMB 1515, Ilorin, Nigeria, Phone: +234 806 592 4120, E-mail: awoyemi.oa@unilorin.edu.ng, ORCID: https://orcid.org/0000-0002-5940-2528

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Introduction

Women's empowerment, politically, socially, economically, and health-wise, has been globally recognized as critical in bridging the gender gaps and achieving the 2030 Agenda for Sustainable Development. Hence, sustainable development and empowering of women are directly related. Rural women empowerment is increasing and improving social, economic, political, legal, and environmental prowess of rural women to guarantee their equality, give them the self-assurance to assert their rights, and enable them to actively participate in decision-making processes (Ojukwu, 2013).

According to Rathnachandra and Malkanthi (2020), women's empowerment is the process of gaining more control over family decision-making, access to resources, social participation, freedom of movement, and financial capability. However, empowerment could be in the form of cash, grants, equipment, and tools. The purpose of empowerment programs is to support interventions aimed at uplifting the underprivileged and marginalized members of society which normally include women and youths (Obetta, 2009). These programs are done throughout the various interventions, dependent on the beneficiary's developmental needs (Imonikebe, 2010; Ejumudo, 2013).

Women have key role in sustainable growth of economy by contributing to household and agricultural operations such as crop production, livestock rearing, horticultural, post-harvest activities, agroforestry, fisheries, etc., oftenly together with men (Umar, 2019; Kayode, Okunade, 2019). Mahmud et al. (2017) affirm that women empowerment in agriculture is an important dimensions of empowerment for rural women.

Over the years, government has been introducing several poverty alleviation programs supposedly targeted to rural women empowerment in Nigeria, such as, Better Life for Rural Women, Family Economic Advancement Programme, Family Support Program, or many microcredit schemes for women. Unfortunately, empowerment programs have not been able to transform rural development for rural women to benefit from. This manifest itself in failure of development and poverty alleviation strategies to create synergy between rural poverty and rural agricultural development (Kelvin Iloafu et al., 2019; Mukoro, 2020). Many researches (Ering et al., 2014; Akpomuvie, 2018; Ohowofasa et al., 2013, Natukunda et al., 2021) have revealed empowerment programs among rural women, but there is weak focus on the effects of these programs on women farmers' agricultural activities. So, it is pertinent to analyze if empowerment programs accessed by the women affects their agricultural activities, or not. Performed research will be looking at the following objectives: describing socioeconomic characteristics of respondents in the study area, determining level of accessibility to empowerment programs, ascertaining level of effectiveness of empowerment programs on agricultural activities among the respondents, identifying constraints of empowerment programs for women farmers in the study area, and testing the hypothesis, which state that there is no significant relationship between women socio-economic characteristics and level of effectiveness of accessed empowerment programs. The performed research contributes to the existing empowerment studies by identifying socioeconomic value influencing empowerment programs in Nigeria.

Methodology

Study Area

The research was performed in Kogi state, Nigeria. It is located between latitudes 7 45'N and longitudes 6 45'E, covering in total area of about 28,312.64 km^2 (Adah et al., 2022). Kogi state has a projected population of 1,996,700 at 2016. (WPR, 2020). The climate condition of the area is favorable for growing the wide variety of staples like yam, cassava, beans, maize, sorghum, rice, cotton, fruits, and vegetables.

Sampling Techniques

Three-stage sampling procedure has been used to select respondents for the research. The first stage involved random selection of 25% of the 21 Local Government Areas (LGA) in the state, arriving at 5 LGAs which are Ijummu, Mopa-muro, Kabba-bunnu, Yagba-east, and Yagba-west. In the second stage, 5 communities were randomly selected from each LGA, given a total of twenty-five communities. Third stage involved used of snow ball technique to select five women farmers who have accessed empowerment programs. A total of 125 respondents were used for the research work. Snow-ball technique was used because there is no association of women empowerment within the Local Government Areas (LGA) which could form the sampling frame. The selection was done with the aid of extension workers in 25 communities and it was done in four days during 2022.

Limitations of the Research

This research has a few limitations. Out of the six empowerment programs accessible to the women farmers only two were initiated at the state level while four were at the national level. Hence women have more access to the empowerment programs at grassroot levels than national level. Also, there was no registered list or association of women farmers who were empowered for agricultural purposes in the LGA which could form the sampling frame. That was why the snow-ball sampling procedure was used. Also, the empowerment programs were not designed for agricultural purposes, so it could be easy for beneficiaries to divert the empowerment opportunities to another business out of agriculture. More so, there was dearth of empirical evidence about effects of empowerment programs on agricultural activities in the Kogi state. It was also noted that most rural women farmers were in disadvantaged position, mainly related to being empowered for agricultural production because of the strict conditions attached to the programs (Adeleke, Akinbile, 2019).

Data Analysis

Descriptive statistics used in data analysis involves frequency, percentages, mean, and standard deviation, while multiple regression analysis (Ordinary Least Square Method) has been performed to test the predefined hypothesis.

The used regression model is expressed by next formula:

$$Y = \beta0 + \beta1X1 + \beta2X2 + \beta3X3 + \ldots. + \beta6X6 + \beta7D1 + ei$$

Where,

$\beta0$ = intercept,

$\beta1$ - $\beta8$ = coefficients,

Y = level of effectiveness of empowerment programs,

X_1 = age (years),

X_2 = household size (number of people feeding from the same pot),

X_3 = highest level of education (years of schooling),

X_4 = average annual farm income (amount in NGN),

X_5 = farm size (in ha),

X_6 = frequency of extension contact,

D_1 = marital status (1 = married, 0 = otherwise),

ei = error term.

Level of effectiveness of empowerment program on agricultural activities of rural women in the study area was measured on a three-point Likert type scale: Very effective (1), Effective (2), Not effective (3). The level of accessibility to empowerment programs was measured on a four-point Likert-type scale: Highly accessible (4), Moderately accessible (3), Low accessible (2), Not accessible (1), while constraints to empowerment programs among rural women was measured on the level of these constraints which was based on three-point Likert-type scale: Very serious (3), Serious (2), Not serious (1).

Results and Discussion

Socioeconomic Characteristics of the Respondents

Table 1. revealed that mean age of the rural women is 47.1 years, what implies that majority are within their economic age, being actively engaged in agricultural operations.

Table 1. Socio-economic Characteristics (N = 125)

Variables	Frequency	Percentage	Mean	SD
Age				
18-25	6	4.8	**47.1**	**6.11**
26-35	24	19.2		
36-45	51	40.8		
> 45	44	35.2		
Marital Status				
Married	115	92.0		
Other wise	10	8.0		
Household size (persons)				
≤ 2	25	20.0	**3.67**	**1.37**
3-5	85	68.0		
> 5	15	12.0		
Years of Schooling				
0	22	17.6	**12.0**	**2.86**
1-6	23	18.4		
7-12	66	52.8		
> 12	14	11.2		
Annual Income (NGN)				
≤200,000	21	16.8	**466,000.00**	**223992.37**
200,001-300,000	19	15.2		
300,001-400,000	21	16.8		
400,001-500,000	18	14.4		
≥500,000	46	36.8		
Farm Size (ha)				
≤ 2.00	52	41.6	**2.82**	**1.10**
3.00-4.00	68	54.4		
> 4.00	5	4.0		
Extension contact in the last six month				
≤ 2	64	51.2	**1.97**	**0.49**
3-6	48	38.4		
7-10	11	8.8		
>10	2	1.6		

Source: Kayode et al., 2022.

Women farmers have average 12 years of schooling, which contradicts findings of, Ayebuomwan et al. (2016) who state that most rural women are non-literate. Previous is in line with the findings of Kayode et al. (2017) that Kogi state women farmers are usually within the age categories of 41-50. The mean annual income of farmers was 466,000 NGN, setting their daily income at about 1,309 NGN, while average of 6 persons lives at one household, it implies that respondents are living below the poverty line of 1 USD/day/person. Mentioned is in line with results of Falola et al. (2020) who states that the mean income earned by women was 15,344.65 NGN monthly. Farm size available to respondents show that over the half of farmers (54.4%) have at disposal a farmland in range 3-4 ha with 1.97 mean of frequency of extension contact.

Accessibility of Women Farmers to Empowerment Programs

Results presented in next table (Table 2.) are focused to accessibility to several empowerment programs active in Nigeria. Its shown that Kogi Appeals (MS = 3.77) is the most accessible. This may likely be because, the program is sponsored by the World Bank, offering to its beneficiaries many valuable benefits. Program also empowers women, youth and people with disabilities to take the lead role in farming by providing farm inputs, incentives, and training for the farmers. Kogi Appeals is followed by Farmer moni program (MS = 3.46), Women and Youth Empowerment Program (WYEP), (MS=3.10), Trader moni (MS = 2.09), Kogi Women and Youth Empowerment Foundation (MS = 1.56), while the least accessible is Aliko Dangote Foundation (MS = 1.15). Previously mentioned implies that women access the empowerment programs at different levels, what is contradict to the findings of Adeleke and Akinbile (2019).

Table 2. Level of accessibility to the Empowerment Programs

Empowerment program available	Not accessible	Low accessible	Moderate accessible	Very accessible	Mean
Kogi appeals	1(0.8)	3(2.4)	20(16.0)	101(80.8)	3.77
Farmer moni	7(5.6)	11(8.8)	24(19.2)	83(66.4)	3.46
Women and Youth Empowerment Program (WYEP)	12(9.6)	20(16.0)	37(29.6)	56(44.8)	3.10
Trader moni	67(53.6)	9(7.2)	20(16.0)	29(23.2)	2.09
Kogi Women and Youth Empowerment Foundation (KOWYEF)	72(57.6)	40(32.0)	9(7.2)	4(3.2)	1.56
Aliko Dangote Foundation (ADF)	114(91.2)	5(4.0)	4(3.2)	2(1.6)	1.15

Source: Kayode et al., 2022.

It is worth noting that while Kogi appeals is funded by the World Bank while trader moni, farmer moni, women and youth empowerment programs were funded by the Federal government and Aliko Dangote foundation is been funded by a non-governmental organization.

Effectiveness of Empowerment Programs on Agricultural Activities

Results in Table 3. show the level of positive influence of empowerment programs on agricultural activities within the study area (positive effects such are increase in farm output (primarily gained yields) by providing adequate farm input, giving farmers' loans with little or without collateral, providing extension services, etc.). The result shows that the Kogi appeals empowerment program had the highest effect (MS = 2.83) on agricultural activities within the study area, followed by Farmer moni, (MS = 2.50), Women and Youth Empowerment Program (MS = 2.28), Trader moni (MS = 1.68), Kogi Women and Youth Empowerment Foundation (MS = 1.32), while the least impactful was Aliko Dangote Foundation (MS = 1.10). This indicates that the Kogi appeals empowerment program has more expressed effects on rural women's agricultural activities, since it is more accessible than another empowerment programs. Reason of this is because the Kogi appeals program focuses on women just within the Kogi state, while the rest of empowerment programs are nationwide, having more beneficiaries to cater to.

Table 3. Level of effectiveness of empowerment programs on agricultural activities

Empowerment program available	Not effective	Effective	Very effective	Mean
Kogi appeals	2(1.6)	17(13.6)	106(84.8)	2.83
Farmer moni	14(11.2)	34(27.2)	77(61.6)	2.50
Women and Youth Empowerment Program (WYEP)	23(18.4)	44(35.2)	58(46.4)	2.28
Trader moni	70(56.0)	25(20.0)	30(24.0)	1.68
Kogi Women and Youth Empowerment Foundation (KOWYEF)	96(76.8)	18(14.4)	11(8.8)	1.32
Aliko Dangote Foundation (ADF)	114(91.2)	9(7.2)	2(1.6)	1.10

Source: Kayode et al., 2022.

Categorization of Respondents Based on Level of Effectiveness

In Table 4. was showed the categorization of respondents based on level of effectiveness of empowerment programs among women farmers. The high effect level (>1.50) has the highest share, 97.6%, followed by the low effect level (≤ 1.50) with 2.4%. The mean score for the effectiveness level is 1.95, indicating that the empowerment programs in general have helped to ease the challenges associated with agricultural activities within the study area. Effectiveness of Kogi appeals comes from the fact that it could be well and easily monitored to ensure proper usage of agricultural tools and input provided to women. Mentioned is in line to statement of Goel and Sah (2015) and Akpomuvie (2018), believing that rural women empowerment facilitates rural and agricultural development process.

Table 4. Categorization of the level of effectiveness of empowerment programs on agricultural activities

Level	Frequency	Percentage	Mean
Low (≤ 1.50)	3	2.4	1.95
High (>1.50)	122	97.6	

Source: Kayode et al., 2022.

Constraints of Empowerment Programs for Rural Women Farmers

Results presented in Table 5. show that inadequate training on how to effectively use the farm technologies is ranked as the first among the constraints of empowerment programs for rural women farmers with a mean score 2.54.

Table 5. Constraints of empowerment programs for rural women farmers

Constraints	Not serious F (%)	Serious F (%)	Very serious F (%)	Not a constraint F (%)	Mean	Rank
Inadequate training on how to effectively use farm technologies	4(3.2)	41(32.8)	76(60.8)	4(3.2)	2.54	1st
Inappropriate information about the empowerment Program	7(5.6)	56(44.8)	60(48.0)	2(1.6)	2.41	2nd
Level of education	6(4.8)	43(34.4)	63(50.4)	4(3.2)	2.35	3rd
Corruption on the part of implementers	10(8.0)	61(48.8)	54(43.2)	0(0)	2.35	3rd
Excess household burden on women	4(3.2)	45(36.0)	61(48.8)	15(12.0)	2.34	5th
Influence of spouse	21(16.8)	66(52.8)	27(21.6)	11(8.8)	1.96	6th
Women's non-chalant attitude	10(8.0)	74(59.2)	21(16.8)	20(16.0)	1.93	7th
Membership of association and co-operative societies	22(17.6)	43(34.4)	20(16.0)	40(32.0)	1.66	8th
Cultural background	75(60.0)	34(27.2)	16(12.8)	0(0)	1.53	10th
Gender	72(57.6)	32(25.6)	16(12.8)	5(4.0)	1.51	11th
Number of farming years	70(56.0)	35(28.0)	13(10.4)	7(5.6)	1.49	12th
Political affinity	96(76.8)	16(12.8)	6(4.8)	29(23.2)	1.22	14th

Source: Kayode et al., 2022.

Mentioned indicates that inadequate training towards the use of new farm technologies is the highest form of constraint for the proper implementation of empowerment programs, followed by the inappropriate information related to empowerment programs with mean score of 2.41. These results show that there is need for adequate organization of extension services within the study area, that will properly educate the women to appropriate use the available farm technologies, and also create awareness on the empowerment programs. Political affinity is the least constraint. It means that the political affinity of the women does not affect the implementation of the empowerment program.

The Result of Tested Hypothesis

In Table 6. is shown the multiple regression analysis between some selected socioeconomic variables and accessibility of empowerment programs among the women farmers. It shows that at $p < 0.05$, marital status ($\beta = 0.063$), size of household ($\beta = 0.067$) and level of education ($\beta = 0.061$) were the main determinants of accessibility of empowerment program among the women in Kogi state. The positive coefficients of the variables indicate that increase in each factor initiate the increase in level of accessibility to empowerment program. Educational level ($\beta = 0.061$) may increase sophistication, knowledge, and attitude, altering the level of accessibility to empowerment programs. It may also imply that women with higher level of education are involved more to household expenditure contrary to those with lower one. Mentioned could be explained that education level supports innovation. So, educated women are likely to be more oriented to innovatios and entrepreneurial activities, contributing more to households' consumption expenditure. As observed by Falola et al. (2020), Olomukoro (2015) and Aromolaran (2010), globally, countries tend to invest in education, as it facilitates personal and social development.

Table 6. Result of Multiple Linear Regression of Determinants of Accessibility of Empowerment Programs

Variables	Unstandardized Coefficients		T	Sig.
	B	Std. Error		
(Constant)	1.908	0.186	10.234	0.000
Age	0.007	0.030	0.237	0.813
Marital Status	0.063*	0.024	2.681	0.008
Household size	0.067*	0.029	2.292	0.024
Level of education	0.061*	0.030	1.999	0.048
Income	3.436E-7	0.000	1.788	0.076
Farm Size	-0.011	0.038	-0.286	0.775

Source: Kayode et al., 2022.

Note: * *Significant at $p < 0.05$, $R^2 = 0.391$.*

Conclusion and Recommendations

Despite constraints faced by women farmers in accessing empowerment programs in rural areas, they represent the great mean of support for alleviating the level of poverty within the rural areas. It is clear that women are largely involved in farming activities and fully willing and ready to use in best way any empowerment program that could advance their livelihood. The role and impact of empowerment programs for women cannot be undermined, as they play significant role in improving the lives of women. Factors as marital status, household size and level of education were determinant of empowerment programs in the study area. Therefore, it is advised that empowerment programs focused to improving the technical knowledge of women should be organized to increase the technical know-how of rural women on farm modern technologies, while extension agents and relevant stakeholders should create more awareness on women empowerment programs through the mass media channels accessible to rural women farmers.

