

Research Article

Determinants of Rice Output Market Surplus Under Smallholder Rice Producers in North Western Ethiopia

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Abstract

Rice (*Oryza sativa*) is a staple, and cash crop used as the main source of calorie intake for humans and animals in the globe and feeds more than 3.5 billion people worldwide. Introduced to Ethiopia in the 1970s, rice has since become a key source of food, income, and employment for smallholder farmers. The research used a simple and systematic sampling technique to take 180 smallholder rice producers to examine the determinants of rice output market surplus in Northwester Ethiopia. The research used descriptive statistics and a multiple linear regression model. The descriptive statistics revealed that 87.22%, 52.78%, 46.11%, 47.22%, and 61.67% of the respondents were male-headed, got extension services, owned fertile rice land, were members of cooperatives, and owned their cell phones respectively. The multiple linear regression model identified that Adoption of improved rice variety, rice farming experience, cultivated land allocated for rice production, soil fertility, and training on rice production practices are variables that determined the rice output marketable surplus in Northwestern Ethiopia. All these factors maximize the marketable rice output surplus. Thus, policy interventions should focus on enhancing infrastructure, supporting farmer cooperatives, and promoting the adoption of modern agricultural technologies to improve productivity and competitiveness in the rice market. By overcoming these barriers, Ethiopia can further harness the potential of rice farming to improve food security and economic development for smallholder farmers.

Keywords

Rice, Determinant, Value Addition, Market Surplus, Multiple Linear Regression, Ethiopia

1. Introduction

Rice (*Oryza sativa*) is one of the most important staple food crops worldwide, feeding more than 3.5 billion people [1]. It is a key source of nutrition and plays a crucial role in food security, employment, and income generation. Globally, major rice-producing countries such as China, India, and the USA have achieved significant productivity improvements through mechanization, modern agronomic practices, and strong market integration [2].

Ethiopia introduced rice cultivation in the 1970s, and since

then, it has gained increasing importance in the country's agricultural sector. The crop has become a vital source of food, income, and employment, particularly for smallholder farmers in swampy lowland areas. Due to its high productivity, rice has been integrated into traditional Ethiopian diets in various forms, such as Injera, "Nifro," and "Genfo." Additionally, rice straw is widely used for constructing mud houses and as animal feed, particularly during the dry season when fodder is scarce [3].

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Recognizing the strategic importance of rice in addressing food insecurity, the Ethiopian government has actively promoted its production and productivity. Federal and regional research centers have been established to develop and distribute improved rice varieties suitable for different agroecological zones. As a result, the area under rice cultivation has expanded significantly. Between 2005 and 2020, rice cultivation increased by 13.67 times from 6,241.16 hectares to 85,288.87 hectares, while production rose by 23.85 times from 12,443.11 quintals to 2,682,235.14 quintals [4]. Productivity has also nearly doubled from 18.02 quintals per hectare to 31.45 quintals per hectare.

Despite these advancements, Ethiopia's rice productivity remains lower than that of leading rice-producing countries. For example, China produces 65 quintals per hectare, India 56 quintals, and the USA 50 quintals. This productivity gap highlights the need for further improvements in farming practices, mechanization, and market integration [5].

Although rice production in Ethiopia has grown significantly, smallholder farmers in Northwestern Ethiopia face numerous challenges that limit their potential benefits from the sector [6]. These challenges include:

Limited access to agricultural inputs: Many farmers lack

timely access to improved rice seeds, fertilizers, and modern agricultural machinery, which hampers productivity.

Poor market integration: Farmers often sell their rice immediately after harvest at low prices due to financial constraints and a lack of storage or processing facilities.

Weak value addition and agro-processing: The majority of farmers sell unprocessed paddy rice, limiting their profit margins. The absence of well-established rice milling industries and storage infrastructure further reduces potential earnings.

Institutional and financial barriers: Smallholder farmers struggle with inadequate access to credit, limited extension services, and weak farmer organizations that could help them negotiate better prices and access markets more effectively.

Production inefficiencies: While Ethiopia's rice yield has improved, it remains lower than that of major rice-producing countries, partly due to suboptimal agronomic practices and the low adoption of mechanization.

To address these issues, it is necessary to strengthen the rice value chain by improving input supply, market linkages, financial services, and processing infrastructure. Without targeted interventions, smallholder farmers will continue to face challenges in maximizing their income and productivity.

