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# Estimating Technical Efficiency in Wheat Production: Empirical Evidence from the Western Highlands, Cameroon

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## ABSTRACT

*Wheat, along with wheat-based products and by-products, is extensively consumed and utilized in Cameroon. Despite the country's potential for wheat cultivation, technical inefficiencies have significantly impeded effective production, leading to substantial imports. This study estimates the technical efficiency in wheat production given the various systems employed. A total of 400 wheat farmers were selected through cluster and snowball sampling methods. Utilizing stochastic frontier analysis, we estimated the mean technical efficiency given the various production systems. Using a Beta Regression, we also deduced the relationship between farmers' socioeconomic characteristics and their technical efficiency. The findings indicate that the predominant production systems employed by wheat farmers include combined irrigation, inorganic fertilization, monocropping, local seed use, and conventional tillage systems. The stochastic frontier analysis revealed that production systems positively associated with technical efficiency include the rain-fed system, the use of inorganic fertilizers, integrated fertilization, and the use of improved wheat seeds. Also, production systems negatively associated with technical efficiency include the integrated irrigation system, the use of the organic fertilization system and the use of locally produced wheat seeds. Farmers cultivating for commercial purposes had higher efficiency levels, while farmers' age, marital status and income level were negatively associated with technical efficiency. The mean predicted technical efficiency of 0.428 implied that farmers have almost 57.2 percent of output they can still increase at their current level of*

  

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*inputs within the Western Highlands. This shows there is still a much needed room for improvement in Wheat production within the Western Highlands of Cameroon. This improvement could arise from sustained focus on efficiency-enhancing systems and the proper use of inputs within these systems.*

**Keywords:** wheat, production system, technical efficiency, Western Highlands, and Cameroon.

**JEL classification codes:** Q12,D24, C61

## I. Introduction

The quest to attain the sustainable development goal of 'Zero Hunger' is intrinsically linked to the agricultural sector's ability to build on sustainable, technically efficient, and productive farming systems, safeguard the food supply chain, and ensure food security. Cameroon's agricultural sector is central to this process, as it engages over 70% of the country's active population and accounts for 80% of the primary sector's contribution to GDP, as well as providing raw materials for the industrial sector (Soh-Wenda, 2021). With a rich endowment of natural resources and production strategically concentrated along the five agro-ecological zones, Cameroon's agricultural sector boasts enormous potential for attaining food self-sufficiency (Tabe-Ojong, 2023). Wheat (Triticumaestivum L) is an essential part of domestic and global food chains, and together with other cereals such as rice and corn, accounts for 35% of the total calorie intake worldwide (Deyalage et al., 2024). Unlike in advanced economies, wheat cultivation in Sub-Saharan Africa is predominantly carried out by small-scale producers with inadequate mechanization and who are highly reliant on rainfall as their main water source during the production process (Taki et al., 2018). With increasing demand for wheat and wheat products, insistence on low-input wheat production systems within this region acts as a significant obstacle to the attainment of food security and results in high levels of importation (Sacko, 2022).

Despite the potential benefits associated with wheat production, Cameroon's wheat sector has been massively underexploited and hindered by technical and policy issues. Technical issues, such as poor on-farm management and the use of unsuitable production systems, aggravate the issues plaguing the Cameroon wheat sector (Tadesse et al., 2018). Policy issues relate to historical neglect, lack of government support, and opportunities, such as the availability of land and a highly demanding market for wheat within the Cameroonian economy (Negassa et al. 2013). Neglected and characterized by subsistent practices, Cameroon's wheat stock is hugely reliant on efficient domestic production. These challenges result in inefficiencies in wheat production, and as a result, domestic wheat producers fail to meet domestic demand for wheat (Kindzeka, 2022). This inability to meet domestic demand results in heavy expenses on wheat

  