Future studies should explore gender inclusion in empowerment programs among farmers and the effect on agricultural activities. Also, this study can be replicate outside the study area.

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LAND EXCHANGE PRACTICE AND TECHNICAL EFFICIENCY OF RICE FARMERS IN NORTH-EASTERN ZONE OF NIGERIA

Mohamadou Sani[1], Josephine Bosede Ayoola[2], Djomo Choumbou Raoul Fani[3], Gbolagade Babalola Ayoola[4], Rabiu Mohammed Sani[5], Ukpe Udeme Henrietta[6]

Abstract

In the context of agricultural development, economic growth, and food security in Africa, examining the practice of land exchange holds significant relevance. This study analyses the practice of land exchange and its effect on farmers' performance in Norther Eastern Zone of Nigeria. A multi-stage sampling procedure was employed to select a sample of 400 rice farmers engaged in irrigation farming. The selected farmers participated in structured interviews, providing the necessary data for the study. Descriptive analysis (of the mean) revealed that farmers are engaged in land exchange (16.07%) using two methods: land exchange for agricultural use (or farming purposes) and land exchange for property. Using a logistic regression model, it was found that number of plots, decrease in distance among plots, practice of mechanization, decrease in production costs, and improvement of efficiency were factors influencing farmers to exchange land. The result also suggested that farmers exhibited a high level of technical efficiency, implying that there is room for further enhancement in efficiency through the adoption of advanced technologies and the optimal utilization of existing resources. The beta regression's results indicated that

1 Mohamadou Sani, Ph.D., Department of Public Economics, University of Garoua, P.O. Box: 346 Garoua, North Region, Cameroon, Phone: +237 691 125 909, E-mail: sanimohamadou47@gmail.com, ORCID: 0000-0002-9530-7034

2 Josephine Bosede Ayoola, Ph.D., Institute of Food Security, Joseph Sarwuan Tarka University Makurdi, P.O. Box: 2373 Makurdi, Benue State, Nigeria, Phone: +234 812 379 98 58, E-mail: jboseayoola@gmail.com, ORCID: 0009-0009-0690-1276

3 Djomo Choumbou Raoul Fani, Ph.D., Department of Agricultural Economics and Agribusiness, University of Buea, P.O. Box: 63 Buea, South West Region, Cameroon, Phone: +237 653 227 737, E-mail: djomo.choumbou@ubuea.cm, ORCID: 0000-0003-3028-2558

4 Gbolagade Babalola Ayoola, Ph.D., Farm and Infrastructure Foundation (FIF), Abuja, Nigeria, Phone: +234 814 785 65 40, E-mail: gbayoola@yahoo.com, ORCID: 0000-0003-2152-7779

5 Rabiu Mohammed Sani, Ph.D., Department of Agricultural Economics, Abubakar Tafawa Balewa University, Bauchi, Nigeria, Phone: +237 806 965 30 74, E-mail: msani65@gmail.com, ORCID: 0000-0002-3546-7968

6 Ukpe Udeme Henrietta, Ph.D., Department of Agricultural Economics and Extension, Federal University Wukari, P.M.B. 1020 Wukari, Taraba State, Nigeria, Phone: +234 808 423 57 00, E-mail: ukpe@tuwukari.edu.ng, ORCID: 0000-0001-7633-5112

land development have a negative effect on technical efficiency, while household size, rented land, and hired labor have positive effects. However, it was found that the practice of land exchange did not affect the level of technical efficiency of rice farmers in the study area, because of the observed limited land market and the high level of crop diversification. Hence, policymakers are advised to define land use rights explicitly and encourage land transactions, such as renting among farmers, selling occupancy rights, and transferring leasehold rights. These measures aim to improve land efficiency and bolster the land market.

Key words: Land exchange, efficiency, rice, irrigation, beta regression, Nigeria.

JEL[7]: Q1, Q15, R14

Introduction

Nowadays, farmers are using an increasing amount of fragmented land, which makes distance plot management more laborious and time-consuming. However, it is said that land fragmentation impedes the advancement of mechanical technology and the efficient implementation of irrigation (Demetriou, 2013, Strek et al., 2021). In order to overcome the issue of excessive distance plots into plots as large and regular as feasible, exchange of fragmented parcels (land consolidation) is performed (Len, 2017).

Land consolidation is defined as the voluntary or compulsory reconfiguration of land parcels within a defined area. Its primary objective is to improve the efficiency of land use by establishing larger and more continuous plots that are simpler to handle and cultivate (Holst, 2017). In some cases, land consolidation projects may incorporate land exchange, as a means of achieving consolidation objectives. For example, landowners may voluntarily exchange their fragmented parcels to create larger, more productive holdings. Conversely, land exchange activities can also contribute to the whole process of land consolidation by facilitating the consolidation of land resources in a more efficient manner (Knight, 2010; Asiama, 2019).

A land exchange agreement is generally understood to be a contract in which parties exchange one or more land parcels for better exploitation circumstances (Bullard, 2007). In the context of agriculture, land exchange is more precisely defined as a deal between two or more landowners to exchange lands in order to increase agricultural productivity. As a means to consolidate land ownership for more effective management, land exchange is a crucial tool for managing land tenure. Additionally, it is the method of choice for rearranging and readjusting land ownership with the

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government (Hartvigsen, 2015). The promotion of land exchange has been advocated in various regions as a strategy to tackle the problem of fragmented land holdings (Strek et al., 2021). Before the World War II, Dutch farmers improved their fields by exchanging their properties for one to another in an unregulated manner. According to legal definitions, land exchange is a private initiative that involved a minimum of three landowners (Yimer, 2014).

Klaus and Gershon (2010) highlight that access to land is crucial for household welfare and economic growth in rural areas. However, in developing countries, multiple elements including complex land tenure systems, absence of well-defined land rights, and administrative hurdles limit the use of land and other transactions related to land.

The legal system of several Sub-Saharan African nations stipulates that the state owns all land on behalf of the entire population. So, it is forbidden to sell land, or the land market is prohibited. But land is being exchanged for the cash without any legal documentation of transaction or ownership, nor any public acknowledgement of the terms of sale and purchase (FAO, 2010). It is what the phrase "informal formalization" from Benjaminsen and Lund (2003) refers to. Despite the fact that these transactions seem more frequent and routine, its unable to consider them lawful.

In South Africa, land exchange is a complex issue, deeply intertwined with the country's history of apartheid and the ongoing efforts to address historical injustices related to land ownership. The post-apartheid government has been working on land reform strategies to redistribute land to the historically disadvantaged black majority. This includes land exchange mechanisms as part of broader land redistribution and restitution programs. The process aims to correct the skewed land arrangements that have led to agricultural unproductivity and food insecurity for a significant portion of the population. However, the challenge remains to implement land reform in a way that also promotes food security and nation-building (Lahiff, 2020). In practice, land exchange in South Africa involves legal property transfers where parties exchange ownership over different pieces of land. This can help in rectifying the historical disparities in land ownership. However, it's essential that these exchanges are conducted fairly and transparently to ensure that they contribute positively to the country's socio-economic development (Lahiff, 2020).

Land exchange in Ethiopia is a critical component of the country's agricultural productivity and land tenure security. The Ethiopian government, recognizing the inefficiency of farming fragmented plots, has been encouraging farmers to create larger plots through voluntary land exchange. Nevertheless, there are no explicit statutes, rules, or directives that govern the process of land consolidation or specify its framework (GIZ, 2022). Moreover, Alemu et al. (2019) reveal a serious problem of comprehensive experience of farmers on land exchange projects. According to report, 68% of the surveyed farmers had never used a land exchange strategy to consolidate their holdings and increase output. The possibility of easier access to irrigated land and optimal farm operations, as well as shorting the distance between the holdings and town facilities are the primary drivers of the farmers engaged in land consolidation projects (Alemu et al., 2019).

In many parts of Africa, especially in Nigeria, smallholder farms dominate the agricultural landscape. Land exchange mechanisms can help consolidate fragmented landholdings, which can lead to improved efficiency through better management and the possibility of mechanization (Giller et al., 2021). Saleh et al. (2022) argue that the persistence of small farmland that characterizes agricultural activity in Nigeria is due to increasing land fragmentation, which reduces the efficiency of small farmers and represents a major challenge for Nigerian agriculture. Since it is widely accepted that the large farmers are generally more economically efficient, competitive, and profitable due to their economies of scale. This implies that land exchange, with its many benefits, may enhance the efficiency of farmers in Nigeria.

Some authors have highlighted the significance of land exchange for economic development. They contend that one of the key elements in ensuring agricultural progress through land usage is land exchange. For example, Len (2017) suggested that in order to create plots that are as large as feasible, the exchange of fragmented parcels aims to solve the issue of distant, or fractured plots. Furthermore, the exchange of land is a crucial instrument for land consolidation that individual farmers employ on their own initiative to increase the productivity of their farms (Hartvigsen, 2015).

Previous research carried out within the designated geographical area have examined various aspects such as the impact of rainfall variability on rice yield (Noel et al., 2020), the evaluation of the Dadin-Kowa irrigation scheme (Hassan et al., 2015), the efficiency of utilizing resources in the cultivation of rice (Barau et al., 1999; Tijjani, Bakari, 2013), and the comparison of technical efficiency among rice farmers under different land administration authorities (Sani et al., 2023). Recent research by Ayoola et al. (2022) has explored the reasons behind land exchange among farmers in the study area. However, this particular study did not provide an explanation of the land exchange process and its impact on the technical efficiency of rice farmers. Mentioned creates knowledge vacuum that required to be filled towards to understanding why farmers are exchanging their land. According to mentioned performed study has the main aim to analyze the land exchange practice and its effects on technical efficiency of rice farmers in Dadin-Kowa irrigation scheme area of Gombe and Borno States of Nigeria.

As specific aims of this study are defined: 1) analyze the practice of land exchange in the study area; 2) identify factors influencing farmers to exchange land in the study area; 3) determine the technical efficiency scores of rice farmers; and 4) assess the effects of land exchange on technical efficiency of rice farmers in the study area.

Analytical Framework

Logistic Regression Model

To understand the reasons behind farmers' acceptance or rejection of land parcel exchange, a logistic regression method was employed. Actually, whenever the dependent variable has just two values 0 and 1, or Yes and No, logistic regression is used. The model fits data to a logistic curve, to assess the probability of an event occurring, and analyzes the link between several independent factors and categorical dependent variable. Nonetheless, there exist two primary categories of logistic regression models: binary logistic regression and multinomial logistic regression. Binary logistic regression is commonly employed when the outcome variable is characterized by two distinct categories, while the independent variables can be of either continuous or categorical nature. In instances where the dependent variable comprises more than two categories, multinomial logistic regression is utilized. It allows for a broader range of outcomes.

One of the main advantages of using a logistic regression model relies on its simplicity and efficiency, especially in cases where the dataset features are linearly separable. Logistic regression models also provide well-calibrated probabilities when you're not only interested in the final classification, but also in understanding the certainty of the predictions (Sperandei, 2013).

Since the dependent variable in this work is dichotomous, binary logistic regression is then applied.

The model is specified as: $$P_i = \frac{1}{1 + e^{-(\beta_0 + \sum_{i=1}^{m} \beta_i X_i)}}$$

Where, is the probability to accept exchanging the land.

P_i ranges between 0 and 1, while P_i is nonlinearly related to $\beta_0 + \sum_{i=1}^{m} \beta_i X_i$

$L = \ln(\frac{P_i}{1 - P_i}) = \beta_0 + \sum_{i=1}^{m} \beta_i X_i$ and $\frac{P_i}{1 - P_i}$ is then the odds ratio in favor of exchanging the land. The intercept β_0 represents the numerical representation of the log-odds favoring the exchange of land if others variables are zero. β_i refers to the parameters that need to be calculated or estimated. X_i are independent variables.

If *i* takes any value between 1 and m, for example *k*, β_k represents the slope. It quantifies the alteration in L resulting from a one-unit adjustment in X_k, in other words, it indicates the extent to which the log-odds favoring land exchange are affected when X_k changes by one unit ($k \in [1; m]$).

Technical Efficiency

As explained by Battese and Coelli (1995), technical efficiency refers to the condition where it is possible to decrease the usage of inputs without causing any adverse impact on farm output. In simpler terms, technical efficiency is about achieving the highest possible output from a specific combination of inputs (Palmer, Torgerson, 1999).

In this study, Stochastic Frontier Production (SFP) is preferred, since it confers the advantage of employing econometric models to estimate production frontiers, which serve as benchmarks for measuring the performance of production units. It also provides a numerical value of performance that is objective, aiding policymakers in identifying performance gaps (Nguyen et al., 2022). The SFP function, as introduced by Battese and Coelli (1995), will be utilized in this study. The function is presented as follows:

$$Y_i = f(X_i, \beta) \exp\,(V_i - U_i)$$

Where, i =1,2,3…*n*, Y_i - Output of the i^{th} firm, X_i - a vectors of inputs, *f(i)* - a suitable functional form, such as Cobb-Doubles or tans-log, V_i - represents random errors that are presumed to encompass measurement inaccuracies associated with the farm, U_i – is a non-negative random error that is assumed to capture the technical inefficiency in production. It is reached by truncating (setting to zero) a normal distribution with a mean value of $\mu_i = Z_i\delta$ and the variance σ_μ^2.

Technical efficiency is given by the formula:

$$TE_i = \frac{f(X_i, \beta)\exp\,(V_i - U_i)}{f(X_i, \beta)\exp(V_i)} = \exp(-U_i)$$

Some other important parameters of the model are:

$\sigma^2 = \sigma_v^2 + \sigma_u^2$ and $\lambda = {}^{\sigma_u}/_{\sigma_v}$ and $\gamma = {}^{\sigma_u^2}/_{\sigma^2} = {}^{\sigma_u^2}/_{\sigma_v^2 + \sigma_u^2}$ and

$\varepsilon_i = V_i - U_i$. The maximum likelihood estimation (MLE) method is well-suited for estimating the parameters of the stochastic frontier production equation. Hence, the individual technical efficiency (TE) is determined by the conditional mean of $\exp(-U_i)$, considering the distribution of the composite error term, ε_i.

In the process of obtaining the technical efficiency scores, significant changes in the output levels would be indicated by significant values of σ and λ. If the λ term has a value greater than one, this implies that inefficiencies have a greater impact on changes in output compared to random factors. When γ = 0, it indicates that deviations from the frontier are solely attributable to noise. So, the estimates obtained through ordinary least squares (OLS) align with the results obtained through maximum likelihood estimation (MLE). If γ = 1, then all variances can be solely attributed to variations in TE between farms.

Beta Regression Model

To determine the effects of different factors on technical, allocative and economic efficiencies, Beta regression model was used. This model offers the advantages of modeling dependent variables that are proportions, rates, or fractions, ensuring that predictions stay within the 0-1 range, and handling heteroskedasticity, which is when the variability of the dependent variable is not constant across levels of an independent variable (Heiss, 2021). The model employed in this study adopts a fully parametric approach, assuming that the dependent variable adheres to a Beta distribution characterized by its density function:

$$f(y;\mu,\varphi) = \frac{\pi(\varphi)}{\pi(\mu\varphi)\pi(1-\mu)\varphi} y^{\mu\varphi-1}(1-y)^{(1-\mu)(\varphi-1)}, 0 < y < 1$$

Where, μ - the expected conditional mean value of Y, denoted as $\mu = E(Y/X)$, represents the mean of Y given X. Meanwhile, φ represents the precision parameter in the model, and π is the gamma function.

$$VAR\ (Y) = \frac{V(\mu)}{1+\varphi} = \frac{\mu(1-\mu)}{1+\varphi}$$

To relate the conditional mean μ to the predictor variables, the conventional beta regression model assumes a relationship between predictors and the response variable, which is denoted by:

$$n\left(\frac{\mu_i}{1-\mu_i}\right) = g(\mu_i) = x_i^T\beta$$

Where, the vector of covariates is represented by x_i^T, while β denotes the vector of regression coefficients. $g: (0; 1) \rightarrow \mathbb{R}$ is a link function that exhibits strict monotonicity and is differentiable twice. Based on the added flexibility of the link model, four types of functions were used in order to choose the one that yields fit the best. These four functions are:

$$logit: g(\mu_i) = ln\left(\frac{\mu_i}{1-\mu_i}\right) \quad (1)$$

$$cloglog: g(\mu_i) = \ln\{-\ln(1-\mu_i)\} \quad (2)$$

$$probit: g(\mu_i) = \Pi^{-1}(\mu_i) \quad (3)$$

with $\Pi(.)$ is the standard normal distribution function

$$loglog: g(\mu_i) = -\ln\{-\ln(\mu_i)\} \quad (4)$$

The model that minimizes the Bayesian information criterion (BIC) will be selected.