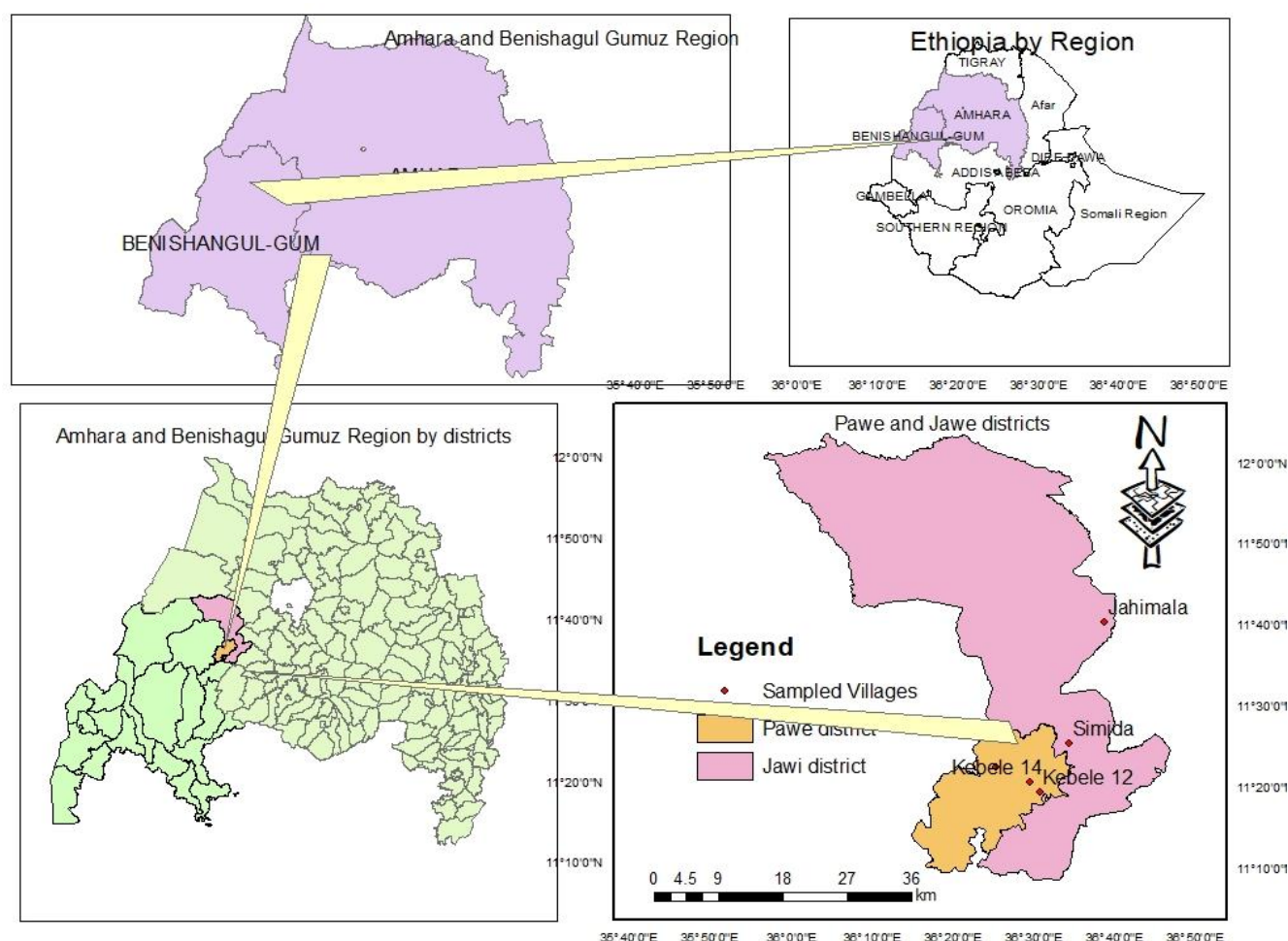


Figure 1. Map of the Study Area.

2. Research Methodology

2.1. Description of the Study Area

The study is conducted in Pawe district, Metekel zone Benshangul Gumuz region, and in Jawi district, Awi zone Amhara region, North Western Ethiopia. Pawe is found at 567 Km to North West direction far away from Addis Ababa with a geographical location at 36°27'21.88"- 36°28'22.95" longitude and latitude of 11°20'04.93"-11°17'50.43". It covers an area of 63,400 hectares with an estimated population of 59,127 (50.76% male) inhabitants [7, 8]. The farming system of the district is characterized as a mixed crop-livestock farming system dominated by cereal and pulses crops. Among the cereals and cereal crops, Rice is ranked second in terms of productivity [3]. The district is bounded in the East and North by the Jawi district, in the South by the Mandura district, and in the West by the Dangur district. It is characterized as a warm humid low land area with high rainfall. The district has 20 kebeles and the climate of the area is hot humid and characterized by unimodal rainfall patterns with high and heavy rainfall that exceeds from May to October. The [8] area receives a mean annual rainfall of 1586.32 mm and it has an altitude of 1120 m with a mean annual temperature of 16 °C to 32 °C which ranges 12 °C to 40 °C [8, 14].

