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ARTICLE

Assessing Maize Enterprise Viability among Smallholder Farmers in Murehwa District, Zimbabwe: Implications for Socioeconomic Policy

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ABSTRACT

In the realm of climate change, maize crop yield continues to decline in most parts of Africa owing to extreme weather events. Although maize production plays a significant role in ensuring food and nutrition security and increasing household income, little is known about the viability of the enterprise for households with different socioeconomic statuses. The study relied on primary data collected from 248 randomly selected smallholder farmers in the Murehwa District of Zimbabwe. We estimated maize enterprise viability using gross margin analysis. We then investigated the factors driving productivity using log-linear regression analysis. We classified rural households into four groups by applying principal component and hierarchical cluster analyses using ward linkages. Our results reveal that maize is viable across all socioeconomic classes of households, with the better-off having the highest gross margin and the poorest having the least. Family size, area cultivated, number of cattle owned, quantity of maize required for household remittances, and distance to market affect the viability of maize production enterprises. Furthermore, we found a positive correlation between maize viability and the socioeconomic status of

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households. Improving market conditions and safety nets in terms of input provision can increase productivity and boost gross margins, especially for the poorest and poor households. There is a need for establishing breakeven areas, and providing credit facilities and subsidies to local agrodealers can help manage cash flow and reduce transportation costs.

Keywords: Gross Margin Analysis; Maize Enterprise; Productivity; Viability; Zimbabwe

1. Introduction

The rapidly growing global population and changing diets are driving the demand for increased food production [1]. Regarding climate change, crop yield continues to decline in most parts of Africa owing to extreme weather events [2, 3]. Within this context, food security has emerged to become difficult to manage as the world needs to feed an estimated 9.7 billion people by producing approximately 70% more food by 2050 [2]. In Africa, 33% of small-scale farmers are already undernourished, implying that they are unable to sustain their families with enough calories or one or more essential nutrients from the land they are cultivating [2]. Maize is the staple food and the most important grain crop cultivated in Zimbabwe. Annually, the country produces an average of 1.8 million metric tons (10-year average) [3]. In 2023, the total production of maize was estimated at 2.2 million metric tons, indicating a slight increase of 0.4 million metric tons from the 10-year average production [3]. Maize production in Zimbabwe is predominantly in areas with high rainfall, although the crop is also grown in the drought-prone drier areas. Farmers in such environments are often at the mercy of insufficient rainfall, resulting in poor harvests and consequential hunger in the aftermath of droughts.

The country's population in 2022 stands at 16 million people, a rise from the 2012 figure of 15 million [4]. An increase in population implies pressure on food systems to increase the production of this essential crop. However, unfavorable macroeconomic conditions and recurrent droughts have made it difficult for Zimbabwe to meet the target of producing enough food for its citizens [5]. Thus, to cover the gap between the demand and supply of maize, the country has been importing crops from different neighboring countries. In response to the increasing impacts of climatic stressors on human populations and in a bid to enhance household resilience capacity, the Government of Zimbabwe introduced the Pfumvudza program in 2020, which mainly targets maize production [6, 7]. The program is a crop production intensification approach under which farmers ensure the efficient use of inputs on a small area of land to optimize its management [1]. The program presents an opportunity to reduce poverty and achieve food security in the country, particularly for communal or subsistence farmers with small pieces of land. In addition, in response to climate stress, the government is on the move to commission, rehabilitate, and revitalize both small-scale and large-scale irrigation schemes to allow farmers to mitigate the impact of climate change and enhance community resilience through crop intensification throughout the year. This may guarantee the country's food and nutrition security [8].

However, farmers face a wide range of challenges in maximizing maize production and ensuring food security, including unpredictable weather patterns, pests and diseases, insufficient farming information, poor extension services, lack of inputs, and lack of reliable markets for maize production [5, 9, 10]. These challenges in maize production can push farmers to seek "greener pastures" to adapt, improve their livelihoods, and reduce their vulnerability to agricultural risks. Thus, the viability of maize enterprises is essential for sustainable maize production in smallholder farming [9]. A growing number of studies have analyzed the profitability and viability of maize production in developing countries [9–13]. Of these, only Basera et al. [9] analyzed the profitability of maize production in the context of Zimbabwe. They found that maize production has a higher potential to move farmers from the vicious cycle of poverty. However, they conducted an analysis assuming homogeneity of smallholder farming. Related studies indicate that smallholder farmers are heterogeneous and follow different technical itineraries depending on their resource bases [14–19]. As such, this study examined the viability of maize enterprises across households of different socioeconomic statuses.

Despite the growing interest in the need to increase maize production, most studies on the profitability and viability of crop production in Zimbabwe have considered the viability of other crops such as tobacco, groundnuts, chilli, and tea [20–23]. To the best of our knowledge, little has been done to investigate the viability of smallholder maize production across households of different socioeconomic statuses. Most developing countries adopt development strategies aimed at reducing poverty and ensuring food security, which heavily depend on the viability of smallholder farms [21, 22, 24]. An improvement in the understanding of maize production viability can help policymakers target support programs (e.g., input subsidies, extension services, and credit access) more effectively. This guarantees the efficient allocation of resources and the maximization of their impact. This study addresses the research gap identified above by analyzing the viability of maize farming across households of different socio-economic status (resource endowments). The objectives of this study were to estimate the costs and returns of maize cultivation, investigate factors affecting maize productivity of households with different socio-economic statuses, and suggest policy recommendations. Therefore, this study answered the following research questions: (1) Does the viability of maize production differ across households of different socioeconomic statuses? (2) What are the factors affecting maize productivity in households with different socioeconomic statuses? The main hypothesis that guided this study was that the viability of maize cultivation differs across farmers of different socioeconomic statuses.