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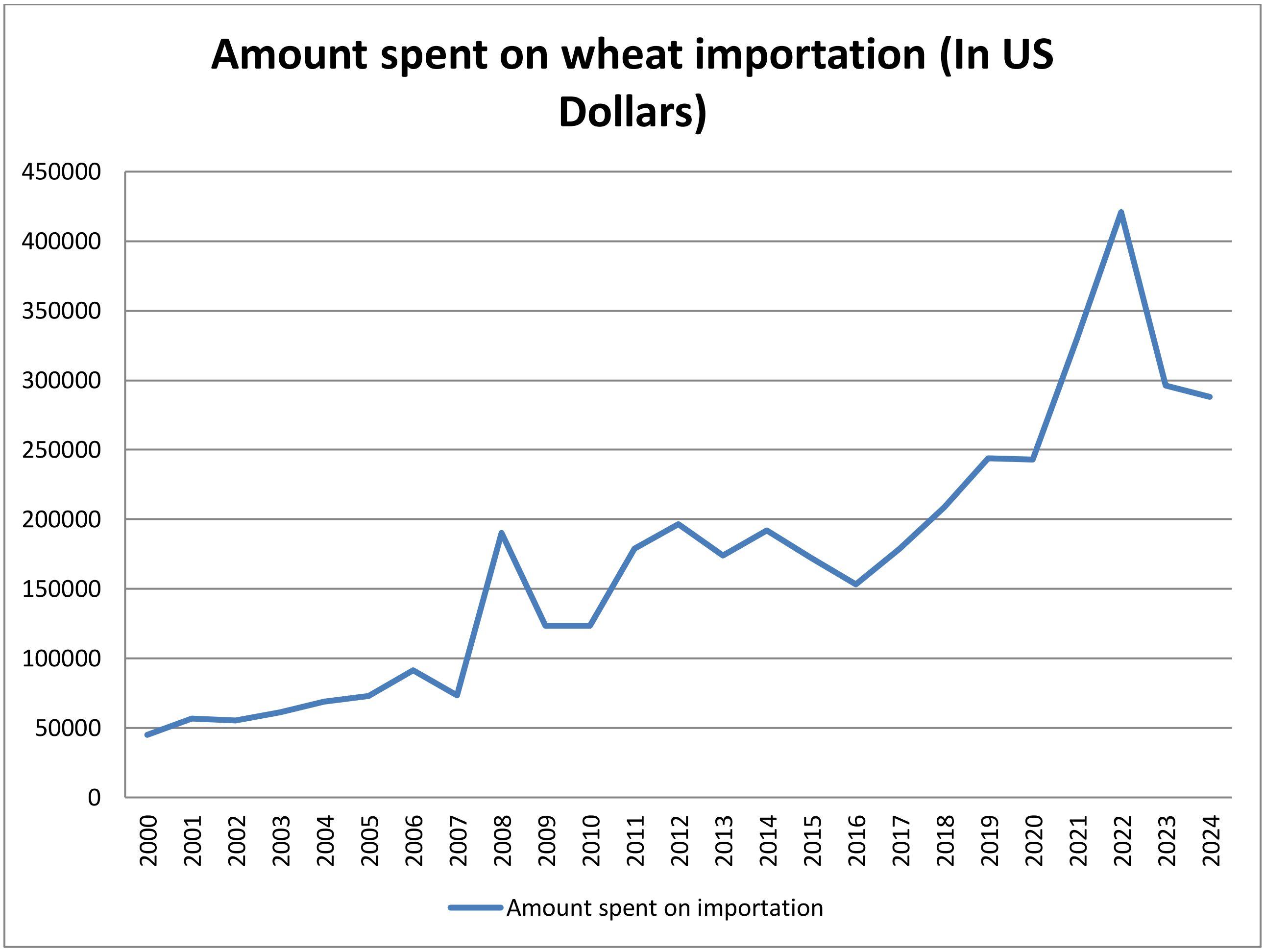
importation (Shillie et al., 2022) and further aggravates the already bleak situation of wheat production in Cameroon. Figure 1 shows the heavy expenses on wheat importation in Cameroon.

**Figure 1: Amount spent on wheat importation in Cameroon (2000-2021)**




Source: Authors' computation from FAOSTAT

To address these challenges, understanding the various wheat production systems used in Cameroon is of significant importance (Tatah et al., 2024). A proper understanding of production systems provides the framework through which we can extend wheat cultivation to non-traditional growing areas through the use of relevant cropping systems with improved efficiency (Tadjufo et al., 2022). An assessment of these production systems provides a pathway to developing a sustainable framework that maximizes the technical efficiency of wheat produced in Cameroon. This study aims to identify the various production systems used in wheat cultivation in Cameroon, deduce the level of technical efficiency within the wheat sector, assess

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the relationship between each production system and wheat farmers' technical efficiency, and propose the best production framework that resonates with local conditions. To achieve our objectives, we hypothesize that wheat farmers are technically inefficient and that the various production systems employed significantly influence the level of technical efficiency of wheat farmers.