Jawi is found at 602 Km to North West direction far away from Addis Ababa with a geographical location at 36°29'17.58" longitude and latitude of 11°33'22.68". It covers an area of 515,400 hectares with an estimated population of 122,259 (53.08% male) inhabitants [9]. The farming system of the district is characterized as a mixed crop-livestock farming system dominated by cereal and pulses crops. Among cereal crops, Rice is ranked second in terms of productivity [3]. Jawi district is bounded in the East by the Dangla district, in the South by the Dangur and Pawe districts, in the West by Quara districts, and in the North by the Alefa Taqusa district. It is characterized as a warm humid low land area with high rainfall. The district has 25 kebeles and the climate of the area is hot humid and characterized by unimodal rainfall patterns with high and heavy rainfall that exceeds from May to October. The area receives a mean an-

nual rainfall of 1250 mm and its altitude ranges from 700 to 1500 m.a.s.l with a mean annual temperature of 16 °C to 32 °C which ranges 12 °C to 40 °C [9, 14].

2.2. Sampling Method and Sample Size Determination

The study used multi-stage probability sampling methods. Awi and Metekel zones are the major Rice producers in the Amhara and Benshangul Gumuz regions respectively in North Western Ethiopia which were the target population for this study [14]. In the first stage of probability sampling methods, Rice producer districts were listed, and selected one district from each zone used simple random sampling methods. Based on this Pawe and Jawi districts were selected randomly from Metekel and Awi zones respectively. In the second stage of the probability sampling method, Rice producer kebeles were listed with consecutive serial numbers in each district, and two and two kebeles were selected from Pawe and Jawi respectively using simple random sampling methods. In the third stage smallholder Rice producers were listed in consecutive serial numbers in each randomly selected kebeles. Finally, Rice producer smallholder farmers were selected using a systematic sampling method and probability proportion to sample size.

The total sample size was taken based on the following formula [10].

$$n = \frac{Z^2 (P Q)}{e^2} \quad (1)$$

where

n - Is number of sample size,

Z - Is 95% confidence,

p - Is 0.4 (proportion of the population to be included in the sample i.e 30%),

q - Is 0.6 proportion of the population not to be included in the sample i.e 60%),

e - Is the margin of error or degree of accuracy desired (0.05).

According to this formula, 180 sample households were taken from two districts. The sample distribution is illustrated as follows.

Table 1. Smallholder farmers' rice producers by district and Keble.

District	Keble	# of sample units selected	Share of sample in %
Pawe	Keble 12	45	25
	Keble 14	50	27.78
Jawe	Smida	35	19.44
	Jahimala	50	27.78
	Total	180	100

Source: (Survey data, 2019)

2.3. Types and Method of Data Collection

The study used both primary and secondary data collected through structured questionnaires and checklists respectively. Primary data were collected by trained enumerators from sample households of Rice producers through face-to-face interview whereas secondary data were collected from published and unpublished documents of zonal and district administrative offices. In addition to this, personal observation, focus group discussion, and key informant interviews were conducted to support the interpretation of the results obtained from the field survey.

2.4. Method of Data Analysis

The research used both descriptive and econometric analysis using STATA version 15.2 and SPSS software version 27.

2.4.1. Descriptive Statistical Analysis

The research adopted a descriptive statistical analysis to characterize the rice production and marketing behavior of smallholder farmers in Northwestern Ethiopia. Mean, standard deviation, frequency, and percentage are among the descriptive statistics employed.

To check the model adequacy, validation, and consistency of the explanatory variables to estimate the model output, it needs to check multicollinearity among explanatory variables, correlation within explanatory variables and dependent variables, and heteroscedasticity that biased the model output result. Therefore, to avoid such problems the variance inflation factor (VIF), contingency coefficient, and Breusch-pagan tests were adopted.