2. Theoretical and Conceptual Framework

2.1. Gross Margin Analysis

Viability studies are generally based on different theories. This study is guided by the theory of production and evaluates the economic viability of maize farm enterprises. Building on previous studies on the viability of farm enterprises, our study applied gross margin analysis to shed light on the viability of maize enterprises across farmers of different socioeconomic statuses. Thus, gross margin is a proxy measurement for viability [21–23]. Gross margin is a key financial metric that represents the profitability of a product or service [25]. The gross margin serves as the unit of analysis to evaluate the economic performance of an enterprise and provides an indicator of its viability and potential contribution to household income [21–23, 26]. Gross margins are generally quoted per unit of the most limiting resource, for example, land, water, labour but in this study, crop gross margins are provided on a per-hectare basis. We used the input-output data from farmers interviewed in the Murehwa district to compute gross margins.

The gross margin relationship is stated as follows:

$$GM = TR - TC \tag{1}$$

$$TR = Yield * Price \tag{2}$$

$$Yield = \frac{QTY_{harvested}}{Area} \tag{3}$$

$$Return_{dollar} = \frac{TR}{TC} \tag{4}$$

Where GM is the gross margin; TC is total variable costs, which include the cost of seed, labour, fertilizers, and transport; gross income (TR) is the total value of yield; gross yield is the quantity of maize harvested in kilograms divided by area in hectares; Quantity harvested is the total quantity harvested in the 2021/22 cropping season; Area is the total cropped area under maize converted to hectares; Return/dollar is the amount gained in return per dollar invested and is calculated by dividing gross income (TR) by total cost (TC).

2.2. Conceptual Framework

The conceptual framework (**Figure 1**) illustrates how distinctive variables associated with the impact of maize yield and viability of maize enterprises translate to improved welfare status and food and economic security of farming households [27]. The framework shows that maize production is affected by existing institutional, farm and environmental, technical, and farmer characteristics within the country. Technical variables such as seeds, fertilizers, areas, and pesticides are very important in maize production. The timely accessibility of these agricultural inputs is also important. Other factors, such as timely weeding and planting, have a great impact on crop yield, leading to higher productivity [28]. Conversely, the viability of an enterprise is affected by productivity and the efficient use of production inputs to lower costs. This is supported by the idea that, for a production process to be efficient, available resources need to be used efficiently, that is, using available inputs to produce maximum output [27]. Furthermore, maize enterprise performance is influenced by the technological, institutional, and socioeconomic characteristics of the farmer. Institutional factors include the adoption of new technologies, market access, group membership, access to credit, and access to extension services [27, 29]. It is assumed that socioeconomic characteristics, such as age, have both negative and positive effects on both viability and profitability depending on the farmer's circumstances [26, 27, 30]. This is because older farmers tend to be risk-averse and, therefore, tend to be late adopters of any improved technologies aimed at improving productivity. On the contrary, older farmers have experience in farming (high up the learning curve) and have the capacity to amass resources that are required in farming [28].

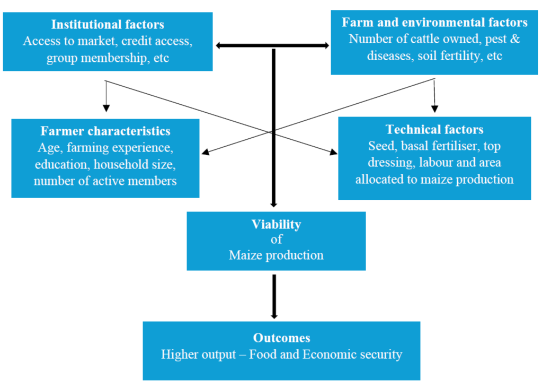

Figure 1. Conceptual framework.

Source: Modified from reference [31].

3. Methodology

3.1. Data Sources and Sampling Methods

The data used in this study were drawn from the Resilience Building through Agroecological Intensification in Zimbabwe (RAIZ) project baseline survey in the Murehwa district. Sampling included a blend of purposive and random sampling methods, with data collection done between July and August 2023 which is almost 3 months after harvesting in a normal agricultural season. The sample frame was drawn from up-to-date lists of farmers from the Agricultural and Rural Development Advisory Services (ARDAS) officers. We purposively selected Murehwa district and the 3 wards (ward 9, 26 and 28) based on the presence of RAIZ project activities, proximity to the main market, which is Murehwa center, and the presence of development projects in the last ten years. Ward 28 had RAIZ project activities. Ward 9 was easily accessible, whereas ward 26 was not easily accessible. Likewise, ward 9 had several development projects in the past 10 years, while ward 26 had no projects at all. In each of the three wards, three villages were randomly picked from a village list, and 30 households were selected using a random walk. Our enumerators picked the 5th homestead as they walked in a village from a specified start point with the guidance of a village head and agricultural extension workers. A replacement was made with the next homestead in cases where there was no adult person to respond to the interview questions. A total of 270 interviews were conducted but only 248 generated usable data after cleaning. Ethical approval to conduct this study was obtained for the surveys from the Government of Zimbabwe through the Ministry of Lands, Agriculture, Fisheries, Water and Rural Development when the RAIZ project was approved.