This study contributes to the literature as follows. Empirically, our study not only addresses the existing gaps relating to wheat production in Cameroon but also identifies the various production systems employed and estimates technical efficiency under these systems. Addressing this empirical gap is vital for the enhancement of the literature related to wheat production systems used in Cameroon. Theoretically, our study further expands on the Stochastic Frontier Analysis method, which has been used extensively in addressing wheat technical efficiency issues globally, but very limited studies exist that apply this theory to wheat production in Cameroon. Methodically, our study linked these production systems to technical efficiency. This makes it one of the pioneer studies on the interaction between these two variables. Several studies have looked at the drivers of technical efficiency, but few studies have focused on production systems as major drivers of technical efficiency in wheat production. For global wheat production, and even more so for wheat production in Cameroon, our study aimed to provide enriched literature that tackles these research gaps.

## II. Materials and Methods

### 1. Study Area

The study was conducted in the Western Highlands of Cameroon which comprises two administrative regions; the North West and West Regions as these two regions are bound by same social, economic and political characteristics. The choice of the study area was done with a view on the important role played by wheat and wheat products to the inhabitants of the Northwest and West Regions. Wheat is not only an important source of food, it also serves as an important source of revenue for farmers engaged in its production, an essential component of animal feed and an important raw material in the production of wheat oil, wheat flour as well as other derivatives. Apart from its economic significance, a study by the Ministry of Agriculture and Rural Development, the North West Region was highlighted as one of the most suitable areas for wheat cultivation and has been involved in wheat cultivation trials since the 1990s. Several areas within the Northwest region have been observed to consist of wheat farmers such as Bambili, Oku, and Nkambe. The West region is also characterized by a significant number of wheat producers with areas like Dschang, Foumban, and Bafoussam boasting a number of wheat farms.Figure 2 presents the map of the Western Highlands of Cameroon.

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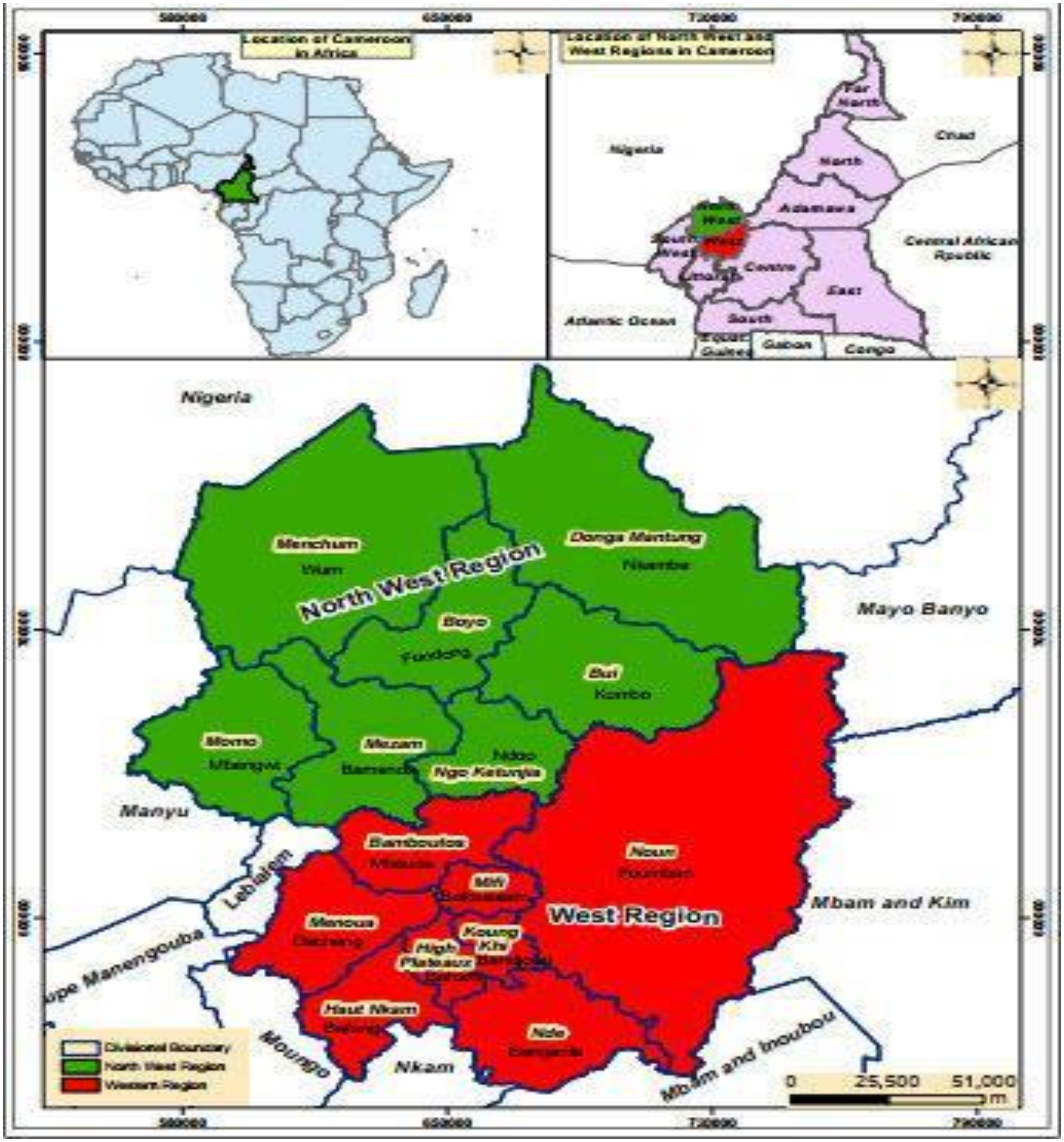
**Figure 2: Location of the Western Highlands in Cameroon**