2.4.2. Econometric Analysis

Depending on the dependent variables' characteristics rice marketing surplus would be estimated using Tobit, double-hurdle, heckman two-stage, and multiple linear regression models. Tobit, Double-hurdle, and Heckman models are appropriate to estimate when the dependent variable has a dummy and continuous characteristic at the first and second stages of the regression process. However, the dependent variable could be only continuous characteristics meaning all producers will supply their product to the market that differs only on the amount of supplied. In this case, the model output is appropriate to estimate using multiple linear regression models.

The research employed a multiple linear regression model due to all rice producers participating in the marketing of rice output during the survey period. They sell rice in the form of paddy and milled form to tackle their money liquidity shortage. A similar study was conducted to determine the soybean market supply in Pawe district in northwestern Ethiopia [11].

The econometric model specification is illustrated as follows:

$$Q_i = X_i\beta_i + \mu_i \quad (2)$$

Where Q_i is the amount of rice supplied to the market, X_i are explanatory Variables that determine the rice output marketable surplus, β_i is the coefficients to be estimated μ_i is the residuals.

3. Result and Discussion

3.1. Demographic Characteristics of Sample Households

3.1.1. Sex of Sample Household Head

The majority of rice producers (87.2%) are male-headed households while the rest 12.8% are female-headed households in the study area. According to Ethiopia's demographic context, it is a good representative of the total population of sex composition in the study area. The Ethiopian rural households are led by male-headed households and only windows are considered as female-headed households and they are few in number. The result is in line with [12].

Table 2. Sex of Sample Households.

Sex of Sample household head		
	Frequency	Percentage (%)
Male	157	12.8
Female	23	87.2
Total	180	100

Source: (Survey data, 2019)

3.1.2. Socio-Economic Characteristics of Sample Households

The average age of rice producers in Northwestern Ethiopia is 42.39 years old with a minimum of 24 and a maximum of 77 years old. Rice cultivation is a new farm activity mostly farmers who have swamp areas have cultivated it. The rice farm experience of rice producers in the study area is in line with this concept which is 5.21 years old with a minimum of 2 and maximum 16 years of experience in rice cultivation during the survey. The land is a critical economic asset that produces or generates income for smallholder farmers by cultivation of crops and rearing livestock. Rice producers own 2.96 hectares of land on average and allocate about 0.59 hectares of land for rice production. Rice producers have 2.4

man equivalent of the labor force on average to accomplish their daily farm activities in the study area.

The sample households are traveling 26.04 minutes on average to reach the nearest market. The sample household traveled a minimum of 20 minutes and a maximum of 40 minutes to buy or sell their agricultural outputs, industrial materials, and utilized services. The sample households sell their rice output at the nearest market. Rice producers supplied rice output of 630.75

Kg on average. A market is a place where buyers and sellers meet each other to exchange their goods at an equilibrium price. The sample households live around the kebele centers which easily access cooperatives and farmer training centers. They reached to Kebele cooperative and farmer training centers within two minutes. This is a good opportunity for farmers to easily access agricultural technology like improved seed and inorganic fertilizers. The result is in line with [13].

Table 3. Socio-Economic Characteristics of Sample households.

Variables	Mean	Std.	min	max
Age in years	42.39	7.76	24	77
Educational Background in years	1.22	1.43	0	7
Rice Farm Experience in years	5.21	2.6	2	16
Total own land in ha	2.96	0.63	1	4.25
Land allocated for rice in ha	0.59	0.28	0.25	1
Labor force	2.40	0.91	0.80	5.40
Distance to Nearest Market	26.04	5.26	20	40
Distance to FTC	1.86	0.79	1	4
Distance Cooperative	1.44	0.95	0.20	6
Rice Marketed Surplus	630.75	228.37	78	918

Source: (Survey data, 2019)

3.1.3. Access to Different Institutional Services of Rice Producers in North Western Ethiopia

A lot of governmental institutions are supporting rice producers to boost their agricultural production, particularly the rice sector by accessing credit, improved rice seeds, and inorganic fertilizers. In addition to this, they give advising and technical training. Among the governmental institutions, Agricultural, Cooperatives, research centers, and Microfinance institutions

take the lion's share by helping the rice producers. About 36.7%, 34.4%, and 52.8% of the rice producers are getting extension services, training on rice production, and access to micro-credits to enhance their rice production during the survey in the study area. 47.2%, 46.1%, and 36.7% of the sample households are responding member of cooperatives, their rice farmland is fertile and works some off-farm activities besides the Agricultural activities respectively. The study is in line with [12].

Table 4. Sample Households Access to Institutional Services.