Methodology

This study utilized a cross-sectional survey approach, employing questionnaires to gather data for analysis. This design also enables a comparative assessment of the technical efficiency of rice farmers across various land administration authorities within the research area. The research was conducted in the Borno and Gombe States of Nigeria, two of the 36 states in country. The favorable land and climate of these two adjacent states facilitate the cultivation of rice.

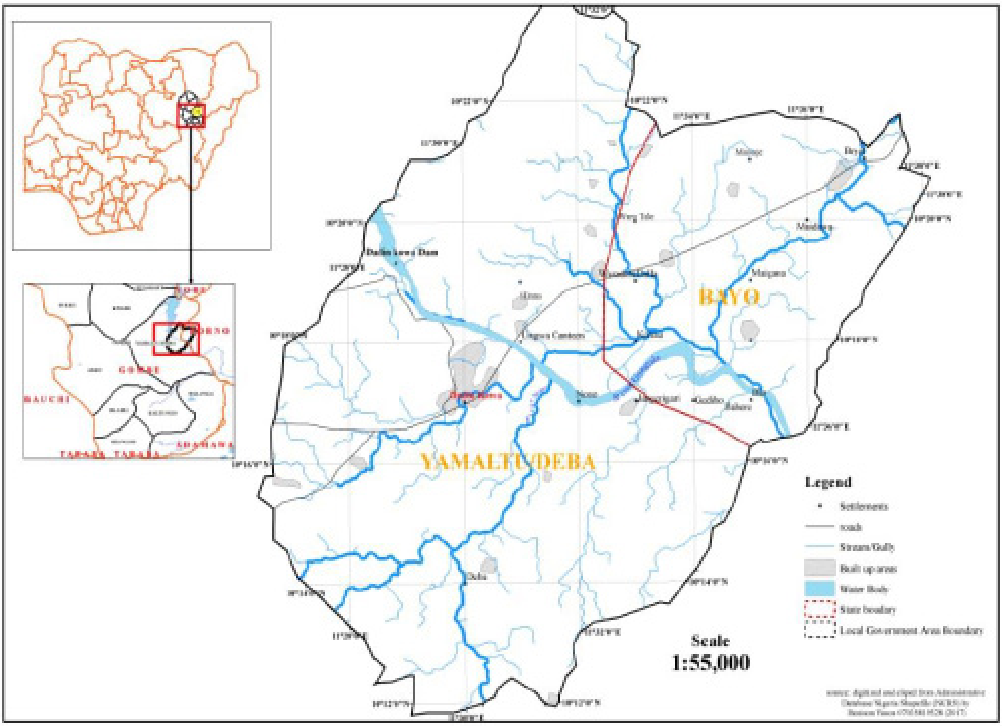
Gombe State is located in the northeastern region of Nigeria, specifically at latitude 10°15' N and longitude 11° 10' E. State capital is Gombe. With a overall population of approximately 3,960,100, the state spans at 20,265 km² (NPC, 2022). Borno is located in the northeastern part of Nigeria, specifically at latitude 11° 30' N and longitude 13° 00' E. Its capital is Maiduguri. With a population of about 6,111,500, the state spreads at the area of 57,799 km² (NPC, 2022).

The study included the entire population of rice farmers in Gombe and Borno States, which consisted of individuals engaged in the Dadin-Kowa Irrigation Project (DKIP) and those practicing irrigation farming outside of the project (Figure 1.).

The study used the multi-stage sampling method to choose the sample for the research. The selection process involved several stages. In the first stage, one senatorial district was intentionally chosen from each state, based on their proximity to the Dadin-Kowa Irrigation Scheme (DKIS) and the Upper Benue River Basin Development Authority (UBRBDA). Additionally, two Local Government Authorities (LGAs) were purposively selected from each senatorial district. Moving to the second stage, three villages were randomly sampled from each selected LGA. Finally, within each village, respondents were randomly chosen after stratifying them into four land administration authorities: DKIS, Vegetables and Fruits Canning Company

(VEGFRU), National Institute for Horticultural Research and Training and College of Horticulture (NIHORT/CoH), and the local authority (responsible for managing and regulating land-related matters within their jurisdiction).

Figure 1. Location of Dadin-Kowa Irrigation Project area and the Irrigation canal in Borno and Gombe States



Source: Upper Benue River Basin Gombe, 2022 (www.gombestate.gov.ng/)

The sample sizes for the different strata were determined through a randomization process, aiming to obtain the required number of respondents for each stratum. Yamane's (1969) formula was applied to the population of 3,691 registered farmers engaged in irrigation farming. It is expressed with next formula: $n = \frac{N}{1+N(e^2)}$

Where, N = real or estimated size of the population; n = sample size; e = level of significance (5% or 0.05). The sample comprised a selection of 400 farmers out of 3,691 listed farmers in the study area (Table 1.).

Table 1. Selection plan for the sample size (margin of error 5%)

States	LGAs	Wards	Villages	Sampling frame	Sample size
Gombe	Balanga	Telesse	Galangun	253	28
			Telesse	268	29
			Nasarawo	248	27
	Yamaltu/Deba	Hinna	Hinna	376	41
			Dadinkowa	172	43
			Yaraduwa	319	34
Borno	Bayo	Briyel	Bayo Briyel	325	35
			Tacha Itache	297	32
			Gama Jigo	253	28
	Kwaya-Kusar	Kwaya-Kusar	Wandali	331	35
			Guwal	375	41
			Kwaya-Kusar	248	27
Total	**4**	**4**	**12**	**3,691**	**400**

Source: Field survey data, 2022 (under DKIP-TRIMING project, Gombe, Nigeria).

Model Specification

Logistic Regression Model

The approach utilized the binary logistic regression model to determine the elements that impact farmer's decision to exchange their land parcels. The model is specified as:

$$P_i = \frac{1}{1 + e^{-(\beta_0 + \sum_{i=1}^{m} \beta_i X_i)}}$$

Where, P_i is the probability to accept exchanging land, β_0 is the intercept. β_i are parameters that need to be estimated, X_i are independent variables, such as: X_1= Indigene of the village (yes=1; no=0); X_2 = Age (in years); X_3=Education (in years); X_4 = Household size; X_5 = Farm income (in NGN); X_6 = Off-farm income (in NGN); X_7 = Increase in farm size (1 = yes; 0 = no); X_8 = Distance from farm to market (in km); X_9 = Distance from farm to home (in km); X_{10} = Irrigation experience; X_{11} = Farming experience (in years); X_{12} = Reduction of plot distances; X_{13} = Practice of mechanization; X_{14} = Reduction of production cost; X_{15} = Improvement of efficiency.

Technical Efficiency Model

The model used is the stochastic production model, specifically the Cobb-Douglas model. It is employed to estimate the score of technical efficiency. It can be expressed as follows:

$$lnY = \beta_0 + \beta_1 lnX_1 + \beta_2 lnX_2 + \cdots + \beta_6 lnX_6 + V_i - U_i$$

Where,

l_n refers to the natural logarithm with base 10, Y_i represents the total rice output of the farmer measured in kg/ha, β_i represents the parameters that need to be estimated, X_1 represents the farm size, measured in hectares and it is assumed to have a positive sign, X_2 represents the labor used, measured in man-days per hectare, and it is assumed to have a positive sign, X_3 represents the planted quantity of seeds, measured in kg/ha, and it is assumed to have a positive sign, X_4 represents the used quantity of fertilizer , measured in kg/ha , and it is assumed to have a positive sign, X_5 represents the used quantity of pesticides measured in liters per hectare, and it is assumed to have a positive sign, X_6 represents the quantity of herbicides used, measured in liters per hectare, and it is assumed to have a positive sign, V_i denotes the random errors, which are assumed to be independently and identically distributed. U_i represents a non-negative random variable related to the production. It is assumed to be independently distributed, and U_i is obtained by truncating (setting to zero) a normal distribution with a mean of Ui is obtained and variance δ^2.

The production inefficiency is presented in terms of factors such as:

$U_i = \sigma_0 + \sigma_1 Z_{1i} + \ldots\ldots \sigma_{10} Z_{10i} + \sigma_{11} Z_{11i}$

Where,

σ represents a vector of unknown parameters that has to be estimated, Z_1 represents the farmers' age measured in years, and it is assumed to have a negative sign, Z_2 represents the education level measured in years of formal education, and it is assumed to have a negative sign, Z_3 represents the rice farming experience, measured in years, and it is assumed to have a negative sign, Z_4 represents the household size, which refers to the number of individuals who reside together within a dwelling, and it is assumed to have either negative or positive sign, Z_5 represents the number of parcels, and it is assumed to have either positive or negative sign Z_6 represents the non-agricultural income measured in NGN (Nigerian Naira), and it is assumed to have either positive or negative sign, Z_7 represents the marital status, with "married" coded as 1 and "otherwise" as 0, and it is assumed to have either positive or negative sign, Z_8 represents membership in a Community Based Organization (CBO), with "yes" coded as 1 and "no" as 0, and it is assumed to have either a positive or negative sign, Z_9 represents the cost of transportation measured in NGN, and is assumed to have a positive sign,

Z_{10} represents rental costs measured in NGN, and is assumed to have a positive sign, Z_{11} represents the costs of water measured in NGN and is assumed to have a positive sign.

Beta Regression Model

The model is specified as:

$$Y_i = \beta_0 + \beta_1 X_{1i} + \beta_2 X_{2i} + \ldots\ldots\ldots\ldots + \beta_{17} X_{17i} + \beta_{18} X_{18i} + \rho_i$$

With, $Y_i = TE_i$

β_0 = intercept, the value of TE_i, when others variables are null; β_i = are the parameters to be estimated; X_1= age (years); X_2= distance to home (in km); X_3= experience (years); X_4= off-farm income (in NGN); X_5= household size; X_6= inheritance (1 = yes; 0 = no); X_7= purchase (1 = yes; 0 = no); X_8= rent (1 = yes; 0 = no); X_9= individual lease (1 = yes; 0 = no); X_{10}= gift (1 = yes; 0 = no); X_{11}= government allocation (1 = yes; 0 = no); X_{12}= land administration service index (LASI), (given by the farmers' perception of the quality of land administration); X_{13}= land value (soil quality: 5 = excellent; 4 = good; 3 = average; 2 = poor; 1 = very poor); X_{14}= land use (Herfindahl index), (intensity of land use: 1 = intensification of the use of farmland; 0 = otherwise); X_{15}= land development (farmers' perception of the quality of physical infrastructures in the study area: 5 = excellent; 4 = good; 3 = average; 2 = poor; 1 = very poor); X_{16}= land exchange practice (1 = yes; 0 = no); X_{17}= land fragmentation (Simpson's Index), (intensity of land fragmentation: 1 = highest level of land fragmentation; 0 = otherwise); X_{18}= hired labor force (in man-day); ρ_i is an error term which is assumed to be independent and identically distributed.

Results and Discussion

Land Exchange Practice

The result of the descriptive analysis of land exchange was presented in Table 2. It showed that farmers had information about the practice of land exchange (66.4%, 60.2%, 71.4%, and 66.2% for DKIS, VEGFRU, NIHORT/CoH, and Local authority, respectively). In the same way, most of farmers affirmed that land was exchanged in their area (50.5%, 42%, 60%, and 54.5% for DKIS, VEGFRU, NIHORT/CoH, and Local authority, respectively). Farmers having information about land exchange suggests their adaptability and willingness to explore different strategies to optimize their land resources. This adaptability reflects their recognition of the potential benefits of land exchange in addressing their specific needs and goals

(Gamal, 2022). From the gained results, 16.07% of respondents have exchanged land in the study area, meaning that few farmers from the study area had certain experience in land exchange process. This finding aligns with the results reported by Alemu et al. (2019), who revealed a serious problem of comprehensive experience of farmers in land exchange, since 68% of farmers interviewed did not have any experience in land exchange practice due to concentration of their land holdings and improving their efficiency.

The practice of land exchange is more important in lands administrated by Local authorities (19.5%), and then in DKIS (17.8%), NIHORT (17.1%), while the VEGFRU shown the lowest importance (9.9%). This means that Land exchange provides opportunities for farmers to expand their operations by acquiring additional land. This expansion allows for increased production capacity, the introduction of new crops, and the ability to implement more diversified farming systems (Len, 2017; Gamal, 2022). However, the practice of land exchange is done informally among farmers, except for land administrated by local authorities, whereby only 6.4% have practiced formal land exchange. Land exchange has been a long-standing practice embedded in local customs and traditions. Informal land exchange methods have been passed down through generations and are deeply rooted in the social fabric of the community (Vincent, 2016).

The land exchange approaches practiced in the study area were land exchange for use (or farming purpose), (13.2%) and exchange of property (2.87%). Land exchange for use is more important in DKIS (16.7%), followed by NIHORT/CoH (14.2%), Local authority (12.9%), and VEGFRU (8.9%). This result showed the importance of land exchange for use in the study area, as presented by Ito et al. (2016) in the case of Japanese agriculture during the agricultural stagnation period in the late 1980s. Then was confirmed the improvement in farmland use efficiency by facilitating land rights transfers from farm households that had ceased farming, or reduced their farm operational size, holding this land temporarily, and subsequently selling or renting it out to farm households that intended to enlarge their farm size. However, exchange of propriety is more important in Local authority (6.6%), followed by NIHORT/CoH (2.9%), DKIS (1.1%), and VEGFRU (1%). The derived results showed that farmers in local lands were very few to exchange their propriety, meaning that farmers did not want to lose the control over their land.

Table 2. Land exchange (LE) approaches

Element	DKIS (%)	VEGFRU (%)	NIHORT/CoH (%)	LOCAL (%)
Farmers having information about land exchange	66.4	60.2	71.4	66.2
Farmers aware of land exchange practice in the study area	50.5	42	60	54.5
Farmers who exchanged land in the study area	17.8	9.9	17.1	19.5
Land exchange approaches				
Land exchange for use	16.7	8.9	14.2	12.9
Exchange of propriety	1.1	1,0	2.9	6.6
None	82.2	91.1	82.9	80.5
Formality				
Formal	0	0	0	6.4
Informal	17.8	9.9	17.1	13.1
LE rights				
Sell	0.9	0.6	0	16.4
Farm	17.8	9.9	17.1	19.4
Develop	17	7.7	2.1	9.4
Lease	11.2	1.7	3.2	10.4
Rent	16.8	3.9	1.2	19.5

Source: Field survey data, 2022 (under DKIP-TRIMING project, Gombe, Nigeria).

The major rights related to a land acquired through land exchange is the right of farming (17.8%, 9.9%, 17.1%, and 19.4% for DKIS, VEGFRU, NIHORT/CoH and Local authority, respectively).

Factors Influencing Farmers to Exchange Land

Table 3. presents the analysis of the factors influencing farmers to exchange the land. According to the Nagelkerke R-squared model, 69.1% of the variations in the probability of exchanging land could be explained by the independent variables in the model. This statement indicates that the independent variables included in the model can account for 69.1% of the variability observed in the likelihood of land exchange. In other words, these variables provide a reasonable explanation for the majority of the changes seen in the probability of farmers engaging in land exchange.

Table 3. Factors influencing farmers to exchange land

Variables	B	SE	Wald	P-value
Indigene	0.28	0.749	0.001	0.97
Age	0.011	0.033	0.119	0.73
Education	-0.154	0.176	0.767	0.381
Household size	0.008	0.045	0.031	0.861
Number of plots	0.346	0.116	8.95***	0.003
Farm income	0.0001	0.0001	0.202	0.653
Non-farm income	0.0001	0.0001	0.842	0.359
Distance to market	-0.043	0.067	0.421	0.517
Distance to home	-0.046	0.119	0.147	0.701
Experience	-0.019	0.038	0.232	0.63
Irrigation experience	-0.007	0.036	0.042	0.837
Increase of farm size (1)	20.633	4,803.98	0.0001	0.997
Reduce plots distance (1)	2.329	1.38	2.82*	0.093
Practice of mechanization (1)	3.803	1.393	7.457***	0.006
Reduce production cost (1)	3.396	1.537	4.882**	0.027
Improve efficiency (1)	4.7	1.249	14.154***	0.000
Constant	4.576	1.386	10.906	0.001

Source: Field survey data, 2022 (under DKIP-TRIMING project, Gombe, Nigeria).

Note: Chi-Squared statistic = 215.013; p-value = 0.001; Nagelkerke R-Squared = 0.691; -2log likelihood = 152.850; Statistical significance: ***, **, * = significance at 1%, 5%, and 10% respectively.