3.2. Study Area

The study was carried out in Murehwa district (17°43′ S, 31°39′ E, 1,300 m above sea level) in Mashonaland East Province of Zimbabwe. The Murehwa district (**Figure 2**) is located in Agroecological Zone II (NR IIA and IIB), which receives rainfall of 750–1000 mm per year [1, 32]. AEZ II is suitable for intensive farming based on maize, tobacco, cotton, and livestock. The district is characterized by granitic sandy soils with varying fertility levels, which are suitable for crop production with intensive farming techniques [32]. Agriculture is the main economic driver (54.8%) in the district, followed by the service industry (45%), and others (0.2%), e.g., vending [33]. The estimated total population in Murehwa district is 199,607, with 94,269 males and 105,338 females [4].

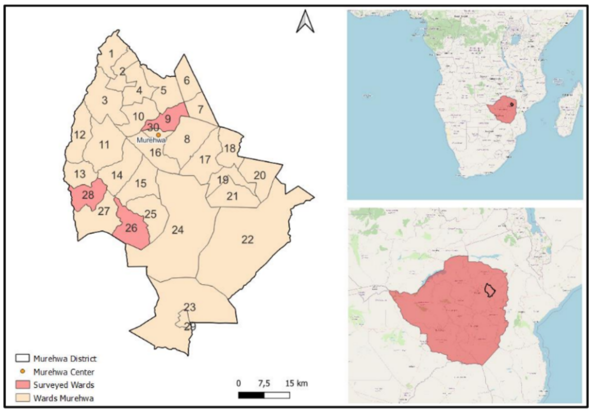

Figure 2. Murehwa district map.

3.3. Data Collection, Cleaning and Analysis

The data used in this study were collected using a structured questionnaire programmed in World Bank survey solutions. The data collection team comprised seven enumerators and two supervisors. Before the fieldwork started, enumerators were trained, and the questionnaire was pre-tested to ensure that all the questions were consistent, and enumerators were comfortable translating from English to local language (Shona). To ensure that revenue and cost data collected were reliable, firstly, we collected detailed information on farm inputs, expenditures, and outputs. Secondly, we cross-referenced the collected data with secondary sources such as data from the agronomist working in the study site and government statistics from the Ministry of Lands, Agriculture, Fisheries, Water and Rural Development. Data cleaning and analysis were performed using STATA 18 and R Studio. A multiple linear regression model and the gross margin analysis presented in the following sections were used for data analysis, and the results are presented in Section 4.

3.4. Multiple Linear Regression Model

A multiple linear regression model includes more than one explanatory variable. To identify the factors affecting maize gross margin across diversified farming systems, the following log-linear regression model was estimated:

$$Ln\_grossmargin = \beta_0 + \beta_1 X_1 + \cdots + \beta_n Xn + \varepsilon_i \quad (5)$$

Where $Ln\_grossmargin$ is the logarithm of the dependent variable maize gross margin, X_i is the vector of household and individual characteristics, respectively, β_0 are the parameters to be estimated. β_1 captures the effects of household and individual characteristics on the maize yield. ε is the stochastic error term assumed to be normal with a mean of zero and variance σ^2. If these parameters have a positive coefficient, it implies that the independent variables are positively correlated with the maize gross margin. The choice of variables used in the analysis was guided by the theory of production, where farmers are regarded as rational decision-makers seeking to maximize production and profit [13]. In addition to theory, an extensive literature review informed the variable inclusion and exclusion strategies.

Data were transformed into logarithms and a log-linear model was applied for data analysis. Data transformation ensures that all variables have positive values, and a lognormal distribution with error terms equal to the exponents of normally distributed errors was obtained [34]. The log-linear model is a widely used method for the analysis of multivariate frequency tables obtained by cross-classifying sets of nominal, ordinal, or discrete interval level variables and assuming the variables to have an exponential growth relationship [35–37]. Using the logarithm of one or more variables makes the effective relationship non-linear while ensuring that the model is still linear. Logarithmic transformations help to normalize skewed data and linearize relationships between variables. Heteroscedasticity was corrected using robust standard errors [38]. Multicollinearity between the independent variables was checked using the variance inflation factor (VIF) [34, 38]. The VIF for all predictor variables was less than 5, implying that there was no multicollinearity between the variables included in the regression model.

3.5. Multivariate Analytical Approach

In this study we employed a two-stage multivariate analysis approach consisting of PCA and CA to come up with farm clusters or socioeconomic classes. In the first stage, we used PCA to reduce variables into a new set of components that measure key latent constructs [38]. Thus, reducing the number of variables is essential in cluster analysis to retain stable and non-overlapping clusters. The varimax method rotated the selected scale variables used to construct factors into each component retained for cluster analysis, thereby reducing the number of highly correlated variables [34].We used all the factors retained from PCA in the cluster analysis utilizing the Ward's hierarchical procedure. The Kruskal-Wallis rank test was applied to determine the significance of differences in cluster means and to verify the authenticity of the clustering procedure [39]. The multivariate analysis included structural variables that describe the household structure and functional variables that describe the performance of the household (**Table 1**).