Institutional Variables	Frequency	Percentage (%)
Access to credit	180	100
Yes	66	36.7
Access to extension service	180	100
Yes	95	52.8
Participate on off farm activities	180	100
Yes	66	36.7
Member of cooperative	180	180

Institutional Variables	Frequency	Percentage (%)
Yes	85	47.2
Status of Soil fertility	180	100
Yes	83	46.1
Getting training on rice production	180	100
Yes	62	34.4

Source: (Survey data, 2019)

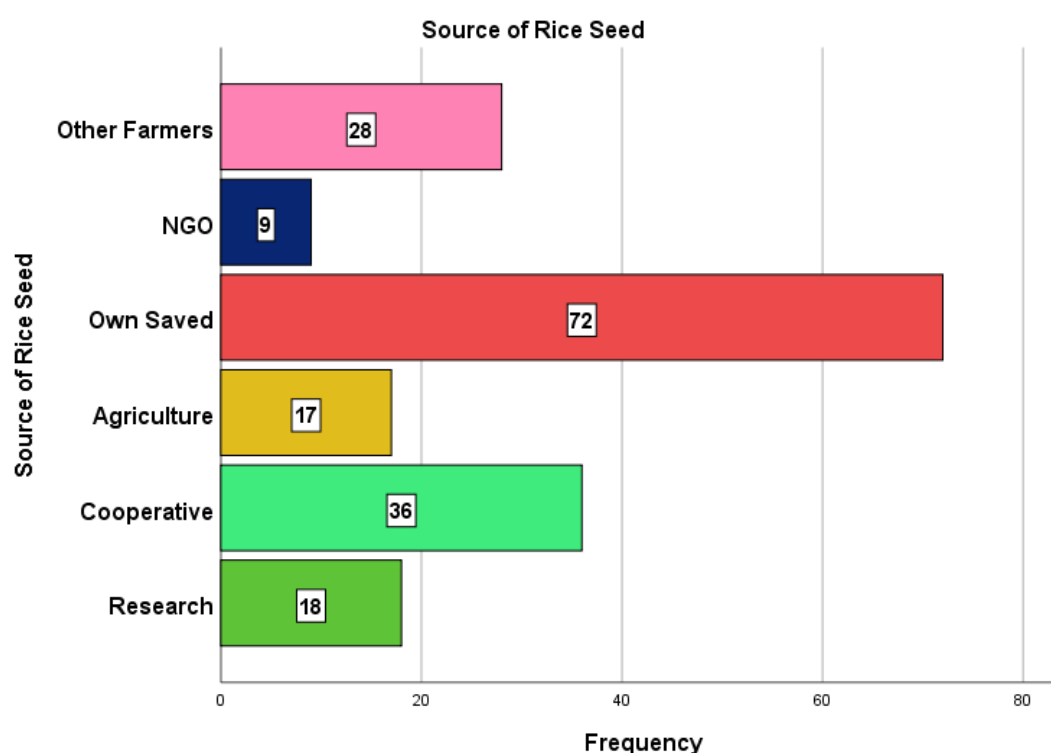


Figure 2. Source of Rice Seed.

3.1.4. Source of Rice Seed in North Western Ethiopia

Among the Agricultural technologies, improved seed have a great value to enhance the productivity of agricultural sector. Hence, delivering improved rice seed on time has its value to boost the rice production and productivity in the study area. Due to theses reason, a few number of institution is participating on delivery of improved rice seed on different modes. Cooperatives, Research centers and Agricultures are the main source of improved rice seed respectively in study area. However, more than 55% of the rice producers are still used uncertified rice seeds from their own saved seed or other farmers.