The findings indicate that the chance of exchanging land was significantly ($p < 0.01$) enhanced by the number of plots. This implies that farmers with many plots might easily come to an agreement to exchange plots in order to maximize their methods of production. Reduction of distance among plots, practice of mechanization, reduction of production costs, and improvement of efficiency, defined as dummy variables increased significantly at 10%, 5% and 1% level respectively, the probability to exchange land in the study area. This implies that farmers were highly aware of the benefits of land exchange. Derived result is more or less in conformity with Akkaya Aslan et al. (2007), who found that farmers are in general motivated to apply the process of land consolidation in order to increase their farm size, to reduce inter-farmer conflicts, to practice mechanization and to implement irrigation system.

Percentage Distribution of Technical Efficiency

As the result of the maximum likelihood estimates of the Cobb-Douglas stochastic production function, the distribution frequency of the predicted technical efficiency is presented in Table 4. The average technical efficiency (TE) for DKIS, VEGFRU, NIHORT/CoH, and the Local authority were found to be 0.88, 0.94, 0.86, and 0.65, respectively. This indicates that farmers in these zones are operating at a high level of technical efficiency. However, there is still room for improvement in the technical efficiency of rice farmers practicing irrigation farming in the study area. By utilizing the available resources and adopting current technological advancements, as well as receiving better extension services, the technical efficiency of these farmers could potentially increase by 0.12, 0.06, 0.14, and 0.35, respectively.

Table 4. Percentage distribution of technical efficiency

TE	DKIS		VEGFRU		NIHORT		LOCAL	
	Freq	(%)	Freq	(%)	Freq	(%)	Freq	(%)
<0.3	0	0	1	0.6	0	0	5	6.5
[0.3 - 0.5[	1	0.9	1	0.5	0	0	12	15.6
[0.5 - 0.7[	9	8.5	3	1.1	3	8.6	31	40.6
[0.7 - 0.9[	31	29.3	28	15.4	22	62.8	18	23.4
>0.9	66	61.3	148	82.4	10	28.6	11	14.4
Total	**107**	**100**	**181**	**100**	**35**	**100**	**77**	**100**
Max	0.99		0.99		0.99		0.99	
Min	0.34		0.29		0.68		0.21	
Mean TE	0.88		0.94		0.86		0.65	

Source: Field survey data, 2022 (under DKIP-TRIMING project, Gombe, Nigeria).

Effect of Land Exchange on Technical Efficiency of Rice Farmers

With a p-value of 0.0001, the likelihood ratio chi-squares of 56.77 indicated the fitness of the model at the 1% ($p < 0.01$) significant level (Table 5.). Comparing with a model without any predictors, this model fits substantially better. This, however, was insufficient to assess the fitness of the model. When the model is properly specified, the estimators in beta regression are consistent and efficient, according to Smithson and Verkuilen (2006). By the way, the model with the lowest Bayesian information criterion (BIC) values is better than the models with higher BIC values. Four links models (logit, cloglog, probit, and loglog) were estimated until the model with the lowest BIC value was obtained. And then, the coefficients on the predictors and marginal effects (dx/dy) were recorded and interpreted.

The findings indicate that among the eighteen variables examined, four variables were identified as having a statistically significant impact on the technical efficiency of rice farmers in the study area. These variables are household size, rental costs, land development, and hired labor. At a significance level of 5% ($p < 0.05$), it was determined that household size had a significant influence on technical efficiency. When all other factors were held constant, it was observed that a one-person increase in family size led to an immediate 0.26% increase in the value of the technical efficiency. These findings align with previous research conducted by Umeh and Atarboh (2007), as well as Adeshina et al. (2020), which also demonstrated the positive impact of household size on technical efficiency.

Table 5. Effects of land exchange on technical efficiency

Variables	coefficients	z-stats	dx/dy
Age	0.006	1.06	0.0008
Distance to home	-0.021	-1.50	-0.0025
Experience	-0.01	0.007	-0.0013
Off farm income	-1.49e-07	-1.13	-1.76e-08
Household size	0.022**	2.10	0.0026
Inheritance	0.078	0.29	0.009
Purchase	0.21	0.62	0.024
Rent	0.48*	1.87	0.057
Lease	0.35	0.84	0.041
Gift	1.26	0.84	0.148
Government allocation	-0.38	-1.52	-0.045
LASI	0.37	0.78	0.043
Land value	-0.014	-0.08	-0.002
Land use	0.033	0.11	0.004
Land development	-0.56***	-2.61	-0.066
LEP	0.014	0.10	0.002
LFI	-0.07	-1.19	-0.008
Hired labor	0.15**	2.04	0.018
Constant	-2.68	-0.94	-
LR Chi2(18)	56.77	-	-
Prob > chi2	0.0001	-	-
Log likelihood	480.04	-	-
BIC	-840.30	-	-

Source: Field survey data, 2022 (under DKIP-TRIMING project, Gombe, Nigeria).

Note: ***, ** and* significant at 1, 5 and 10% respectively. Bayesian information criterion (BIC).

At the 10% level of probability ($p < 0.1$), the results indicated that the rented land was positively correlated and statistically significant. This suggests that renting land improves technical efficiency. More specifically, the technical efficiency score value would instantly rise by 5.7% if rented land was used. Thus, on rented plots, there is no loss in technical efficiency. Farmers who use rented property are forced to adopt suitable production methods in order to offset the high cost of land. The results are consistent with those of Feng (2008), who discovered that rice farmers in rural China produce rice more efficiently when they rent a land. Furthermore, it was observed that households that engaged in land rental exhibited higher levels of technical efficiency compared to households that did not rent land.

The coefficient associated with land development in the study area was found to be negative and statistically significant at a 1% level of probability ($p < 0.01$). This indicates that the farmers' perception of the state of physical infrastructure (irrigation systems, farm storage facilities, processing centers, road, bridge, water supply system, and electricity infrastructure) would result in low technical efficiency. That is to say that one-unit of change in rice farmers' perception of the reliability of infrastructure would result in a6.6% decline in technical efficiency. This result describes the negative effect of the poor physical infrastructure on rice farmers' efficiency. In fact, the land development project that was supposed to boost the irrigation potential of farmers has never been accomplished for many years. This ongoing situation may explain the farmers' bad perception of the state of infrastructure development in the study area, which affects negatively their technical efficiency. However, the result of Adeoye et al. (2017) confirms the fact that technical efficiency is improved by staying in villages with good physical infrastructure.

Hired labor force affects positively the technical efficiency at 5% significance level ($p < 0.05$). An increase in hired labor by one person would result in an instantaneous increase in technical efficiency score value of 1.8%. This means that hired labor contributes to resource use efficiency thanks to the high level of experience acquired by farmers and the technical assistance provided by the DKIS office in terms of training support. The same result was also revealed by Akinbode et al. (2011). From the derived results, it was found that the exchange of land had no significant effect on the technical efficiency of rice farmers in the study area.

Conclusion and Recommendations

This study examines the practice of land exchange and its effects on rice farmers' technical efficiency in the North-Eastern zone of Nigeria. The results show that farmers are involved in land exchange within the study area, since 16.07% of them have already practiced it. However, the practice of land exchange is predominant in lands administrated by local authorities, and it is mainly done informally among farmers. Land exchange for use (or farming purposes) and exchange of property were the two approaches predominantly employed by farmers by farmers in the study area. According to farmers' point of view, number of plots, reduction of distance among plots, practice of mechanization, reduction of production costs, and improvement of efficiency are the dominant factors influencing them to exchange the land. It was also concluded that farmers were technically efficient, while its general level of efficiency could be enhanced by utilizing current technology and improving the effective utilization of available resources. Farmers operating under the administration of VEGFRU exhibited a higher degree of technical efficiency in contract to individuals operating under DKIS, NIHORT/CoH, and the local authority. However, household size, land rental, and the utilization of external labor positively influence technical efficiency. Contrary to previous, farmers' perceptions of land development have an adverse effect on technical efficiency. Furtherly, derived study results show that the practice of land exchange does not affect the technical efficiency of rice farmers, because of the limited land market and the high level of crop diversification. So, it is advisable for the government to establish clear policies that define the rights associated with land use and facilitate land transactions, such as the sale of occupancy rights, transfer of leasehold rights, or land rental among farmers. This would contribute to strengthening the land market and promoting the efficient utilization of land resources. This study may be extended to the effects of land exchange on efficiency and rural livelihoods of farmers in other irrigation schemes in Nigeria, and even in other Sub-Saharan countries. All the same, this study provided insights into the relationship between land exchange practices and the rice farmers' technical efficiency in the North-Eastern Zone of Nigeria. By examining how land exchange affects farmers' efficiency levels, the research also contributed to a better understanding of the factors influencing farmers to exchange land in the study area.

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EFFECTS OF FARMERS-HERDERS CONFLICT ON THE TECHNICAL EFFICIENCY OF CASSAVA-BASED FARMERS IN YEWA NORTH, OGUN STATE, NIGERIA

Abdulquadri Adekunle Akinde[1], Chioma Patricia Adekunle[2]

Abstract

This study, conducted in Yewa North, Ogun State, Nigeria, investigates the effects of conflict on the technical efficiency of 120 randomly selected cassava-based farmers. Results reveal that conflict episodes and their economic costs significantly increase the technical inefficiency of cassava-based farmers. Those unexposed to farmer-herder clashes exhibit lower inefficiency levels. The study highlights the intensity of conflicts, with encroachment of cattle on farmland being a major contributor, leading to forced displacement and economic burdens. Gender imbalances are evident, with a predominantly male farming population, and concerns arise from the relatively low average age of farmers, signaling fewer young individuals engaging in farming. Performed study confirms that the unceasing incidence of herdsmen-farmers conflicts have claimed lives and property, and displaced people, with attendant economic consequences on cassava-based farm household technical efficiency. It is recommended that the designation of grazing fields for nomadic herdsmen, tax imposition, and targeted policy interventions to enhance farmers' production efficiency. The study underscores the need for state governments' intervention, emphasizing policy measures to address farmers-herder's conflicts in promoting agricultural development.

Key words: Conflict, land, nomadic, pastures, crops.

JEL[3]: Q15, C31, D74

1 Abdulquadri Adekunle Akinde, B.Sc. Student, Department of Agricultural Economics and Farm Management, Federal University of Agriculture, Alabata Road, Abeokuta, Ogun State, Nigeria, Phone: +234 90 373 951 37, E-mail: abdulquadriakinde@gmail.com

2 Chioma Patricia Adekunle, Ph.D., Senior Lecturer, Department of Agricultural Economics and Farm Management, Federal University of Agriculture, Alabata Road, Abeokuta, Ogun State, Nigeria, Phone: +234 80 601 741 80, E-mail: adekunlecp@funaab.edu.ng, ORCID: 0000-0001-6841-2165

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Introduction

In contemporary Nigeria, conflicts pose significant challenges, leading to unrest, panic, homelessness, and unemployment across diverse ethnic and religious communities. Persistent security issues include insurgency, election violence, kidnapping, and notably, clashes between herders and farmers. While Nigeria achieved a successful transition to democratic rule in 1999, political conflict-related violence persists (Wogu, 2004; Omotola, 2013). The prevalence of conflicts varies across regions, with the North East, North West, North Central, and South-South experiencing higher rates (Conroy, 2014). Violent conflicts impede economic development and contribute to enduring poverty levels. Historical conflicts stem from resource disputes, conquests, religious tensions, and ethnic rivalries. Farmer-herder conflicts, dating back to the 1900s, have intensified due to population growth, land competition, climate change, and other factors, notably in the North Central geopolitical zone (Buba, 2021). In 2018. farmer-herder conflicts surpassed the Boko Haram insurgency or banditry attacks in lethality, with distinctive characteristics. Boko Haram opposes western education, targeting the government and populace through various means, while farmer-herder conflicts directly impact rural households. The complexities of these conflicts contribute to ongoing challenges in Nigeria's social, economic, and political landscape (Babatunde, 2018; George et al., 2022).

In Nigeria, the historical interaction between farmers and herders, particularly the Fulani ethnic group in the north and farmers in the south, has traditionally been symbiotic. This ethnic group mainly involves shepherds, cattle herders, rural dwellers, pastoralist, while population are dominantly Muslims, speaking the Hausa or Fulfulde language (Moritz, 2016). Their movement is from place to place in search of green pastures and water with no fixed pattern of movement (Okoro, 2018). The mutually beneficial relationship involved cattle grazing near farms, with dung serving as manure and farmers receiving grains in return. Traditional tax systems before independence maintained a sense of communal responsibility, but a significant shift occurred in 1980 when taxes were dismissed, and land ownership ceded to state governments, disrupting the traditional dispute-settling mechanism. The loss of grazing routes and reserves intensified conflicts as herders were seen as external entities. Recent years have witnessed a rise in farmers-herder's conflicts nationwide, exacerbated by factors like drought, desertification, and terrorist attacks, forcing herders further south in search of pasture (Amusan et al., 2017).

So, Fulani herdsmen represents dominant threat, affecting the overall agricultural production in Nigeria, due to their ultra-violent behave toward local farmers, especially in states as are Benue, Gombe and Taraba. Over four days in June 2017, 732 people was killed in Taraba as a result of their attacked-on farming communities (Audu, Audu, 2023). They were classified as a Terrorist group by the Institute for Economics and Peace because of their attendant attack. These herders not only invade and destroy farms and agricultural products, but also deliberately let cows to graze in crops at the previously cultivated plots at certain farm. Conflicts over resources between farmers and herders also lead to reduced access to available areas used for agri-food production. Recently, farmer members have been usually targeted in kidnapping by bandit groups, or armed herdsmen in different regions at the national level (Egbuta, 2018; Ajibefun, 2018).

Observed conflict could be considered as issue of access to land resources towards the economic survival, initiating the economic, political and environmental constraints and tension at the state level, mainly in the Middle Belt and South part of country (Udosen, 2021). This competition for scarce agricultural land has led to increased clashes between herders and farmers, with the conflict escalating notably in north-central states. The conflict is characterized by farmlands destruction by cattle herds (Adigun, 2019).

One of the main security challenges in Nigeria is the farmers-herders conflict. Nigeria accounted a significant rise in the episodes of natural resource conflicts (Tanko, 2021) which are commonly pervasive in Africa, West African sub-region, especially Nigeria (Gbanite, 2001).

The incidence of farmers-herders conflict is often considered as endemic, local, and low-intensity conflicts, but not wars. Meanwhile, observed incidences has been usually ignored in available literature sources covering violent conflicts in Africa (Lind, Sturman, 2002). According to Richards (2005), avoiding to discuss these conflicts leads to potential escalation of local conflicts into the larger conflicts, or even wars, initiating ethnic violence within the field of farming and herding. So, conflicts jeopardize not only the human lives, properties, and livelihoods, but they also threaten agricultural and pastoral production sustainability in wider regions.

In this study, farmers-herders conflict is defined as arguments and fights, over limited land resources, between nomadic herders and farming communities that are majorly agrarians. The majority of herders in Nigeria are known as Fulani who have usually own the large number of livestock heads within the country (Ojo, 2020). Herders traditionally live and graze their livestock in the country's north, while go to south in dry season, searching for greener pasture. With a startling increase in drought and desertification in the north (Adano et al., 2012; Buhaug et al., 2014), or terrorist assaults (George et al., 2021), herders go in deep south much longer, searching for enough pasture to feed their livestock.

Mentioned intensifies their rivalry for limited agricultural land with farmers in Nigeria's central belt and south (Eke, 2020). Typically, farmers-herders disputes occur when herders graze their cattle in crop-growing areas, causing the damage and decreasing the crops' yield. Contrary, farmers chase herders out of their communities, harming their animals, what results in herders fighting back, while farmers-herders conflict increase (CDD, 2021).

In Ogun State, the conflict between Fulani herdsmen and sedentary farmers has been a longstanding issue, intensifying since 2020. The conflict not only impacts local communities but also poses challenges at the national level. Despite the historical prevalence in the north-central states, the south-western state of Ogun is not immune to the farmers-herders conflict and its negative consequences.

The farmers-herders conflict in Yewa, which emerged in the early 2020s, involves complex dynamics with various actors and competing interests. This conflict, primarily between farmers and herdsmen, has profound social, economic, and political implications at local and national levels. Existing studies on crisis in Yewa are scarce creating a significant gap in understanding the causes and effects. This study aims to fill this void, employing a qualitative research strategy, including structured questionnaires and interviews, to explore the conflict's effect on the technical efficiency of farm households. The study considers that the unceasing crises between herders and farmers in rural Nigeria, has affected many lives and estates, while displacing many people, or their conflicts derives certain socio-economic consequences linked to further sustainable development of Nigeria.

The study focuses on defining farmers-herders conflict as disputes over limited land resources and explores the historical background, changing dynamics, and recent escalation of this conflict in the Ogun State. The findings contribute to understanding the multifaceted nature of this conflict, emphasizing its impact on local communities and broader implications for national governance. The study seeks to assess the effect of farmers-herders' conflict on the technical efficiency of cassava-based farmers in Yewa North local government area, Ogun state. Specific objectives were to:

1. Describe the socio-economic characteristics of cassava-based farm households;
2. Describe the various conflicts experienced by the cassava-based farm households;
3. Assess the economic costs associated with conflicts among the cassava-based farm households;
4. Assess the technical efficiency of cassava-based farmers; and
5. Determine the effects of farmers-herders conflict on the technical efficiency.