Table 1. Principal component loadings.

	PC1	PC2	PC3	PC4	PC5
Household size	0.15	**0.80**	0.20	−0.25	0.13
Active members	0.03	0.17	−0.41	**0.66**	0.27
Total cropped area	**0.83**	−0.17	−0.23	−0.07	0.11
Total area cropped area per capita	**0.65**	**−0.63**	−0.33	0.05	−0.01
Tropical livestock unit	**0.56**	0.09	0.07	0.21	0.39
Off farm income	0.11	−0.37	**0.62**	−0.01	−0.02
Total asset value	**0.59**	0.22	0.35	0.36	0.21
Total input cost	**0.57**	0.41	0.15	0.18	−0.24
Total remittances	0.22	−0.36	**0.56**	0.27	−0.15
Agricultural income	**0.65**	0.15	−0.17	−0.40	−0.30
Eigen value	**3.16**	**1.65**	**1.27**	**1.27**	**0.95**
Percentage of variance	**26.30**	**13.76**	**10.61**	**10.59**	**7.90**
Cumulative percentage of variance	**26.30**	**40.06**	**50.67**	**61.26**	**69.16**

3.5.1. Principal Component Analysis and Hierarchical Cluster Analysis

Based on the eigenvalue greater than 1 (one) and cumulative variance greater than 60%, we decided how many principal components (PCs) to keep from the PCA. The Kaiser-Meyer-Olkin measure of sampling adequacy (KMO) was above the recommended minimum of 0.50, implying that PCA was relevant to construct meaningful indices. We tested whether the variables included in PCA were uncorrelated using the Bartlett's test of sphericity, and the results (p-value = 0.05) indicate that PCA was appropriate for the data. We then employed hierarchical clustering using the Ward's minimum-variance method on the outcomes of the PCA (principal component scores) to identify clusters [34]. The Ward's method minimizes within-cluster variation by comparing clusters using a sum of squares summed over all variables [14, 34]. We obtained the number of clusters, which corresponds to our socioeconomic classes, from the dendrogram shape (**Figure 3**). The results from the hierarchical clustering algorithm suggested a four-cluster cutoff point since there is a small difference between the 4th bar and the 5th bar of the dendrogram [40]. The four identified clusters varied in terms of cultivated land, livestock ownership, family labor availability, and participation in off-farm activities.

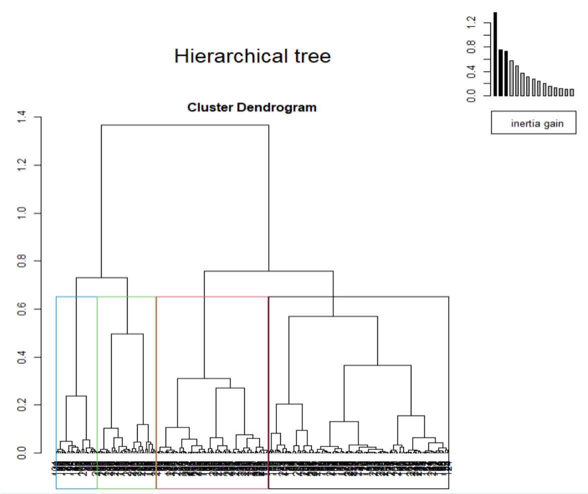

Figure 3. Dendrogram (left) and associated bar plot (right) displaying a range of cluster solutions resulting from Ward's method of PCA.

3.5.2. Distribution of Households by Selected Wards across Socioeconomic Status

The distribution of households across wards and socioeconomic classes adds nuances, as shown in **Figure 4**. First, ward 9 is closest to town (Murehwa centre) and has suffered from the effects of encroachment of urban residential areas, resulting in reduced plot sizes and loss of grazing land in this ward. In this ward, most of the poorest households live (42%). The households in this ward have limited access to natural resources, resulting in the smallest plots and limited opportunities for owning livestock. Those who depend on agriculture as a source of livelihood are among the poorest. However, it is in this ward that most of the better-off households (50%) live because they have diversified livelihood sources and off-farm income activities as their main income sources. Second, ward 26 is a remote ward that is not easily accessible because of a longer distance to the main road and poor road infrastructure. The households in this ward have the biggest plots and mainly rely on agriculture for their livelihood in addition to remittances. They constitute the bulk of the poor subgroup because of limited market activities due to access issues. Lastly, ward 28 has easy access to all major markets of Murehwa and Marondera. The households within this ward constitute the bulk of the middle-class group (46%). Households can buy inputs and sell their produce at the markets without many constraints.