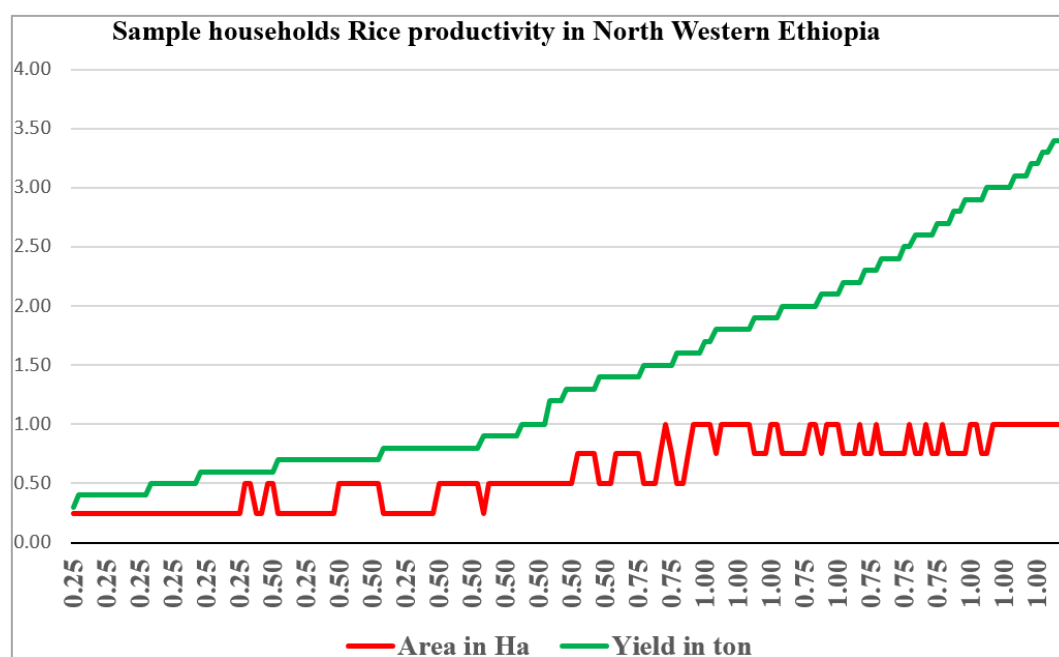
3.1.5. Profitability of Rice Cultivation in North Western Ethiopia

Rice is among the productive crops in Ethiopia's agriculture at smallholder farmer levels next to maize. Due to its biological productivity and suitability to cultivate in swamp areas, it benefited smallholder farmers as the main source of income and food in North Western Ethiopia. According to rice producers, on average they produced 24.32 quintals of rice per hectare with an average variable cost of 17,627.33 ETB. It also responded that on average they earned 36,843.42 and 19,216.10 gross profit and net profit per hectare respectively.

Table 5. Rice Production in North Western Ethiopia.

Rice production and marketing	Mean	Std. Deviation	Min	Max
Rice yield kg per hectare	2,432	1,489.45	508.22	5,759.78
Rice production cost per ha	17,627.33	9,33.81	4,014.91	40,538.71
Rice selling price per quintal	1,500.28	162.34	1,100	1,800
Rice Revenue per hectare	36,843.42	22,565.15	7,699.48	87,260.72
Rice profit per hectare	19,216.10	15,177.27	- 457.40	55,446.38

Source: (Survey data, 2019)

**Figure 3.** Rice Productivity per hectare.

3.1.6. Utilization of Rice by Sample Households in North Western Ethiopia

Sample households responded that almost 70 of their rice products are used for home consumption and about 26% of

their production is supplied to the market to cover their production costs as well as to earn some amount of money. On average they left 4% of their products for seed for the next season.

Table 6. Utilization of rice by sample households in North Western Ethiopia.

Rice Marketing and Consumption	Mean	Std. Deviation	% of rice utilization
Produced rice per ha in Kg	2,432	1,489.45	-
Rice Used for consumption in Kg	1694.35	1037.44	69.66
Sold Rice in Kg	630.75	386.85	25.94
Rice Used for Seed in Kg	106.90	76.65	4.40

3.2. Model Adequacy and Determinants of Rice Market Surplus in North Western Ethiopia

3.2.1. Model Adequacy

The Multiple Regression model was adopted to identify factors that determined the rice marketable surplus in North-western Ethiopia. Fifteen explanatory variables were included in the multiple regression model to examine the marketable surplus of rice in the study area. Multi-collinearity and heteroscedasticity effects on the model result were detected using VIF and Breusch-pagan See Appendix I. The coefficient of determination (R^2) was used as the measure of the overall significance of a model in multiple regression model estimation. The coefficient of determination (R^2) is 0.8753 which indicates that 87.53% of the marketable rice output to market is explained by the explanatory variables included in the model. In the model, $\text{prob} > \chi^2 = 0.0000$ indicated that the Multiple regression model is adequate to determine the factors that influenced the rice marketable surplus to market. Hence, the rice output marketable surplus to the market is best explained by the multiple regression mode [14]. The results of the model below showed that out of the fifteen variables included in the model, five variables determined the rice output marketable surplus to the market. The Multiple linear regression model outputs showed that the Adoption of improved rice variety, rice farming experience, cultivated land allocated for rice production, soil fertility, and training on rice production practices are variables that determined the rice output marketable surplus in Northwestern Ethiopia.