Materials and Methods

The observed area was Yewa North in Ogun State. Yewa North comprises settlements that act as stock routes for pastoralists transporting their livestock to and from the Republic of Benin. Yewa North lies between latitude 7° 13' 60" N and longitude 3° 01' 60" E, with a total land area of 2,087 km², making it the largest expanse of land among the twenty local governments in Ogun State, with a population of 181,826 recorded in the 2006 census (as certain limitation to the research is the fact that no census has been conducted in Nigeria since mentioned year). Ayetoro Ward I, Ayetoro Ward II, Idofi Ward, Sunwa Ward, Ijoun Ward, Eggua Ward, Ohunbe Ward, Igbogila/Ibese Ward, Joga-Orile/Ibooro Ward, and Imasai Ward are among the 11 wards in Yewa North. Yewa North's resident's primary occupation is agriculture, which includes growing a range of commodities like cocoa, cotton, and cassava.

The respondents comprise all the cassava-based farmers in Yewa North who operate in conflict-prone areas and have experienced conflicts at certain time. These are the people who are directly affected, at the forefront of the conflict and as such, are the main objects of study. The primary data was obtained through the interview schedule and structured questionnaires to account for the necessary factors that made up the influence of conflicts on technical efficiency of cassava-based farmers during the March, 2021 to October, 2022 farming season.

The sample size in the observed region is determined using the formula developed by Yamane (1967), implying 95% confidence, as well as maximal variability of 50%. This formula, widely used in previous studies, depends on the size of the population (all rural households) and the level of precision required.

$$n_i = \frac{N_i}{(1 + N_i \times e^2)} \qquad (1)$$

Where, n_i is the sample size, N_i represents the targeted population within the observed region (rural households), while e defines precision level. In line to similarity, i.e. high level of homogeneity of the rural households towards their general characteristics, the precision level (confidence interval) used in sample determining was equal to +/- 9%.

For predefined precision level, and the size of the total population estimated at 5,224 cassava-based households, calculation of the sample size (n - cassava-based households) gives:

$$n = \frac{5224}{(1+5224 \times 0{,}09^2)} = 123 \qquad (2)$$

From the list of cassava farmers obtained from the Ogun State Development Programme, this study used the multi-stage sampling to select a cross-section of 120 out of the 123 cassava-based farm households. The first stage was a simple random sampling of three (3) blocks out of the six (6) blocks that make up the Yewa North in Ogun State. Two (2) cells were randomly selected from each of the three (3) blocks to give a total of six (6) cells in stage two. The third stage was a random sampling of 20 cassava-based farm households from each of the six selected cells to give a total sample size of 120 respondents which was used for this study.

Descriptive statistics was employed to analyze demographic characteristics such as age, gender, educational level, household size, and income distribution among the farm households in Yewa. Also, descriptive statistics was used to assess the different types, frequencies, and intensities of conflicts experienced by farm households in Yewa. Data was collected on the nature of conflicts, such as land disputes, resource competition, or cultural clashes, and analyzed using descriptive statistical measures. This study was not carried out during the period of the conflicts. Therefore, this study used memory recall of the incidence of conflict in the last (2021/2022) production season to assess impacts of the conflicts. The limitation of this study is the use of cassava farming households, instead of arable crop farming households.

The "cost of conflict" approach was used to provide a framework for systematically identifying, quantifying and analyzing the economic costs associated with the conflicts among farmers and herders in a Yewa. Data on different cost components associated with the conflicts was collected. These include direct costs on property damage, medical expenses, loss of livestock or crops and indirect costs on reduced productivity, market disruptions, increased transaction costs, etc.

$$\textit{Economic Cost ofConflict} = \textit{Direct Cost} + \textit{Indirect Cost} \qquad (3)$$

Farrell (1957), defined three (technical, allocative, and economic) forms of efficiency. This focus of this study is technical efficiency defined as the achieving the highest output with little effort (Hossain, 2012) using the stochastic production frontier. It's commonly applied when there's an assumption that observed production outcomes may not be solely due to technical efficiency but could also be influenced by factors beyond the control of farmers (Battese, Coelli, 1995).

$$Y_i = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \cdots + \beta_4 X_4 + \varepsilon_i \qquad (4)$$

Where,

Y = Quantity of cassava output (t/ha), β_0, β_1, β_2, β_3, β_4 - the coefficients estimated for each variable, X_1 = Farm size, X_2 = Labor, X_3 = Fertilizer usage, X_4 = cassava stem cutting, ε - error term. Meanwhile, technical inefficiency effects are specified below:

$$U_i = \delta_0 + \delta_1 Z_1 + \delta_2 Z_2 + \cdots \dots\dots\dots\dots\dots + \delta_{12} Z_{12} + \varepsilon_i \qquad (5)$$

Where,

U_i = Technical inefficiency, Z_1 = Age (years), Z_2 = Gender (1 = male, 0 = otherwise), Z_3 = Marital status (1 = married, 0 = others), Z_4 = Education (years of schooling), Z_5 = Household size (persons), Z_6 = Extension contacts, Z_7 = Farming experience (years), Z_8 = Livestock ownership (total livestock units), Z_9 = Farm income (NGN/year), Z_{10} = Access to credit (1 = yes, 0 = otherwise), Z_{11} = Number of conflict episodes, Z_{12} = Economic cost of conflict (NGN/year), δ_1 - δ_{12} = estimated parameters, ε = error term.

Results with Discussion

Socioeconomic Characteristics of Cassava-based Farmers

In (Table 1.) are presented socioeconomic data on cassava-based farm households, indicating a gender imbalance, with 96.67% of males contrary to 3.33% of females. Most of them were married (98.33%) and over 50 years old (70.83%). This suggests limited youth participation. The majority had household sizes of 4 to 6 persons (53.34%), potentially enabling cost-effective family labor.

About 18.33% had no formal education (Table 1.). The respondents' average farming experience was 9 years, with 45% having access to credit, facilitating efficiency and expansion. Additionally, 48.33% of them had extension contact, and 45% had less than 1 ha plots, indicating predominantly subsistence and small-scale cassava farming in the observed area. Ologbon et al. (2021) found that almost 70% of the smallholder farmers have been cultivated less than 2 ha (in average 1.1 ha), including land plots accessed usually (around 68%) through communal arrangement in Yewa North. This has negative influence on farmland expansion, as well as to likelihood of the cassava farmers to go into the commercial production.

Table 1. Socioeconomic characteristics of the respondents

Characteristic	Frequency	Percentage
Sex		
Male	114	96.67
Female	6	3.33
Age		
<30	22	18.33
31-50	54	45.00
51 and above	44	36.67
Mean age (years)	53	-

Characteristic	Frequency	Percentage
Level of education		
None	24	20.00
Primary	56	46.67
Secondary	33	27.50
Tertiary	7	5.83
Monthly income (NGN)		
<30,000	21	17.50
31,000-50,000	62	51.67
51,000 and above	37	30.83
Mean	46,000	-
Marital status		
Single	11	9.17
Married	108	90.00
Others	1	0.83
Household size (persons)		
1-3	16	13.33
4-6	64	53.34
7 and above	40	33.33
Mean	4	-
Farming experience (years)		
>10 years	79	65.83
11-20	22	18.34
21 and above	19	15.83
Farm size (hectares)		
<1.0	54	45.00
1.01-5.0	36	30.00
1.01 – 10.0	18	15.00
>10.0	12	10.00

Source: Akinde, Adekunle, 2023.

Intensities of Conflicts Experienced by the Cassava-based Farmers

In Table 2., it is evident that 81.67% of cassava-based farmers in Ogun State have experienced varying degrees of conflicts between farmers and herders, disrupting their daily lives and farm activities.

Encroachment of cattle into farmlands accounted for a significant share of these conflicts, forcing 73.33% of affected farmers to seek refuge in other rural communities (Table 2.). Women and girls bore a heavy burden as widows were often evicted from their husband's land after male family members were killed in the violence. These clashes resulted in significant losses in both production and increased poverty and food insecurity, impacting 71.67% of the farmers. Households were categorized as having no exposure (18.33%), moderate exposure (57.50%), or high exposure (24.17%) to farmer-herders and communal conflicts.

Table 2. Farmers/herder's conflicts of cassava-based farmers

Patterns	Frequency	Percentage
Conflict exposure	**98**	**81.67**
Incidence of conflict*		
Land disputes	22	18.33
Cattle grazing farmlands in agrarian communities (encroachment of cattle into the farms)	86	71.67
Others (Labor or employment issues)	12	10.00
Number of conflict episodes		
1-3	82	54.67
4-6	36	24.00
7 and above	2	1.3
Effects of conflict*		
Loss/decrease of crop outputs	88	73.33
Loss of livestock outputs	31	25.83
Loss of lives	3	2.50
Loss of land and assets	64	53.33
Disruption of planting/harvesting seasons	80	66.67
Decreased trade/market opportunities	55	45.83
Displacement of farmers	88	73.33
Women and girls' vulnerability to sexual and economic predation	62	51.67
Extents of conflict		
Low	22	18.33
Moderate	69	57.50
High	29	24.17

Source: Akinde, Adekunle, 2023.

Note: * implies multiple responses.

Cost of Conflict

Table 3. shows the result of the economic burden of farmers-herders conflict. It was found that the direct cost of farmers-herders conflict accounted for 42.86%, while 57.14% accounted for the indirect cost of mentioned conflict. The directed cost of conflict is attributed to the values of loss of properties, assets, crops, lands, livestock, and displacement of farmers. The indirect cost of farmers-herders conflict is attributed to the loss of productive days.

Table 3. Cost of Conflict

Element	Cost	Percentage
Direct cost	84,600.40	42.86
Indirect cost	112,785.25	57.14
Total cost of conflict	197,385.65	100

Source: Akinde, Adekunle, 2023.

Note: 785 NGN is equivalent to 1 USD.

Technical Efficiency Level of Cassava-based Farmers in the Study Area

In Table 4., the technical efficiency of sampled cassava farmers differs substantially among the cassava-based farmers, with predicted efficiencies ranging from 0.371 to 0.996, and a mean technical efficiency of 74.12%. Mentioned refers that cassava-based farmers are still out the frontier production level, i.e. there is still the room for advancement in their technical efficiency by around 26%. The result of the mean technical efficiency is lower than that gained by Akinola et al. (2020), who assessed the technical efficiency of small-scale cassava farming, while finding the mean technical efficiency of 89%. Conflict had a significant impact on the largely agriculture-based economy. During the conflict, there is disruption of farming activities, while the farm production, lives and properties are destroyed. Hence, many farmers were not able to obtain the quantity of inputs such as labor, land and fertilizer that they needed, which resulted in a reduced area of land under cultivation and lower yields. Farmers were cut off from their fields and thus unable to produce as a result of limited factors of production which lowers their efficiency.

Table 4. The distribution of the technical efficiency scores

Scores	Frequency	Percentage
<0.5	15	12.50
0.50–0.69	30	25.00
0.70–0.89	52	43.33
0.90–1.00	23	19.17
Mean	0.741	-
Minimum	0.336	-
Maximum	0.941	-
Number of observations	120	-

Source: Akinde, Adekunle, 2023.

This suggests a potential 25.88% increase in cassava output at current input levels (Table 4.). The range in efficiencies highlights room for improvement among cassava-based farmers. Efficiency scores vary from 33.6% to 94.1%, with an average technical efficiency of around 34%, indicating that 66% of potential cassava yield is unrealized. Specifically, 12.5% of farmers scored below 0.5 in technical efficiency, 25% between 0.5 and 0.69, 43.33% between 0.7 and 0.89, while 19.17% scored above 0.9.

The Maximum Likelihood Estimates of the Stochastic Frontier Production Function

The Cobb-Douglas stochastic production model's is used to explain the methodological framework of production efficiency. The results are detailed in Table 5., showcasing a good fit with a sigma-square ($\sigma 2$) of 0.0183 for cassava farmers. The variance ratio gamma (γ) at 0.8089 suggests that 81.89% of the difference between observed and maximum production frontier outputs is due to variations in technical efficiency (Table 5.). Significantly different chi-square values at 1%, confirming the model's goodness of fit. Notably, farm size, labor, fertilizer, and cassava seed quantity significantly influenced the cassava production efficiency. Positive coefficients indicate that a 1% increase in these inputs leads to corresponding increase in cassava production, reinforcing the positive relationships observed between variables. This implies that if farm size, labor, fertilizer, and cassava seed quantity increase by 1%, there will come to marginal increase in cassava output. This result is in line with Akerele et al. (2019) study on smallholder cassava farmers also carried out in Ogun State. The findings of performed study are not in line with results gained by Akinbode et al. (2011), who found that increase in used labor level will not result to increase in output of cassava production in the study area.

The Effects of Farmers-herders Conflict on Cassava-based Farmer's Technical Efficiency

The inefficiency model analysis, as depicted in Table 5. unveils key insights into cassava farmers' technical efficiency. Coefficients' signs and significance in this model bear substantial implications. Negative coefficients for extension contact and education suggest increased technical efficiency, contrasting with the positive coefficient for gender, indicating female farmers' lower efficiency. Variables related to farmers and herders' clashes display positive coefficients, indicating a negative impact on efficiency with more conflicts. The significance of the household head's sex, age, and education levels is also observed.

Male-headed households exhibit higher efficiency, aligning with the male-dominated agricultural activities. Surprisingly, higher age correlates with increased inefficiency, implying a decline in technical efficiency with age. Education positively influences efficiency, aligning with increased exposure to agricultural technology. Livestock ownership, farm income, and access to credit also significantly impact efficiency, with increased livestock, higher income, and credit access correlating with reduced inefficiency. These findings emphasize the multifaceted influences on cassava farmers' efficiency, incorporating social, demographic, and economic factors.

Table 5. The maximum likelihood estimates of the technical efficiency

Variables	Coefficients	t-values
Efficiency function		
Farm size (ha)	1.128***	6.369
Labor (man-days)	0.095***	4.376
Fertilizer (l)	1.023**	2.113
Quantity of cassava stem cuttings (kg)	0.143***	3.767
Constant	7.513***	3.142
Inefficiency function		
Age (Years)	-0.052*	-1.745
Gender (1 = male, 0 = otherwise)	-0.024**	-2.028
Marital status (1 = married, 0 = others)	0.3903	0.613
Education (years of schooling)	-2.114***	4.764
Household size (number of persons)	0.338	-1.081
Extension contact	-0.462	-2.382
Farming experience (years)	-4.047**	-2.022
Livestock ownership (total livestock units)	-0.066**	-2.561
Farm income (NGN/year)	-0.029**	-2.063
Access to credit (1 = yes, 0 = otherwise)	-0.004***	-4.652
Number of conflict episodes	1.185***	3.233
Economic cost of conflict (NGN/year)	0.124*	1.983
Constant	-0.239**	2.098
Diagnosis statistics		
Sigma-square ($\sigma 2$)	0.0183	2.353
Gamma (γ)	0.808	8.046
Number of observations	120	-
Wald chi2(3)	798.7	-
Log-likelihood	-19.937	-
Prob > chi2	0.000	-

Source: Akinde, Adekunle, 2023.

Note: Values in parentheses represent t-statistics. *** implies the 1%, ** implies the 5% and * implies the 10% significance level.

Confirming the findings of Ajibefun and Abdulkadri (2004), education is important for the adoption of technology innovation in cassava farming, while more persons at households generate more family labor for cassava production. Ogunniyi et al. (2012) posited that as the higher the man-days of labor used at the farm, as more the cassava output in terms yield will be attained. Oduntan et al. (2015) found that quantity of cassava stem cuttings, farm size, quantity of labor, and agrochemicals were the major determinants of cassava output, while level of education, farming experience, household size, and age were the drivers of cassava production inefficiency.

Number of conflict episodes is significant at 1% level of significance. The results show that the coefficient for this variable is positive which is similar to the expected sign. Cassava-based farmers' exposure to violent conflict can decrease the farm yield per hectare. This implies that cassava-based farmers with high incidence of herders-farmers conflict are technically inefficiency when compared to their counterparts with low or no herders-farmers conflict incidence.

Economic cost of conflict is significant at 1% level of significance. The results show that the coefficient for this variable is positive which is similar to the expected sign. The cost associated with violent conflicts experienced by cassava-based farmers in the study area can increase their technical inefficiency.