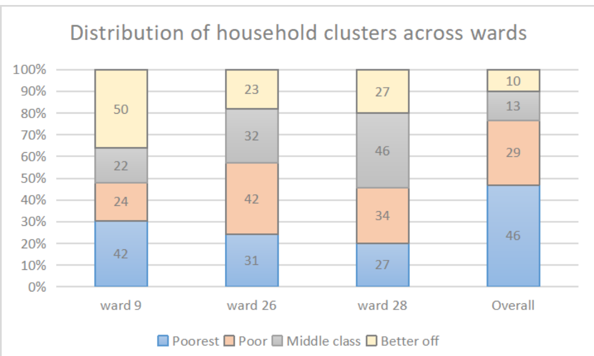

Figure 4. Distribution of households by selected wards across socioeconomic status.

4. Results

4.1. Descriptive Statistics

The average gross margin of the pooled sample was USD 204 ha^{-1}, with a return per dollar of USD 2.40 (**Table 2**). We multiplied the official price of maize per kilogram by the gross output, which included the quantities sold and consumed, to calculate the gross margins. The average age of the household heads was 54 years, and 38% (94) of the interviewed households are female-headed. The farmers who were interviewed cultivated approximately 0.9 hectares, with 0.6 hectares dedicated to maize production. This concurs with related studies indicating maize constitutes a bigger area cultivated since it is the staple food and source of livestock feed in many Southern African countries, including Zimbabwe [29]. Within the context of inputs, the average seed applied by farmers was 22 kg ha^{-1}, which is closer to the recommended 25 kg ha^{-1} [10]. Additionally, farmers used 131 kg ha^{-1} of basal fertilizer and 153 kg ha^{-1} of topdressing. Overall, on average, each household owned two cattle. A small number of cattle owned confirmed the outbreak of cattle disease, known as January disease or theileriosis, which recently resulted in high cattle deaths in most districts of Zimbabwe [30]. Furthermore, on average, households earn USD 427 and 178 per year from off-farm activities and remittances from local and abroad, respectively.

4.2. Maize Crop Viability across Different Socio-Economic Status

Given the presence of unobserved heterogeneity and reverse causality, we should interpret the results of the gross margin analysis (**Table 3**) with caution, as they only show associations. As shown in the conceptual framework, the viability of maize enterprises can influence the use of inputs because households with access to resources are motivated to increase maize production, which translates into increased income. All sampled farmers grow maize as a staple food. The analysis showed that the poorest households had the lowest maize yield of 769 kg ha^{-1}, with a gross margin of USD 64 and a return per dollar of USD 1.31. Poor households had an average maize yield of 1159 kg ha^{-1}, with a gross margin of USD 252 and a return per dollar of USD 3.36, which is the highest across all clusters. The middle class had an average maize yield of 894 kg ha^{-1} with a gross margin of USD 154 and a return per dollar of USD 2.38. Better-off households had the highest maize yield of 1932 kg ha^{-1} with a return per dollar of USD 2.14 and the highest gross margin of USD 347. The highest return per dollar among the poor households may be because they have lower costs and higher yields than the other clusters. Overall, the farming techniques employed by the poorest households resulted in poor maize yields, leading to the lowest gross margins.

Table 2. Summary statistics of key variables used in the analysis for the different classes.

Variable Name	Description and Measurement of Variables	Poorest (n = 114)	Poor (n = 71)	Middle Class (n = 31)	Better Off (n = 26)	Overall (n = 248)
	Dependent Variable					
Gross margin (USD ha^{-1})	Gross margin per hectare	64 (222)	252 (240)	154 (220)	347 (483)	204 (285)
	Farm and Household Characteristics					
Maize yield (kg ha^{-1})	Maize yield per hectare	769 (689)	1159 (734)	894 (782)	1932 (1497)	1021 (908)
Return per dollar (USD)	Total return per dollar invested in maize enterprise	1.31 (1.93)	3.36 (9.70)	2.38 (1.77)	2.53 (1.77)	2.40 (2.41)
Female-headed household (*yes = 1, %*)	Number of female-headed households	37%	28%	22%	15%	38%
Age (n)	Household head age	56 (18)	54 (17)	55 (16)	50 (10)	54 (17)
Household size (n)	Total number of household members	3.8 (1.8)	4.7 (1.8)	2.6 (1.0)	5.7 (1.5)	4 (2)
Active members (%)	The proportion of total family members between 15 and 65 years old	55%	45%	67%	59%	54%
Maize area (ha)	Area cultivated under maize	0.39 (0.24)	0.58 (0.28)	0.89 (0.54)	0.79 (0.51)	0.56 (0.39)
Area cultivated (ha)	Total area cultivated	0.57 (0.39)	1.16 (0.68)	1.64 (0.71)	1.67 (1.19)	0.87 (0.87)
Cropped area per capita (ha)	Total cropped area divided by household size	0.20 (0.25)	0.26 (0.14)	0.72 (0.46)	0.29 (0.18)	0.24 (0.16)
Hired labour (*yes = 1, %*)	Number of households hiring in labour for farm activities	86%	87%	92%	81%	87%
Cost (USD ha^{-1})	Total cost of maize inputs	284 (273)	297 (264)	419 (345)	938 (199)	220 (227)
Seed quantity (kg ha^{-1})	Total quantity of seed used	24 (12)	21 (8)	18 (6)	22 (6)	22 (10)
Basal fertilizer quantity (kg ha^{-1})	Total quantity of basal fertilizers used	190 (171)	136 (85)	129 (88)	194 (111)	131 (142)
Quantity of top dressing (kg ha^{-1})	Total quantity of top-dressing fertilizers used	200 (177)	160 (121)	135 (83)	187 (97)	153 (144)
Labour days (days ha^{-1})	Total number of days from land preparation to harvesting	101 (96)	79 (66)	58 (39)	82 (87)	87 (82)
Cattle owned (n)	Total number of cattle owned	1.1 (2.4)	0.8 (1.6)	1.8 (4.4)	3.8 (6.3)	2 (3)
TLU (n)	Tropical livestock unit	6 (9)	8 (8)	12 (17)	12 (10)	10 (11)
Off-farm income (USD)	Total income from off-farm activities	43 (227)	8 (60)	115 (294)	5 (24)	427 (0.36)
Total maize income (USD)	Total value of maize harvested	254 (229)	383 (244)	295 (262)	638 (504)	337 (300)
Asset (USD)	Total value of productive and non-productive assets	460 (900)	366 (935)	678 (919)	1,176 (1,540)	376.3 (339.9)
Remittances (USD)	Total remittances from abroad and local	119 (242)	24 (40)	258 (339)	737 (3,265)	178 (107)
Distance to market (km)	Distance to the main input and output market i.e nearest town	48 (35)	61 (32)	59 (30)	42 (35)	53 (34)
Quantity of maize required (kg)	Quantity of maize required from time of harvest to the harvest of the following season in a normal year	254 (229)	383 (244)	295 (262)	638 (504)	337 (300)