3.2.2. Determinants of Rice Output Marketable Surplus

The factors that affect the rice output marketable surplus were identified using the multiple linear regression model. Fifteen explanatory variables were included in the model to identify the rice output marketable surplus to the market under smallholder farmers in northwestern Ethiopia. Five out of fifteen variables were statistically significant and determined the rice output marketable surplus to the market in North-western Ethiopia. The Multiple linear regression model outputs showed that the Adoption of improved rice variety, rice farming experience, cultivated land allocated for rice production, soil fertility, and training on rice production practices are variables that determined the rice output marketable surplus in Northwestern Ethiopia. These determining factors are explained one by one as follows.

Adoption of Improved Rice Variety: - it is a dummy variable that indicates the use of improved rice variety or not by rice producers. The result of multiple linear regression indicated that the adoption of improved rice variety influenced

the marketable surplus of rice output positively and significantly at $P (0.000)$. This indicated that as rice producers adopted new improved rice varieties, they produced more rice output and supplied more rice output to the market. Figural as rice producers use one improved rice variety, they increased their rice marketable surplus by 149.35Kg. The finding is similar to [1, 15].

Rice Farm Experience: - the period the rice producers participated in rice cultivating is a continuous variable measured by years. The length of time measured in years in which the rice producers produced rice positively and significantly determined the volume of marketable supplied to the market at $P (0.03)$. The result of the model revealed that as rice producers more experienced by a year, the quantity of rice output market supplied increased by 2.31 kilograms of rice. This indicated that as rice producers were more experienced in rice farming, they acquired more skills and knowledge on rice production very well. This increased their rice output and marketable surplus to the market. The finding is similar to [11] who found that positive and significant on soybean market supply.

Allocated land for Rice production: - it is a continuous variable measured in hectares. It is the total land allocated for rice farming in the 2019 cropping season. The volume of rice output marketable surplus is determined by the rice land allocated for rice production at $P (0.000)$. The model result showed that as cultivated land for rice production increased by one hectare, the volume of marketable surplus to the market increased by 707.50 kilograms. This indicated that as rice producers allocated more cultivated land for rice production, they supplied more rice output to the market. This is due to rice being both a staple food and a cash crop in the study area. The finding is consistent with [11].

Soil fertility: - The more fertile their land the sample households being confidential on adoption improved rice variety. This is because farmers more fertile land gives more output and helped to repaid their input expense credits that borrowed or taking by gifts to repay after harvesting of their output. It influences the rice variety adoption at a positive and statistically significant 5%. The marginal effect tells us, that Soli fertility has a 21% increment of probability of adopting improved rice variety. The result is familiar with [14].

Training on rice production: - Training on rice production can fill the gap of knowledge and skill of smallholder farmers on how to use improved inputs, and agronomic practices, and control disease and pests. The result of the multiple linear regression model revealed that training on rice production has a positive effect and statically significance at 1% on rice output marketable surplus (Table 7). The result is in line with the result is familiar with [11, 14].

Table 7. Model Adequacy and Determinants of Rice Marketable Surplus.

Rice Marketed Surplus (dependent Variable)				
Explanatory Variables	Coefficient	Std. Err	T-Value	P> t
Adoption	149.35	15.86	9.42	0.0000
Sex of HH	0.96	19.40	0.05	0.96
Age of HH	-1.31	1.05	-1.25	0.22
Education of HH	1.88	4.46	0.41	0.69
Rice Farm Experience	2.31	2.96	2.15	0.03
Access Credit	7.07	13.88	0.51	0.61
Access to Off-farm	5.04	13.68	0.37	0.71
Rice land	707.50	23.18	30.52	0.000
Access to Extension	6.16	13.26	0.46	0.64
Soil Fertility	25.76	13.08	1.97	0.05
Training	52.56	13.95	3.77	0.000
Distance to Market	0.92	1.54	0.6	0.55
Distance to Extension	-8.09	8.65	-0.94	0.35
Labour Force	5.75	8.70	0.66	0.51
Distance to Cooperative	5.80	7.60	0.76	0.45
Constant	-109.72	63.61	-2.20	0.03
Observation = 180				
F (15, 164) = 76.77				
Prob>F = 0.0000				
R-Square = 0.8753				
Adj R-Square = 0.8639				

4. Conclusion

Rice production in Northwestern Ethiopia has emerged as a crucial agricultural activity, playing a significant role in ensuring food security, enhancing rural incomes, and providing employment opportunities. The government's initiatives, including the establishment of federal and regional research centers, have contributed to increased rice productivity, improved seed availability, and expanded cultivated areas. Over the last 15 years, rice production has shown remarkable growth, demonstrating its potential as a key cash and food crop for smallholder farmers.