Conclusion and Recommendations

The study evaluates the effects of farmers-herders conflict on technical efficiency among cassava farmers in Yewa North Local Government Area of Ogun State, Nigeria. Households were categorized based on their exposure to conflicts, revealing varying degrees of exposure. The economic burden of conflicts, including direct and indirect costs, further highlighted the challenges faced by farmers. Cassava stems cuttings, fertilizer quantity, and farm size significantly affected cassava production. Age and farming experience contributed to technical inefficiency. The mean technical efficiency of cassava was 0.741. The study underscores the complex interactions between conflicts, socio-demographic factors, and technical efficiency in cassava farming. It emphasizes the need for targeted interventions to mitigate conflict-related challenges, promote gender equity, and enhance farmers' technical efficiency. Understanding the multifaceted influences on agricultural productivity is crucial for devising effective policies and support systems in conflict-prone regions. It was concluded cassava-based farmers operated with maximum efficiency given the current technology, and herdsmen-farmers conflict is the main driver of technical efficiency of cassava-based farmers.

The study recommends that the state governments should designate field for cattle grazing for the nomads, and make them pay for it through taxes. Also, there is need for directional policy intervention targeted at female farmers to raise cassava production efficiency.

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INCENTIVES FOR CREDIT SUPPORT OF AGRICULTURE IN THE REPUBLIC OF SERBIA[1]

Gordana Radović[2], Vesna Popović[3], Biljana Grujić Vučkovski[4]

Abstract

Since 2004, in the Republic of Serbia incentives for credit support to entities active in sector of agriculture have been included in the agricultural policy measures. Although the national model for mentioned financial support has been changed over time, in essence it remains the same. The main goal of the paper is to analyze incentives derived from the national agricultural budget used for credit support of agriculture, i.e. to review the main characteristics of the current support model, while to recommend possible improvements. The research was based on desk research and descriptive methods, as well as on methods of analysis and synthesis. According to performed research, it can be concluded that the average share of incentives for credit support within the total incentives paid from national agricultural budget was less than 2% in analyzed period (2014-2022.). The average level of realized incentives in observed period was 73%, indicating the significant need of agricultural entities for subsidized loans. In order to develop agriculture in the Republic of Serbia, the authors suggest certain advancement of current model of credit support, considering possibilities for extension of repayment period and increase in upper value limit for investment loans. Besides, authors suggest the consideration of establishing a "specialized agricultural bank" as a state financial institution, which will provide comprehensive credit support covering the developmental requirements of domestic agricultural producers.

Key words: Financing of agriculture, agrarian budget and policy, credit support, Republic of Serbia.

JEL[5]: Q14, Q18

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2 Gordana Radović, Ph.D., Research Associate, Institute of Agricultural Economics, Volgina Street no. 15, Belgrade, Serbia, Phone: +381 64 13 78 643, E-mail: gordana_r@iep.bg.ac.rs, ORCID: 0000-0001-9770-6306 (corresponding author)

3 Vesna Popović, Ph.D., Principal Research Fellow, Institute of Agricultural Economics, Volgina Street no. 15, Belgrade, Serbia, Phone: +381 11 69 72 854, E-mail: vesna_p@iep.bg.ac.rs, ORCID: 0000-0003-1018-2461

4 Biljana Grujić Vučkovski, Ph.D., Senior Research Associate, Tamiš Research and Development Institute, Novoseljanski put no. 33, 26000 Pančevo, Serbia, Phone: +381 65 23 17 001, E-mail: grujic@institut-tamis.rs, ORCID: 0000-0003-2588-4888

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Introduction

In the second half of the 20th century, agricultural loans with a low (subsidized) interest rate were financially supported from the primary issue of the national Central bank. With the monetary system reconstruction program (implemented in January 1994), mentioned type of credit support was abolished, as it was one of the causes of hyperinflation. In 1996., the was established an agricultural budget as a form of unified financial support for agriculture. Since 2004., incentives for credit support have been defined as a measure of current agricultural policy. Therefore, for a decade, agriculture was without privileged credit support, what primarily affected economic status of family farms.

Family farms are the most numerous entities within the structure of agricultural holdings, through entire Serbian history of agriculture. Current situation is the same. Although there come to slight decrease in their number between the last two agricultural censuses, they retain a dominant share, e.g. the participation of family farms in overall number of farms, according to FSS in 2018, was 99.7% (Subić, Jelocnik, 2021). In line to preliminary results of the Census of Agriculture - 2023, the number of family agricultural holdings decreased for 20% compared to the previous Census of Agriculture - 2012, while these farms keep the dominant position (99.6%) in the structure of agricultural holdings (SORS, 2024). There are several causes for decline in the number of family agricultural holdings, such are: consolidation of holdings, frequent farms leaving due to expressed migration from rural to urban territories, issues linked to uncertainty of agricultural products realization, as well as problems in securing appropriate sources of financing agricultural production.

Financing agriculture is complex and always actual issue in the Republic of Serbia. This problem is pronounced the most at the family farms, as they have small, i.e. very limited farm estates, and low economic power. Majority of these farms are facing the liquidity issue, mainly during the sowing period. Therefore, they need adequate external sources for financing their agricultural production.

Crediting conditions on the banking market historically have been continuously unfavorable for family farms. Besides high interest rate and binding the credit debt to currency clause, other disadvantages are also the high cost of bank guarantees, usual impossibility of using a mortgage as a loan security, etc. Therefore, in order to provide beneficial agricultural loans in the Republic of Serbia, there has been carried out the state financial support.

Literature Review

Several domestic and foreign authors have dealt with the issue of agricultural crediting and its importance. They generally agree that due to the specifics of agricultural production, crediting is necessary to maintain the liquidity of most of agricultural holdings. Some of them (Dimitrijević, 2023) concludes that size of sources of financing and volume of lending in agriculture directly affect the growth of agricultural production. However, there are also some opinions that challenge the importance of loans for agricultural development. For example, Madžar (2021, p. 129) concludes that "the use of agricultural loans does not have a statistically significant impact on the introduction of agricultural innovations in Serbia".

Many authors agree the stance (Tomić, 2004, p. 437) that "credit is the most expensive and irrational way of financing agriculture". There are also some studies indicating that the leasing is even more expensive and unfavorable source of agricultural financing (Pejanović, Tica, 2005).

Stevens and Jabara (1988, p. 252) state that the importance of loans, regarding the liquidity provision, arise from fact that "loans enable farmers to manage resources more flexibly, as well as better manage all risks of agricultural production, caused by changing weather conditions and price movements on the market of agricultural products". Potential explanation is found in (Vunjak, 1999, p. 134), that during the determination of level of debtors' creditworthiness, bank specifically analyze: characteristics and business conditions of loan seeker (borrower), his capital power, as possibilities for securing the loan. One of the most pronounced negative characteristics of the loans is high interest rates. Samuelson and Nordhaus (2005, p. 505) state that the interest rate depends on "maturity, risk, taxation and other characteristics of the borrower", while Mishkin (2006, p. 82) indicates that "the real interest rate is defined as the difference between the nominal interest rate and the expected inflation rate". The level of the real interest rate, in addition to the inflation rate, also depends by the level of reference interest rate predetermined by the national Central Bank, as well as by the supply and demand ratio active on the credit market, or by the price of financial sources that was previously paid by business (commercial) bank. Pilbeam (2005, p. 44) points out that "the perennial problem of the largest commercial banks is rather expensive sources of financing".

There are different types of loans on the credit market. According to Rodić (1991, p. 160) among other categories, they can be systematized as "uncovered and covered". Van Horne and Wachowicz (2007, p. 289) state that "property pledged by the borrower as security for loan repayment" is most often used as loan security. The problem of securing collateral is one of the obstacles in the Republic of Serbia related to credit borrowing by family farms from commercial banks. Grujić Vučkovski and associates

(2023, p. 232) state that "from the point of view of farmers, significant obstacle is their non-involvement in implementation of loans, as a consequence of distrust in the banking sector due to uncertainty of agricultural products realization". From the research of Radović and associates (2013, p. 49) derives the conclusion that from the point of view of farmers, the main reasons why they are cautious when deciding to borrow money from the banking sector are "instability and disorganization of the agri-food products market, uncertain realization, unknown crops' prices at the time of delivery and inconsistency of the agrarian policy measures". Meanwhile, according to Popović and associates (2018, p. 77) commercial banks are "dominantly oriented towards larger producers and agricultural companies (larger than 25,000 EUR), while the smaller producers are "removed" from the market".

In line to previously mentioned, family farms in the Republic of Serbia really need the state financial support that will enable them to borrow under more favorable conditions. As possible solution could be current one that assumes subsidizing part of the interest on agricultural loans. Another could be to establish a specialized financial state institution, or "specialized agricultural bank", which will be primarily turned to lending to entities involved in agriculture (Radović, 2014, pp. 89-94). Similar example (state financial institutions) exists in Croatia. There functions the Croatian Bank for Reconstruction and Development, that approves loans under favorable conditions for the development of agriculture (CBRD, 2016).

Besides agriculture, there are views that the support of state institutions is also crucial in other areas of economy. Specifically, Popović and Grujić (2015, p. 522) believe that "imperative for the state authorities is to provide adequate amounts of budget support to finance the development-oriented investments in agriculture and rural areas". Jovanović and Zubović (2022, p. 118) concluded in their research that "creation of indicators for implementation, monitoring and evaluation of the impact of the incentive system" is also required.

Methodology and Data Sources

Paper aims to analyze incentives from the agrarian budget used for credit support to agriculture in the Republic of Serbia, reviewing the main characteristics of existing support model, while recommending some possible improvements. The paper uses the desk research method, the descriptive method, as well as the methods of analysis and synthesis. Data sources are available literature, mainly scientific papers of domestic and foreign authors, as well as national legislation, and reports of the Ministry of Agriculture, Forestry and Water Management of the Republic of Serbia (MAFWM), or other state institutions.

Research Results and Discussions

Subject of analysis is credit support in agriculture, that was introduced in 2004. as one of agricultural policy measures. The general source of loans was the agricultural budget, while the loans were granted through the Development Fund of the Republic of Serbia, or commercial banks. Credit beneficiaries could only be the registered agricultural holdings (Radović et al., 2013, pp. 49-50). Since 2011., MAFWM has been changed the way of support, while according to new conditions, incentives, i.e. subsidies was turned to cover the part of interest on loans approved by commercial banks, previously approved from the agricultural budget. Every year, MAFWM signs contracts with eligible commercial banks, enabling the subsidized credit support for agriculture. Essentially, "the main goal of the relevant Ministry is to provide financial support to devastated agricultural production, as well as to build the "credit history" of agricultural farms" (Radović, 2014, p. 51). Over time, the way of realizing mentioned credit support has been slightly changed, as well as the terms of lending, but in its essence remains the same. Incentives for credit support were used from the date of their introduction in 2004. until today. Only in 2013., there come to short break in incentives implementation, although they were previously planned in the agricultural budget

In initial years of this agrarian policy measure implementation, incentives for credit support had a dominant share in the structure of agrarian budget. For example, „this participation was 13.6% in 2005., or more than a fifth of the agricultural budget in 2006." (Radović, 2014, p. 51).

Tables 1. and 2. show the participation of planned and realized incentives for credit support in agricultural budget (part of agricultural policy measures) for the period 2014-2022.

Table 1. Planned incentives for credit support (period 2014-2022.)

Year	Total planned incentives (in RSD)	Planned incentives for credit support (in RSD)	Participation of planned incentives for credit support in total planned incentives (in %)
2014.	29,485,428,000	500,000,000	1.70
2015.	19,568,700,000	500,000,000	2.56
2016.	23,826,620,000	600,000,000	2.52
2017.	28,649,803,000	600,000,000	2.09
2018.	30,415,258,266	950,000,000	3.12
2019.	40,551,522,000	500,000,000	1.23
2020.	42,203,673,000	802,017,000	1.90
2021.	44,384,346,000	470,000,000	1.06
2022.	56,672,887,000	722,000,000	1.27
Total	**315,758,237,266**	**5,644,017,000**	**1.79**

Source: MAFWM, 2023-2015.

Table 2. Realized incentives for credit support (period 2014-2022.)

Year	Total realized incentives (in RSD)	Realized incentives for credit support (in RSD)	Participation of realized incentives for credit support in total realized incentives (in %)
2014.	34,462,539,418	357,104,872	1.04
2015.	22,892,435,534	125,605,359	0.55
2016.	23,277,425,628	360,972,034	1.55
2017.	26,774,567,824	599,999,062	2.24
2018.	28,274,397,854	912,198,129	3.23
2019.	33,970,316,199	476,341,198	1.40
2020.	39,077,630,460	104,826,670	0.27
2021.	40,624,672,849	451,625,799	1.11
2022.	53,873,739,245	712,341,220	1.32
Total	**303,227,725,011**	**4,101,014,343**	**1.35**

Source: MAFWM, 2023-2015.

Based on the data presented in Table 1. derives a conclusion that the average share of planned incentives for credit support within the overall planned incentives (agrarian policy measures) in analyzed period (2014-2022.) was less than 2%. This is a very small share considering the real needs for this type of credit support, as a source of agricultural financing. However, the average share of realized incentives for credit support in entire realized incentives is even smaller and amounted to only 1.35% (Table 2.).

Analyzing the relationship between planned and realized incentives for credit support (Table 3.) shows that there are also significant oscillations in certain years.

Table 3. Realized vs. planned incentives for credit support (2014-2022.)

Year	Planned incentives for credit support	Realized incentives for credit support	Participation of realized in the planned incentives for credit support (in %)
2014.	500,000,000	357,104,872	71.42
2015.	500,000,000	125,605,359	25.12
2016.	600,000,000	360,972,034	60.16
2017.	600,000,000	599,999,062	99.99
2018.	950,000,000	912,198,121	96.02
2019.	500,000,000	476,341,198	95.27
2020.	802,017,000	104,826,670	13.07
2021.	470,000,000	451,625,799	96.09
2022.	722,000,000	712,341,220	98.66
Total	**5,644,017,000**	**4,101,014,343**	**72.66**

Source: MAFWM, 2023-2015.

The highest utilization of planned incentives for credit support was in 2017., while the lowest was in 2020., which can be justified by the situation caused by the corona virus pandemic. The average share of realized in planned (available) amounts of incentives for credit support, in analyzed period, was around 73%. There is belief that the incomplete utilization of available benefited credit support can be partly explained by caution and negative experiences with credit debts of agricultural entities, primarily family farms, in previous period. Other possible reasons are insufficient information, problems in implementation of this support through commercial banks, etc. Nevertheless, in the last analyzed year, the utilization of available fund is almost maximal, and it can be considered that the difficulties in implementation of this agrarian policy measure have been removed (Table 3.).

Current credit support is realized in accordance with the Law on Agriculture and Rural Development (OGRS, 2021), the Rulebook on the Conditions and Ways of Exercising the Right to Credit Support (OGRS, 2017-2024), as well as the Regulations on the Distribution of Incentives in Agriculture and Rural Development, which are adopting for each year. General purposes, types and characteristics of current benefited loans are shown in Table 4.

Table 4. Purpose, types and characteristics of subsidized loans (period 2017-2022.)

<table>
<tr><th>Purpose of the loan</th><th colspan="2">Characteristics of loans</th><th>Loan amounts</th></tr>
<tr><td rowspan="5">* Development of animal husbandry (purchase of animals and payment of insurance premium);
* Development of holding, fruit growing, viticulture, vegetable and flower growing;
* Investments in agricultural machinery and equipment;
* Procurement of feed for animals;
* Investments in certain types of mechanization and equipment used in plant production;
* Livestock development, which includes the acquisition of quality breeding heifers and cows up to five years old and the insurance premium for these animals;
* Development of crops farming, fruit growing, viticulture, vegetable and flower growing, including the procurement of fertilizers.</td><td>Repayment period is maximally 3 years</td><td>Repayment term 3-5 years</td><td>For natural persons (commercial family farms) and entrepreneurs up to 6 million RSD</td></tr>
<tr><td colspan="2">The loan is approved and disbursed in RSD</td><td rowspan="4">For legal entities up to 18 million RSD</td></tr>
<tr><td colspan="2">Fixed annual interest rate of 3%</td></tr>
<tr><td colspan="2">Fixed annual interest rate of 1%:
- for farmers up to 40 years old;
- for female persons engaged in agriculture;
- for farmers whose residence is in an area with difficult farming conditions.</td></tr>
<tr><td>Repayment in monthly, three-month, six-month or annual annuities</td><td>Repayment in six-month annuities</td></tr>
</table>

Purpose of the loan	Characteristics of loans	Loan amounts
Users of credit support can be: • physical person - holder of a commercial family farm; • entrepreneur; • legal entity (micro or small enterprise, or agricultural cooperative with at least 5 members).		

Source: OGRS, 2017-2024.

After analyzing the data from Table 4., it can be concluded that besides the favorable characteristics of current credit support, there are also some terms that could be improved. In particular, the favorable characteristics are: low interest rate, exclusion of currency clause, almost all the most important lines of agricultural production in Serbia are covered by the defined loans' purposes. There is also opinion that, further developing of agriculture could assume the maturity of investment loans to at least 10 years, while the upper limit of credit indebtedness should be increased.