Source: RAIZ Baseline Survey, (2022); Standard errors are in parentheses.

The poorest farmers face economic difficulties in terms of access to food and agricultural input. Major challenges include a shortage of cash, labor, and draught power. As shown in **Table 3**, some farmers in the poorest cluster used extensive farming techniques; however, in return, they had lower gross margins. The riskiness of smallholder farming, particularly drought and poor crop management practices, accounts for this. **Table 3** presents the detailed average and standard deviation of the yield, area cultivated, total costs, total revenue, gross margin, and return per dollar for maize across the four household socioeconomic statuses. After the gross margin analysis, we used the Kruskal-Wallis rank test to see if differences in cluster means were statistically significant. This ensured that the clustering procedure was correct [39]. The resulting p-values reported in **Table 3** show that there is a significant difference across all four socioeconomic classes in terms of maize enterprise viability, as measured by gross margins.

Table 3. Maize crop viability across different socio-economic status.

	Poorest[1]	Poor[1]	Middle Class[1]	Better Off[1]	Overall[1]	p-Value[2]
Yield (kg ha^{-1})	769	1159	894	1932.	1021	<0.001***
Area cultivated under maize (ha)	0.39	0.57	0.89	0.79	0.57	<0.001***
Price (USD)	0.33	0.33	0.33	0.33	0.33	<0.001***
Total costs (USD ha^{-1})	189	171	140	289	175	<0.001***
Total revenue (USD ha^{-1})	253	382	295	637	337	<0.001***
Gross margin (USD ha^{-1})	64	252	154	347	204.3	<0.001***
Return/dollar (USD ha^{-1})	1.31	3.36	2.38	2.53	2.40	<0.001***
Seed quantity (kg ha^{-1})	24	21	18	22	21	0.7
Quantity of basal fertilizer (kg ha^{-1})	190	136	129	194	119	<0.001***
Quantity of top dressing (kg ha^{-1})	200	160	135	187	134	<0.001***
Total labour days	101	79	58	82	86	<0.001***
Observations	114	71	37	26	248	

[1] Mean (SD); [2] Kruskal-Wallis rank sum test; Pearson's Chi-squared test.
Note: Standard errors are in parentheses; *** p < 0.01, ** p < 0.05, * p < 0.1.

4.3. Factors Influencing Maize Viability of Smallholder Farmers

Results from the log-linear regression model suggest several drivers of maize viability among smallholder farmers (**Table 4**). The drivers include household size, area cultivated, number of cattle, quantity of maize required by the household, remittances, distance to market, and household socioeconomic status. At the 1% significance level, there was a positive correlation between household size and the maize gross margin. An increase in family size by one member increased the gross margin by 15%. There was a negative correlation between the area cultivated and the maize gross margin. An increase in the total area cultivated decreased the maize gross margin by 8%. Furthermore, there was a significant 1% correlation between the number of cattle owned and the maize gross margin. An increase in the number of cattle owned significantly increased maize's gross margin by 4%. The required quantity of maize increased the maize gross margin by 0.4%, while remittances also contributed to this increase by 0.3%. Conversely, there was a 0.7% negative correlation between the distance to market and the maize gross margin. Lastly, there was a 44% positive correlation between household socioeconomic status and the maize gross margin.

Table 4. Factors influencing maize viability among smallholder farmers.