Despite these advancements, several constraints hinder smallholder farmers from fully benefiting from rice cultivation. Limited access to improved rice varieties, timely input supply (such as fertilizers and seeds), modern agricultural machinery, and financial credit pose significant barriers to

increasing production efficiency. Additionally, inadequate market integration and poor value chain coordination result in lower profitability for farmers, as many sell their rice immediately after harvest at unprocessed, lower prices due to financial constraints and lack of storage facilities.

The study identifies key determinants of rice marketable surplus, including the adoption of improved rice varieties, farming experience, land allocation for rice cultivation, soil fertility, and training on rice production practices. Farmers who adopt improved rice varieties, allocate more land to rice cultivation, and receive adequate training tend to achieve higher marketable surpluses. However, poor market access, weak infrastructure, and a lack of agro-processing industries limit the value addition and profitability of rice farming.

To address these challenges and maximize the benefits of rice production for smallholder farmers, the following measures are recommended:

Improving Access to Inputs: Ensuring the timely and adequate supply of high-quality seeds, fertilizers, and other essential inputs is critical to boosting rice yields. Strengthening cooperative-based input distribution systems can enhance accessibility for farmers.

Enhancing Market Linkages: Strengthening the integration of rice producers with buyers, agro-processors, and exporters can help farmers' secure better prices and improve their income. Establishing market-oriented cooperatives and improving price transparency will enable farmers to make informed selling decisions.

Encouraging Value Addition: Promoting post-harvest technologies such as milling, storage, and packaging can enhance the value of rice products. Training farmers and cooperatives on rice processing and marketing will enable them to increase their revenue and reduce post-harvest losses.

Expanding Financial Services: Providing accessible credit and financial services will help farmers invest in improved seeds, fertilizers, and mechanized farming. Expanding microfinance institutions and cooperative credit programs can reduce financial constraints and enable farmers to store rice for better market prices.

Strengthening Capacity Building: Continuous training and extension services on improved agronomic practices, irrigation management, and post-harvest handling will enhance farmers' knowledge and skills, leading to higher productivity and better market participation.

Developing Infrastructure: Investments in rural road networks, irrigation systems, and storage facilities are essential for improving market access, reducing post-harvest losses, and enhancing the overall efficiency of the rice value chain.

By implementing these measures, smallholder rice farmers in Northwestern Ethiopia can increase their productivity, enhance their market participation, and achieve greater economic benefits. Strengthening the rice value chain through policy interventions, infrastructure development, and institutional support is essential to ensure the long-term sustainability and competitiveness of the Ethiopian rice sector. Ultimately, these efforts will contribute to improving food security, reducing poverty, and enhancing rural livelihoods.

Abbreviations

CSA	Central Statistics Agency
EIAR	Ethiopia Institute of Agriculture Research
ETB	Ethiopian Birr or Currency
FTC	Farmer Training Center
QT	Quintal
KG	Kilo Gram
KM	Kilo Meter
MARC	Mehoni Agriculture Research Center
MASL	Meter Above Sea Level
MLRM	Multiple Linear Regression Model

NEW	North Western Ethiopia
USA	United State of America

Author Contributions

Welay Tesfay is the sole author. The author read and approved the final manuscript.

Conflicts of Interest

The author declares no conflicts of interest.

Appendix

Table 8. Checking multi collinearity using Variable Inflation Factor.

Explanatory Variables	VIF	1/VIF
Age of HH	1.68	0.59
Distance to Market	1.66	0.60
Labor Force	1.59	0.62
Adoption	1.57	0.63
Rice Farm Experience	1.49	0.67
Distance to Cooperative	1.32	0.75
Distance to Extension	1.20	0.83
Training	1.13	0.88
Access Credit	1.11	0.89
Access to Off-farm	1.11	0.89
Access to Off-farm	1.10	0.90
Education of HH	1.10	0.90
Rice land	1.09	0.92
Soil Fertility	1.08	0.92
Sex of HH	1.06	0.94
Mean	1.29	

hettest

Breusch-Pagan / Cook-Weisberg test for heteroskedasticity

Ho: Constant variance

Variables: fitted values of Sold

chi2 (1) = 0.62

Prob > chi2 = 0.4245

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