Conclusion and Recommendations

The subject of analysis in this paper are credit incentives contained in agricultural budget of the Republic of Serbia, for the period from 2004. to the present day. According to performed research, there is conclusion that the share of mentioned incentives in total sum of incentives paid out from the agricultural budget slightly decreased over the time. For example, this participation was 13.6% in 2005., or even 20% in 2006., while up to 2022. observed share has been dropped to only 1.2%. However, analyzing the average utilization of available incentives for credit support, there could be conclusion that it reached 73% for the analyzed period (2014-2022.), showing the minor deviations in certain years. Previous data indicate a high demand of entities active in Serbian agricultural for loans approved with subsidized interest.

It is important to point out the main research limitations, considering that the subject of analysis was just the subsidized loans paid by the state financial institutions, but without including Fund for Development of the Autonomous Province of Vojvodina, and Provincial Fund for Development of Agriculture.

In order to improve the current model of credit support, suggestions are turned to possibilities for extending the repayment period of investment loans. Then, suggestion is turned to increase in upper credit limit for loans approved for investments in development of agricultural production. At the end, one of suggestions is oriented to considering the establishment of "specialized agricultural bank" in the Republic of Serbia, while this state-owned financial institution should provide more comprehensive credit support to the developmental needs of domestic agricultural producers.

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OPTIMIZATION OF PRIMARY MILK PRODUCTION IN THE HILLY-MOUNTAINOUS REGIONS OF THE REPUBLIC OF SERBIA[1]

Mersida Jandrić[2], Grujica Vico[3], Miroslav Nedeljković[4]

Abstract

Paper presents a model for the optimization of primary milk production in the hilly-mountainous regions of the Republic of Serbia. The goal of creating the model is to demonstrate and analyze the conditions and outcomes of production at the farm, while to find the optimal production structure, considering the organizational, economic, technical, and technological circumstances in which the farm performs its agricultural activities. The model is based on the linear programming optimization method. A mathematical model, or objective function, was established, and constraints were identified. A logical model was created for optimization. The main goal of solving the linear programming problem is to find the maximum or minimum of the objective function. In presented model, the task is to maximize the objective function, what is represented by the farm's net income. By using the linear programming, it is possible to determine the optimal quantities of resources and products to maximize net income, while adhering to resource constraints and other relevant factors.

Key words: Optimization, linear programming, primary milk production.

JEL[5]: Q1, Q13, C61

Introduction

Linear programming (LP) is successfully used for decades in different studies of agroeconomic issues. During these activities, LP continuously proves to be a powerful

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2 Mersida Jandrić, Ph.D., Assistant Professor, Faculty of Agriculture, Bijeljina University, Pavlovića put no. 24, 76300 Bijeljina, Bosnia and Herzegovina, Phone: +381 63 661 350, E-mail: mersida.jandric@hotmail.com, ORCID: https://orcid.org/0000-0002-8785-7052

3 Grujica Vico, Ph.D., Associate Professor, University of East Sarajevo, Faculty of Agriculture, East Sarajevo, Vuka Karadžića no. 30, 71123 East Sarajevo, Bosnia and Herzegovina, Phone: +387 65 728 323, E-mail: vicogrujica@yahoo.com, ORCID: https://orcid.org/0000-0003-1719-7412

4 Miroslav Nedeljković, Ph.D., Research Associate, Institute of Agricultural Economics, Volgina Street no. 15, 11060 Belgrade, Serbia, Phone: +381 65 447 1201, E-mail: miroslavnedeljkovic2015@gmail.com, ORCID: https://orcid.org/0000-0002-7393-2146

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tool with great informational potential for agricultural production organizers. Despite the proven benefits of the LP, it has not found yet its significant practical application in Serbia and wider region. Reasons for this primarily lie in the relative complexity of the process, which involves not only the creation of logical and mathematical models, but also the interpretation and understanding of derived results.

LP is considered as part of larger progressive development that provides to humanity possibility to set general objectives and to outline the steps of deep decisions to be made towards the "best" achievement of its goals facing the practical situations of huge complexity. Dantzig discusses the competences to articulate common objectives and later defining of optimal policy alternatives for practical decisions of large complexity (Dantzig, 2002).

There are specialized software and add-ons, such as Solver in MS Excel that support the LP method. Unfortunately, they are still not sufficiently accessible to wider group of users in the agri-food sector. Additional efforts are needed to facilitate access to these tools, while increasing their practical application.

Literature Review

Agriculture is facing the challenge of enhancing the sustainability of food production, which requires the implementation of new systems and technologies (Springmann et al., 2018; Möhring et al., 2023). Livestock farming is crucial for many economies but often relies on government subsidies to sustain required activities (Kamilaris et al., 2020). However, some researchers (Maksimović Sekulić et al., 2024) emphasize the importance of choosing production structures independent of such subsidies, thereby promoting fair competition and innovation.

Many authors underline the significance of mathematical models and optimization in realizing the biophysical relations within a complex system (Romera et al., 2004; Neal et al., 2007; Addis et al., 2021). Andrić Gusavac (2020) highlights the benefits of applying operations research in agriculture, particularly in optimizing livestock feed. These methods have been proven as useful in better understanding the complexity of agricultural systems and improving their management (Weintraub, Romero, 2006).

Optimization methods, dating back to the 1950s, and firstly proposed by Waugh (1951), include the application of linear programming (LP) for optimizing livestock feed, while Dantzig published his first paper on LP in 1948. (Dantzig, 1948). With the development of information technology, optimization methods increasingly rely on software packages, becoming fundamental tools supported by computers and computer applications, such as the use of Solver tools. After its launching during the February 1991., Microsoft Excel Solver becomes the most widespread and arguably the most widely utilized general-purpose system for optimization modeling (Fylstra et al., 1998). So, optimization tool that use LP will be beneficial for agricultural producers to optimize the resource utilization (use of inputs) and overall farm profitability, as well as for strategic approach in planning, or making better decisions, or better understanding used systems (Addis et al., 2021). Furthermore, increasing productivity in agriculture is crucial for decreasing the regional poverty (Irz et al., 2001; Byerlee et al., 2009; Hoel et al., 2024).

According to Vico and Rajic (2019), research relying on the application of LP in optimizing agricultural production in this region dates back to the 1960s (Kamenečki, 1963; Dobrenić, 1966; Galev, 1966; Bubica, 1968). It was often applied in creating and analyzing macroeconomic models of agricultural development (Jakovljevski, 1984; Bogdanov, 1994; Rodić, 2001; Ljubanović Ralević et al., 2013; Babovic, Radovic, 2014; Paunovic et al., 2016; Vulević et al., 2018). Vico et al. (2013) optimized production on a cattle farm using minimization of labor as the criterion for optimality. Jandrić (2019) formulated a LP model for optimizing primary milk production.

In previous couple decades there are several researches focused to the optimization of milk production (Eshraga et al., 2011; Sharma et al., 2012; Chen et al., 2020; Gahroui et al., 2021). Therefore, the aim of the paper is to find the maximum of the objective function of the observed dairy production, i.e. to formulate such a model leading to that.

Methodology

The method used for optimizing primary milk production in hilly-mountainous regions of Serbia was linear programming optimization. Initially, a mathematical model was established, including a criterion function, to define the set goals. Then, constraints relevant to milk production in these regions were identified, such as the availability of resources, capacities, and other production conditions. Based on this, a logical model was formed to enable the analysis of different scenarios and their impacts on production. Research data has been collected in the period 2018-2019., within the observed region of Serbia. In the continuation of the paper statements of the criterion function are given as well as the set limitations and that:

Criterion Function

$$(\max) f = \sum_{i=1}^{p} \sum_{j=1}^{q} c_{ij} x_j \qquad (1)$$

Constraints

$$\sum_{i=1}^{p}\sum_{j=1}^{q} a_{ijkl} x_j \leq=\geq u_k \text{ while, } k = 1, 2, \dots, r; l = 1, 2, \dots, s \qquad (2)$$

Non-negativity Condition: i = 1, 2, ..., p; j = 1, 2, ..., q. Indices: p – number of activity groups, q – number of activities in a group, r – number of constraint groups, and s – number of constraints in a group. Activities: x_{ij}, while i = 1, 2, ..., p; j = 1, 2, ..., q. Constraints: u_{kl}, while k = 1, 2, ..., r; l = 1, 2, ..., s. Coefficients in the objective function: c_{ij}, while i = 1, 2, ..., p; j = 1, 2, ..., q. Coefficients in the constraints: quantity of the j^{th} activity in the i^{th} activity group of the l^{th} constraint in the r^{th} constraint group.

This approach allows producers to precisely plan and optimize their resources, maximizing profitability and sustainability of milk production in mountainous areas. Therefore, the research goal would be the formulation of such a model.

Results and Discussion

In optimizing primary milk production in the mountainous regions of the Republic of Serbia, the method of linear programming optimization was used. Key elements of the farming system important for achieving the research objectives were identified and analyzed. The logical model considers activities, constraints, and resources necessary for optimization.

Activity Groups:

- Cattle Farming: Including dairy cows and supporting categories. Calves are sold within fifteen days after birth, except for some female calves retained for herd replacement.
- Crop Production on Own Land: Encompasses different crops, including grass-clover mixtures, cereals, buckwheat, and potatoes for market sale.
- Meal Preparation: Provides animal feed and concentrates from various sources.
- External Inputs for Crop Production: Include fertilizers, pesticides, and other resources.
- Other Costs: Cover various operational expenses.
- Labor Force: Comprises both family and hired labor.
- Final Products: Include dairy and other agricultural products.

Constraint Groups:

- Capacities: Include livestock and storage of agricultural products.

- Biotechnical Constraints: Relate to production processes and methods.
- Market Constraints: Include market demands and limitations.
- Input Balances for Cattle Farming: Include capacities for feed, water, and other resources.
- Input Balances for Crop Production: Cover requirements for fertilizers, pesticides, and other resources.
- Other Costs: Encompass general farm costs.
- Labor Force: Include requirements for labor, including internal and external labor and machinery.
- Mechanization: Relates to the use of equipment and tools for various tasks.
- Final Product Balances: Encompass stocks of final products ready for sale.

The logical model was created based on information gathered from interviews with farmers and advisors, and reflects the real circumstances in which the farm operates, considering new trends in the observed area.

The following assumptions were made in creating the model:

- The farm has five hectares of its own arable land, with the possibility of leasing additional land at annual cost.
- The areas under pastures are not a constraint as there is assumed to be sufficient available land.
- One dairy cow is kept in production for eight lactations, and herd replacement is done through internal reproduction.
- The production of roughage feed is ensured by sowing grass-clover mixtures.
- The age of first calving for pregnant heifers is 26 months.
- The summer-feeding period lasts for 215 days and it is based on grazing with concentrates, while the winter-feeding period lasts for 150 days and is based on hay from artificial meadows with concentrates.

These assumptions establish the framework for optimization and the creation of a sustainable model of primary milk production in hilly and mountainous areas of Serbia.

At the heart of the logical model is one dairy cow, which, along with its supporting categories, forms the structural unit or activity "cattle farming" in the mathematical model. From one dairy cow, three products are obtained: milk, calves, and beef (which is obtained when adult cattle become unproductive for breeding).

These products are sold on the market, while some female calves are kept for herd replacement. Inputs such as animal feed and additional inputs used in livestock production can be purchased from the market or produced at the farm. For example, the production of animal feed within farms' crop production provides internal inputs for livestock.

Some final products from crop production, such as potatoes and buckwheat, can be sold on the market. The market, with its requirements, can limit the minimum and maximum quantities of plant products the farm can produce and sell. Additionally, the structure of crop production partly depends on biotechnical constraints, such as crop rotation.

Plant and livestock production represent the production capacities available to the farm. These two types of production share certain resources, such as labor and machinery. Some capacities are specific to plant production, such as arable land, while others are related to livestock farming, such as the stalls for dairy cattle. These distinctions between capacities and resources help to optimize production and the sustainability of the farm.

Activities in the model of optimizing primary milk production: After establishing the logical model, analysis of each individual element of the system was performed. As a result of this process, activities that will be included in the criterion function of the mathematical model were identified. All activities can be categorized into ten groups: 1. Cattle farming, 2. Plant production on farms' land, 3. Plant production on rented land, 4. Forage, 5. Purchased animal feed, 6. External inputs for plant production, 7. Other costs, 8. Internal labor, 9. External labor, and 10. Final products.

Activities from the second group, namely plant production on rented land, deserve further explanation. Since farm is limited by its own arable land, but has the possibility for using other land sources through rental agreements, the model treats production on owned and rented land separately. Production on rented land involves additional costs (rental expenses), so it is necessary to treat these activities separately. Otherwise, both types of production would be equated in the model, which would not reflect the real circumstances.

The same situation applies to internal and external labor. Due to the methodological approach in calculating coverage margins, internal labor is not represented as a cost, while this is the case with the external labor. Forage is recognized as a separate activity because it can be obtained by combining different grains or processing grains individually.

Constraints in the model of primary milk production: Similar to the dairy farm optimization model, the model for optimizing primary milk production includes the establishment of multiple groups of constraints. Based on further considerations of the logical model, constraints and technical coefficients were defined. In defining such a mathematical model, the constraints can be categorized into two main groups: capacity constraints and constraints that are linked to activities (so-called "balances").

A more detailed classification of the predefined constraints reveals eight groups: capacity constraints, biotechnical constraints, market constraints, balances of inputs for cattle farming, balances of inputs for plant production, labor, mechanization, and balances of final products.

Capacity Constraints:

1. The maximum capacity of the barn is limited to 12 places for dairy cattle, or $X_1 \leq 12$
2. Own arable land - the farm has available 5 ha of arable land, or $X_2 + X_3 + X_4 + X_5 + X_6 + X_7 \leq 5$

Biotechnical Constraints:

3. Maximum area under potatoes - on farms' arable land, potatoes can occupy up to one quarter of the total area, or $X_2 \leq 1.25$
4. Maximum share of cereals - cereals on farms' land can be sown on up to 50% of the total area, or $X_3 + X_4 + X_5 + X_7 \leq 2.50$
5. Maximum share of grass-legume mixtures – similarly to cereals, grass-legume mixtures can be sown on up to 50% of farms' land, or $X_6 \leq 2.50$

Market Constraints:

6. Maximum production of potatoes - based on practical experience, the constraint on maximum potato production is set at 2 ha, or $X_2 + X_8 \leq 8$
7. Maximum production of buckwheat - given to previous experience regarding sales, the maximum buckwheat production is limited to 3 ha, or $X_5 + X_{11} \leq 3$

Balance of Inputs for Dairy Farming:

8. Cereal balance for fodder - based on information related to feeding of cows with concentrated feed, it has been found that in the diet for milking cows and breeding heifers, cereals in the form of fodder are used in addition to concentrated feed mixtures with 18% protein. The fodder itself

may consist of one or more different cereals. Its composition depends on the structure of plant production, which is defined by the competitiveness of different lines of plant production. Additionally, the model allows the purchase of part or all of the raw materials on the market, or $-3{,}000X_3 - 2\ 800X_4 - 3{,}000X_7 - 3{,}000X_9 - 2{,}800X_{10} - 3{,}000X_{13} + X_{14} - X_{15} - X_{16} - X_{17} = 0$

9. Fodder balance - annual fodder requirement is 1,100 kg. As previously explained, the model includes the "dairy farming" activity, i.e. representing a milking cow with its categories. So, this constraint needs to include the corresponding share of fodder needs related to feeding heifers. It is important to consider that milking cows are used for eight lactations in practice. Based on practical information and additional calculations, the value of technical coefficient is presented as 1,220 kg: $-1\ 220X_1 + X_{14} = 0$
10. Hay balance - only coarse fodder used for feeding animals in the winter period is artificial meadow hay. A daily quantity of 20 kg per milking cow is planned. Additionally, the corresponding portion of hay used for breeding heifers must be added, or $-3{,}600X_1 + 9{,}000X_6 + 9{,}000X_{12} = 0$
11. Concentrate balance with 18% protein - in addition to fodder, the concentrated part of the diet also consists of certain amount of ready-made concentrated feed mixtures with 18% protein. The mixture is given in different amounts over the year, depending on the stage of lactation and pregnancy. As like in previous case, calculation of technical coefficient reflecting the consumption of concentrates per structural unit was carried out, considering the needs for a milking cow and corresponding portion of needs for a breeding heifer, or $-600X_1 + X_{18} = 0$

Balance of Inputs for Plant Production:

12. Balance of potato planting material, or $-2{,}500X_2 - 2{,}500X_8 + X_{19} = 0$
13. Balance of barley seed, or $-300X_3 - 300X_9 + X_{20} = 0$
14. Balance of oat seed, or $-180X_4 - 180X_{10} + X_{21} = 0$
15. Balance of buckwheat seed, or $-150X_5 - 150X_{11} + X_{22} = 0$
16. Balance of clover-grass seed mixtures - in defining this technical coefficient, it is necessary to consider that the average exploitation period of land sown under the clover-grass mixtures lasts for five years. This requires the need to adjust the "load" of one hectare under clover-grass mixtures with the necessary inputs for seeding (establishment). The need for seed during the sowing of one hectare is 40 kg of seed, but this amount

will not be used as a technical coefficient in the model, or $-8X_6 - 8X_{12} + X_{23} = 0$