	Coef.	St.Err.	t-Value	p-Value	[95% Conf	Interval]	Sig
Household head age	0.006	0.004	1.41	0.161	−0.002	0.014	
Household size	0.151	0.046	3.28	0.001	0.06	0.243	***
Number of active members	0.338	0.253	1.34	0.183	−0.161	0.838	
Area cultivated	−0.086	0.194	−4.06	0	−1.168	−0.404	***

Table 4. *Cont.*

	Coef.	St.Err.	t-Value	p-Value	[95% Conf	Interval]	Sig
Number of cattle	0.043	0.013	3.19	0.002	0.016	0.069	***
Quantity of maize required	0.004	0.001	4.31	0	0.002	0.006	***
Asset value	0	0	−0.89	0.375	−0.001	0	
Remittances	0.003	0.001	3.56	0	0.001	0.004	***
Distance to market	−0.007	0.003	−2.16	0.032	−0.014	−0.001	**
Socioeconomic status	0.439	0.095	4.61	0	0.251	0.627	***
Ward FE	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*	*
Constant	3.523	0.431	8.17	0	2.672	4.375	***
Mean dependent var			5.061	SD dependent var			1.030
R-squared			0.323	Number of obs			189
F-test			8.654	Prob >F			0.000
Akaike crit. (AIC)			496.952	Bayesian crit. (BIC)			535.853

Note: *** p < 0.01, ** p < 0.05, * p < 0.1.

5. Discussion

Our study revealed that there is variation across household socioeconomic statuses. At the extreme end of the classification, a small number of farmers earn a living from farming and view it as a business. These are the better-off farmers who can make farming-related investments, such as buying livestock, which in turn enhances their farming activities. Better-off farmers had the highest yield and gross margin. Nearly half of all farmers face severe economic challenges and struggle to maintain a state of zero hunger throughout the year as shown by the lowest yield and gross margin. The lack of resources, such as labor, cash, equipment, and, above all, draft animals, explains why the areas cultivated are extremely small. Given the low yields, these households have the least gross margin. Therefore, better-off farmers enjoy higher gross margins and return per dollar primarily due to their access to crucial agricultural inputs for maize production. Thus, the results are supported by Mango et al.[30], who found that wealthier farmers have access to cash, labor, and markets in Malawi and Mozambique. Furthermore, low crop yields can be attributed to low levels of fertilizer intensity and the use of low-yielding crop varieties, primarily due to the high cost of agricultural inputs[21, 30]. This study indicates that high input costs hinder maize production, which in turn reduces its viability for the poorest farmers. In addition, transportation invariably increases the domestic prices of inputs. According to Mango et al.[30], traders are likely to have higher gross margins than farmers (producers), mainly because of the high perceived transaction risks in most remote areas, which limits the gross margins for producers rather than traders because they have transportation facilities. The factors influencing maize viability among smallholder farmers are discussed below.

5.1. Household Size

Household size had a positive influence on the gross margin. These results are in line with research by Binge, Mshenga and Kgosikoma[41] on farmers in Ethiopia, who argued that labor availability ensures that no labor is hired, thereby reducing variable costs and resulting in higher income for maize farmers. These findings are also in agreement with Katema et al.[21], who indicated that household size is an important reflection of the availability of labour for cropping activities and is an indication of labour demand corresponding to critical stages of crop development, resulting in higher yield and gross margin. We discovered a negative correlation between the total area cultivated and maize gross margins. This is due to additional costs such as labour, fertilizers, and seeds that come with expanding the cultivated area. These costs can outweigh the increase in revenue, resulting in a decrease in the gross margin. This aligns with the research that discovered a negative correlation between the area cultivated and the profitability of tobacco[22, 42]. Moreover, diminishing returns to scale can occur when the increased inputs needed for larger areas fail to yield commensurate improvements. The area cultivated has a negative impact on the technical, allocative, and economic efficiency of maize farms. This is because farmers must spread their resources across a larger area, which can be difficult to manage and lead to lower yields [22].

5.2. Number of Cattle

In rural areas, owning cattle is a sign of wealth, as it provides draft power for timely planting and access to cattle manure, thereby resulting in a high maize gross margin for smallholders. Manyanga, Pedzisa and Hanyani-Mlambo [28] also support these findings, arguing that the use of animal manure is an important agroecology principle that positively impacts crop yields in Southern Africa. Mafongonya et al. [5] and Chiweta et al. [43] found that farmers in Zimbabwe, who owned cattle in the study site, could achieve high manure application rates on small plots and rotate manure application according to crop sequences. The consistent application of manure in combination with mineral fertilizers can be an effective option to improve crop yields and moisture conservation under smallholder farming conditions.

5.3. Quantity of Maize Required for Consumption

We found a positive correlation between maize gross margins and the amount of maize needed by a household. First, a higher demand for maize can call for more intensive agricultural methods, including more fertilizer and quality seeds. These methods can raise gross margins by increasing productivity. Thus, households that require more maize for consumption per year use more inputs to get higher yields in Zimbabwe [44]. Second, households that require more maize may be more inclined to produce as much as possible to ensure food security and potentially produce excess for sale, thereby increasing gross margins.