17. Balance of triticale seed, or $-300X_7 - 300X_{13} + X_{24} = 0$
18. Balance of NPK fertilizers - required quantities of NPK mineral fertilizers are determined according to the standard technology for each sown crop. In the case of clover-grass mixtures, the calculated coefficient implies the annual requirement together with the corresponding portion of the requirement in the year of sowing, or $-400X_2 - 250X_3 - 200X_4 - 150X_5 - 200X_6 - 250X_7 - 400X_8 - 250X_9 - 200X_{10} - 150X_{11} - 200X_{12} - 250X_{13} + X_{25} = 0$
19. Balance of urea - requirements for urea were calculated similarly as the previous case, or $-200X_2 - 150X_3 - 100X_4 - 100X_5 - 130X_6 - 150X_7 - 200X_8 - 150X_9 - 100X_{10} - 100X_{11} - 130X_{12} - 150X_{13} + X_{26} = 0$
20. Balance of calcium ammonium nitrate (KAN) - it is assumed in the model that KAN is used just in potato production, or $-100X_2 - 100X_8 + X_{27} = 0$
21. Balance of diesel (fuel) - requirements for diesel are presented through technical coefficients based on technological charts, or $-10X_1 - 300X_2 - 150X_3 - 100X_4 - 100X_5 - 130X_6 - 150X_7 - 200X_8 - 150X_9 - 100X_{10} - 100X_{11} - 130X_{12} - 150X_{13} + X_{28} = 0$
22. Balance of other variable costs - accepted approach to creating the model involves some inputs as separate activities in the criterion function. This is the case with concentrated feed in cattle production, as well as seeds, mineral fertilizers, and diesel in crop production. Given the research goals, there is no need for an additional analytical presentation of inputs in crop and cattle production, as this would only increase the model without improving the quality of obtained solutions.
23. Therefore, one aggregate activity called "other variable costs" is defined in the criterion function. This activity represents a combined value of inputs for each production. In cattle production, it encompasses the costs of artificial insemination, treatment and care of livestock, electricity, hygiene products, advisory services, and other consumable materials and services. In crop production, it covers the costs of soil chemical analysis, pesticides, binders, bags, and other consumable materials and services, or $-30{,}000X_1 - 50{,}000X_2 - 15{,}000X_3 - 12{,}000X_4 - 10{,}000X_5 - 18{,}000X_6 - 15{,}000X_7 - 70{,}000X_8 - 35{,}000X_9 - 32{,}000X_{10} - 30{,}000X_{11} - 38{,}000X_{12} - 35{,}000X_{13} + X_{29} = 0$
24. Labor Force 23-34 - labor balance includes a group of twelve constraints

where technical coefficients link the activities of production lines with activities related to internal labor and those concerning external labor. With the adopted approach, where activities related to external (paid) labor are specifically defined in the objective function, the model can independently determine the need for external labor during problem-solving. The model considers that internal labor is unpaid, while external labor represents a cost. This cannot be achieved through a synthetic treatment of labor, or $-18X_1 + X_{30} + X_{42} = 0$, $-18X_1 + X_{31} + X_{43} = 0$, $-18X_1 + X_{32} + X_{44} = 0$, $-18X_1 - 20X_2 - 7X_3 - 7X_4 - 7X_5 - 1.7X_6 - 7X_7 - 20X_8 - 7X_9 - 7X_{10} - 7X_{11} - 1.7X_{12} - 7X_{13} + X_{33} + X_{45} = 0$, $-18X_1 - 8X_2 - X_3 - X_4 - X_5 - X_6 - X_7 - 8X_8 - X_9 - X_{10} - X_{11} - X_{12} - X_{13} + X_{34} + X_{46} = 0$, $-18X_1 - 7X_2 - X_3 - X_4 - X_5 - 16X_6 - X_7 - 7X_8 - X_9 - X_{10} - X_{11} - 12X_{12} - X_{13} + X_{35} + X_{47} = 0$, $-18X_1 - 5X_2 - 0.5X_3 - 0.5X_4 - 0.5X_5 - 0.5X_6 - 0.5X_7 - 5X_8 - 0.5X_9 - 0.5X_{10} - 0.5X_{11} - 0.5X_{12} - 0.5X_{13} + X_{36} + X_{48} = 0$, $-18X_1 - 3X_2 - 5X_3 - 5X_4 - 5X_5 - 16X_6 - 5X_7 - 3X_8 - 5X_9 - 5X_{10} - 5X_{11} - 16X_{12} - 5X_{13} + X_{37} + X_{49} = 0$, $-18X_1 - 125X_2 - 125X_8 + X_{38} + X_{50} = 0$, $-18X_1 - 5X_2 - 5X_3 - 5X_4 - 5X_5 - X_6 - 5X_7 - 5X_8 - 5X_9 - 5X_{10} - 5X_{11} - 1X_{12} - X_{13} + X_{39} + X_{51} = 0$, $-18X_1 + X_{40} + X_{52} = 0$, $-18X_1 + X_{41} + X_{53} = 0$

25. Capacities of internal labor 35-46 - as was previously mentioned, when creating the model, it was assumed that the farm has two family members who are permanently engaged in agricultural production, or $X_{30} \leq 400$, $X_{31} \leq 400$, $X_{32} \leq 400$, $X_{33} \leq 400$, $X_{34} \leq 400$, $X_{35} \leq 400$, $X_{36} \leq 400$, $X_{37} \leq 400$, $X_{38} \leq 400$, $X_{39} \leq 400$, $X_{40} \leq 400$, $X_{41} \leq 400$
26. Mechanization 47-58 - available mechanization Labor - model assumes that the farm has one medium-sized tractor with required equipment, allowing the performing of activities for both, crop and livestock production. In defining the available monthly mechanization labor capacity, all circumstances that influence availability were considered. This information was collected through interviews with agricultural producers and advisors. The farm does not own a combine harvester, so it relies on external services during the harvest period, or $X_1 \leq 120$, $X_1 \leq 120$, $X_1 \leq 120$, $2X_1 + 9X_2 + 4X_3 + 4X_4 + 4X_5 + 1.5X_6 + 4X_7 + 9X_8 + 4X_9 + 4X_{10} + 4X_{11} + 1.5X_{12} + 4X_{13} \leq 140$, $2X_1 + 5X_2 + 1.5X_3 + 1.5X_4 + 1.5X_5 + 1X_6 + 1.5X_7 + 5X_8 + 1.5X_9 + 1.5X_{10} + 1.5X_{11} + 1X_{12} + 1.5X_{13} \leq 140$, $2X_1 + 5X_2 + X_3 + X_4 + X_5 + 6X_6 + X_7 + 5X_8 + X_9 + X_{10} + X_{11} + 6X_{12} + X_{13} \leq 170$, $2X_1 + 5X_2 + 5X_8 \leq 170$, $2X_1 + 5X_3 + 5X_4 + 5X_5 + 6X_6 + 5X_7 + 5X_9 + 5X_{10} + 5X_{11} + 6X_{12} + 5X_{13} \leq 170$, $2X_1 + 20X_2 + 20X_8 \leq 150$, $2X_1 + 4X_2 + 4X_3 + 4X_4 + 4X_5 + 1.5X_6 + 4X_7 + 4X_8 + 4X_9 + 4X_{10} + 4X_{11} + 1.5X_{12} + 4X_{13} \leq 130$, $X_1 \leq 120$

27. Balances of Final Products 59-63 - model assumes that the farm can deliver five final products to the market, i.e. milk, calves, culled dairy cows, potatoes, and buckwheat. The expected milk yield is 3,700 liters per dairy cow annually. Calves are sold up to 15th day after calving. When defining the technical coefficient for calves, the needs for herd replacement were considered, as well as the fact that the fertility index is approximately 90%, or $3{,}700X_1 - X_{54} = 0$, $0.8X_1 - X_{55} = 0$, $75X_1 - X_{56} = 0$, $18{,}000X_2 + 18{,}000X_8 - X_{57} = 0$, $1{,}600X_5 + 1{,}600X_{11} - X_{58} = 0$

Objective Function in the Optimization Model of Primary Milk Production

Solving a LP task implies finding the maximum or minimum of the objective function. The specific goal in a given task depends on the research objective. In this model, the task is to maximize the objective function, which represents the net income. The following Table (Table 1.) provides an overview of the used input prices in the model.

Table 1. Input prices in the optimization model of primary milk production

Code	Input	Unit of Measure	Purchase Price (RSD/UM)
X_{15}	Animal feed - barley grain	kg	22.00
X_{16}	Oat grain - purchased	kg	25.00
X_{17}	Triticale grain - purchased	kg	18.00
X_{18}	Concentrate (18% protein)	kg	50.00
X_{19}	Seed potatoes	kg	70.00
X_{20}	Forage barley seed	kg	50.00
X_{21}	Oat seed	kg	50.00
X_{22}	Buckwheat seed	kg	160.00
X_{23}	Grass-legume mixture seed	kg	360.00
X_{24}	Triticale seed	kg	50.00
X_{25}	NPK fertilizer	kg	63.00
X_{26}	Urea	kg	60.00
X_{27}	KAN (calcium ammonium nitrate)	kg	59.00
X_{28}	Diesel fuel	l	155.00
X_{42-53}	External labor	Hour	240.00

Source: According to authors calculations.

The coefficients in the objective function for activities, representing production lines, have a zero value, while coefficients are negative for inputs purchased at the market or positive for final products sold in the market. The prices of final products used in the model could be seen in next table (Table 2.).

Table 2. Prices of final products in the optimization model of primary milk production

Code	Final Products	Unit of Measure	Selling Price (RSD/UM)
X_{54}	Milk	l	28.00
X_{55}	Calves	pcs	25,000.00
X_{56}	Cows removed from milking herd	kg	160.00
X_{57}	Potatoes	kg	40.00
X_{58}	Buckwheat	kg	95.00

Source: According to authors calculations.

Solving the model

Model that directly includes inputs and outputs in the objective function has several advantages compared to approach that includes production lines. The advantages lie in faster and simpler interpretation of results after solving the model, as they are deriving directly from the model without additional calculations. This approach is allowing separate consideration of related products, what is particularly important for post-optimal analysis, as well as for easier experimentation with the initial model, by changing initial parameters. Interpreting the values of activities representing final products directly from the model allows determination of the production structure.

The optimal solution was achieved in the sixtieth iteration. The advantages of using approach that includes inputs and outputs in the objective function, as explained in the previous model, are also present in this case.

The clover-grass mixtures should be sown on a total area of 4.80 ha, including 2.50 ha at the farm's own land and 2.3 ha on rented land. Mentioned yields in total 43,200 kg of hay in two harvests (mowing), what meets the needs of twelve dairy cows and supporting cattle categories. Potatoes should be planted on a total area of 2 ha, including 1.25 ha at the farm's own land. The same area should be sown with buckwheat, while 1.75 ha has to be sown on rented land. Other cereals were not competitive, so the needs for concentrated feeds will be met through market procurement. For these purposes, the farm has to annually purchase 7,200 kg of 18% protein concentrate and 14,640 kg of triticale grain, which is used as crumbled feed for feeding dairy cows and breeding stock.

An overview of the production structure can be easily read from the optimal solution. Annual production provides the market with 44,400 l of fresh raw milk, nine calves, 900 kg of beef from culled breeding cows, 36 t of potatoes, and 4.8 t of buckwheat grain. In this way, the farm can achieve an annual net income of 1,287,536.00 RSD. In next table is visible the optimal production structure (Table 3.).

Table 3. Optimal structure of primary milk production

Cod	Element	Unit of Measure	Quantity
X_1	Cattle heads	heads	12.00
X_2	Potatoes, own land	ha	1.25
X_3	Barley, own land	ha	0.00
X_4	Oats, own land	ha	0.00
X_5	Buckwheat, own land	ha	1.25
X_6	Grass-clover mixtures, own land	ha	2.50
X_7	Triticale, own land	ha	0.00
X_8	Potatoes, leased land	ha	0.75
X_9	Barley, leased land	ha	0.00
X_{10}	Oats, leased land	ha	0.00
X_{11}	Buckwheat, leased land	ha	1.75
X_{12}	Grass-clover mixtures, leased land	ha	2.30
X_{13}	Triticale, leased land	kg	0.00

Source: According to authors calculations.

The largest share in the structure of external variable costs is given to other costs, 30.08%. This is due to the level of detail in the model creation, highlighting only key elements (inputs), while others are shown as aggregate and expressed in value as the activity "other costs". These include land rent, protective agents, veterinary services, cattle care and treatment costs, protective agents in crop production, and the costs of other materials and external services. Within the sum of external variable costs, the costs of livestock feed account for 27.89%. Clearly, these costs should be added to the costs of hay production and the fact that the grazing period lasts for seven months, indicating that the cost of livestock feed has a greater share in external variable costs, providing a realistic picture of cattle production in hilly and mountainous areas. After livestock feed costs, the large share has also the costs of seed potatoes (15.66%) and diesel (11.52%).

September is the month with the highest labor expenditure, as in addition to own capacities, 66 hours of paid (external) labor have to be hired. This is the month when potatoes are harvested, requiring the labor use in larger volume. After September, the other months with the high labor expenditure are August (313.80 hours) and June (309.80 hours). In these months, the first and second mowing and hay storing is done. April represents the so-called "spring labor peak". In next table (Table 4.) is observed the structure of external variable costs occurred in milk production.

Table 4. Structure of external variable costs in primary milk production

Code	Element	Costs (RSD)	Share (%)
X_{15}	Purchased feed - barley grain	0.00	0.00
X_{16}	Purchased - oat grain	0.00	0.00
X_{17}	Purchased - triticale grain	263,520.00	11.79
X_{18}	Concentrate 18% protein	360,000.00	16.10
X_{19}	Seed potatoes	350,000.00	15.66
X_{20}	Feed barley seed	0.00	0.00
X_{21}	Oat seed	0.00	0.00
X_{22}	Buckwheat seed	72,000.00	3.22
X_{23}	Grass-clover mixtures seed	13,824.00	0.62
X_{24}	Triticale seed	0.00	0.00
X_{25}	NPK	139,230.00	6.23
X_{26}	Urea	79,440.00	3.55
X_{27}	KAN	11,800.00	0.53
X_{28}	Diesel	257,610.00	11.52
X_{29}	Other costs	672,400.00	30.08
X_{42}-X_{53}	External labor	15,840.00	0.71
Total		2,235,664.00	100.00

Source: According to authors calculations.

A quantitative analysis of the optimal solution can be conducted through a post-optimal analysis. This information is useful for the farmer for both, annual planning and long-term business orientation.

Raw milk, as the main product of cattle farming, has an average selling price of 28 RSD/l. Sensitivity analysis shows that a reduction in the price of milk by 3.94 RSD/l (14.01%) would affect a change in the optimal solution, resulting the decrease in the volume of cattle production. Increase in selling price of raw milk would not affect a change in the optimal solution because the maximum stable capacity has been fully utilized.

Post-optimal analysis, including the assessment of constraint utilization and the so-called "shadow prices" provides valuable information for the farmer. Each additional increase in stables' capacity for one stall increases the net income by 14,578 RSD, but in this case, the increase can amount to only three stalls (3.67). Beyond that threshold, the second constraint becomes a real constraint.

Additional hectare of planted potatoes would contribute to increase in total net income by 355,400 RSD, but this increase can be achieved for a maximum of around half hectare (0.528 ha). For every additional hectare of planted buckwheat, the total net income of the farm would increase by 68,600 RSD, while by the starting parameters, the maximum increase can be 1.75 ha. Each additional hectare of arable land would increase net income by 20,000 RSD, what is equivalent to rental costs.

Conclusion

The solution of the established linear programming (LP) model for the optimization of primary milk production indicates the need to combine cattle farming with crop production. This approach includes not only the production of roughage on artificial meadows, but also entails the production of other crops for the market. Mentioned combination allows better utilization of farm production capacities.

The results derived from the model show that systematic analysis can encompass resources and production activities in primary milk production, providing a logical model with clearly defined system elements and their mutual interconnection. This creates the conditions for observing primary milk production as a system that can be modeled and subjected to agro-economic analysis using LP. Based on systematic analysis and developed logical model, there was defined mathematical model, considering the specificity of production conditions at the particular farm.

The special value of this research is in development and applying of optimization methods in primary production of milk in observed region. The goal of the model was to maximize the use of all available natural and production resources, thereby enabling the achievement of maximum economic effects. The next research steps could be based on the assessment of influence of certain factors in the development of dairy farming, i.e. in development of model that would optimize that production.

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