5.4. Remittances

Remittances influence maize's gross margin. Our findings are consistent with Katema et al. [21] and Sadiq et al. [24], who discover a significant positive link between remittances and small-scale maize production. Remittances are essential for the development of maize-farming enterprises, as shown in the pooled sample results. In Malawi, Dhakal et al. [45] precisely argued that remittances are connected to higher commercialization levels, suggesting that they are an important external inflow for funding agriculture as a business. In a recent publication, Mbida et al. [46] further suggested that most remittance-receiving households in both rural areas use the money to purchase agricultural inputs that are important for maize grain production. Thus, remittances are important for a good harvest, as they ensure access to chemical fertilizers, which is very difficult for the majority of farmers without them. More than half of Zimbabwe's off-farm income comes from diaspora remittances, primarily from citizens who have migrated due to economic decline over the past two decades [47].

5.5. Distance to Market

Higher transportation costs and restricted market access cause a negative link between distance to market and maize gross margins. Greater distances increase the cost of delivering inputs, such as seeds and fertilizers, as well as harvested maize, to markets. The increase in cost reduces profitability as the farmers incur additional costs or accept lower prices due to limited market options. This result is in line with Binge, Mshenga and Kgosikoma [42], who found a negative relationship between distance to market and gross margin. Our results are also consistent with Santpoort et al. [48], who revealed that remotely located markets may have cheaper prices, lowering potential revenue.

5.6. Socioeconomic Status

The findings show a positive association between household socioeconomic status and maize gross margins. Higher socioeconomic status households typically have higher maize gross margins due to their possession of productive assets like land, livestock, and machinery, which they can utilize for more efficient maize production. They also have better access to resources like credit, improved seeds, and fertilizers, leading to higher yields, which translate to higher gross margins. This correlation between socioeconomic status and gross margin aligns with the findings of Manyanga, Pedzisa and Hanyani-Mlambo [28], who found a positive relationship between the wealth of the farmer and maize yield. On the other hand, households with lower socioeconomic status may have limited or no access to education and information, which could hinder them from adopting effective agronomic practices for their maize production.

6. Conclusions, Recommendations and Limitations

The study reveals that farmers with higher socioeconomic statuses earn a living from farming, with better-off farmers enjoying higher yields and gross margins. However, nearly half of farmers face severe economic challenges, with low yields and minimal gross margins. Better-off farmers, with access to resources like labor, cash, and markets, enjoy higher gross margins and return per dollar, supporting previous research in Malawi, Mozambique and Zimbabwe. High input costs hinder maize production, reducing its viability for the poorest farmers. Factors influencing maize viability among smallholder farmers include household size, area cultivated, and number of cattle. Household size positively influences the gross margin, while area cultivated negatively impacts the technical, allocative, and economic efficiency of maize farms. Owning cattle is a sign of wealth in rural areas, providing draft power for timely planting and access to cattle manure, resulting in a high maize gross margin for smallholders. The study found a positive correlation between maize gross margins and the amount of maize needed by a household in Zimbabwe. Higher demand for maize leads to more intensive agricultural methods, such as more fertilizer and quality seeds, which increase productivity and gross margins. Remittances also influence maize gross margins, as they are essential for the development of maize-farming enterprises and access to chemical fertilizers. More than half of Zimbabwe's off-farm income comes from diaspora remittances, primarily from citizens who have migrated due to economic decline. Distance to the market has a negative link, as it increases the cost of delivering inputs and harvested maize to markets, reducing profitability. Higher socioeconomic status households typically have higher maize gross margins due to their possession of productive assets, better access to resources, and higher yields. Households with lower socioeconomic status may have limited access to education and information, which could hinder effective agronomic practices for maize production.

Enhancing the agronomic yield of maize by implementing efficient production methods and utilizing production inputs to increase it significantly boosts gross margins. Since maize provides a good return for all socioeconomic classes, farmers should prioritize its production for their food security needs at the household and national levels. Improving market conditions and safety nets in terms of input provision can increase productivity and boost gross margins, especially for the poorest households. There is a need to provide credit facilities and subsidies to local agrodealers, allowing them to stock inputs and manage cash flow more effectively, such that households reduce transportation costs to access input and output markets. Because of data limitations, the influence of some important actors could not be directly captured in the analysis, which may lead to an oversimplification of a very complex situation in the maize sector. Therefore, we encourage researchers to further investigate the effects of such important variables on maize viability, encompassing both variable and fixed costs of production.

Author Contributions

Conceptualization, M.M. and B.M.; methodology, M.M. and B.M.; software, M.M.; validation, M.M., F.G., T.P., and B.H.-M.; formal analysis, M.M., F.G. and T.P.; investigation, M.M.; data curation, M.M.; writing—original draft preparation, M.M., B.M., F.G., T.P. and B.H.-M.; writing—review and editing, M.M., B.M., F.G., T.P. and B.H.-M.; visualization, M.M.; supervision, F.G., T.P. and B.H.-M. All authors have read and agreed to the published version of the manuscript.

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are the sole responsibility of the authors.

Informed Consent Statement

Prior to the commencement of the interview, all participants were informed of the voluntary nature of their participation and the anonymous utilization of their data for research purposes. This information was conveyed verbally to ensure clear understanding. Subsequently, the first question posed to everyone was a binary option: 'Do you agree to participate in this interview?' Only those who gave a verbal consent to this initial inquiry proceeded with the interview. This approach ensured that all participants entered the study with full awareness of the research objectives.

Data Availability Statement

The data can be made available upon request from the corresponding author.

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Conflicts of Interest

The authors declare that they have no competing interests.

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