Source: Wutofeh & Ngwainbi, 2021

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## 2. Data and Sampling Strategy

The data used in this study comes from a survey conducted in the Western highlands between (from May to July 2024). A multistage sampling technique involving a combination of both cluster and snowball sampling was employed. The cluster sampling technique is a probability sampling technique in which the population is divided into clusters. In this study, the potential respondents were divided into clusters based on their specific zones within the western highlands. These zones were selected based on the recommendation from the Ministry of Agriculture and Rural Development (MINADER) whose report highlighted key areas where wheat can be cultivated. The number of respondents included per cluster was influenced by a number of factors including the estimated number of wheat farmer per locality. In the second stage, a snow-ball sampling technique was employed. The snow-ball sampling technique is a non-probability sampling technique which often focuses on referrals from participants in order to identify other participants and is important in cases where identifying participants is often difficult. The researcher during this survey asked participants to refer them to other wheat farmers, who also referred him to other wheat farmers. So within each cluster, snowball sampling was used to identify individual wheat farmers. Primary data used for this study was obtained through the issuing of questionnaires. The first section obtained information on the demographic characteristics of the farmer, section two included information on the production system employed by the wheat farmer captured via the use of indirect questions while section three obtained information on the technical efficiency of the wheat farmers. The actual sources of data collected per localities after sampling is summarized on **Error! Reference source not found.**.

**Table 1: Distribution of respondents per zone**

| Locality | Targeted respondents |
|---|---|
| Bambili, Ndop | 100 |
| Nkambe and Ndu | 100 |
| Kumbo | 40 |
| Oku | 100 |
| Dschang | 60 |
| **Total** | **400** |

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**3. Predicting Technical Efficiency given the various production systems**

To predict wheat farmers' technical efficiency, we first carry out a frontier analysis of the relationship between the wheat yield (in logarithmic form) and the vector of farm inputs. Stochastic Frontier analysis has been employed by previous studies to control for statistical noise and to test hypotheses about inefficiency drivers. Atanja et al (2019) employed SFA to determine inefficiencies in rice farming. Setiawan et al. (2025) used a SFA to estimate the efficiency of soybean producers. Benimana et al. (2025) also utilized the SFA to identify specific sources of technical inefficiencies among smallholder farmers in Rwanda. These empirical studies justify the utilization of this model within this study. This analysis gives us the platform to predict the technical efficiency of each individual farmer (i). This requires the use of a one-stage stochastic frontier analysis with a logarithmic function. The log system ensured the farm output was in its appropriate form required for the prediction of Technical Efficiency. This model was denoted as follows

$$ln\, y_i = \beta_0 + \sum_{k=1}^{k} \beta_k\, lnx_{ki} + v_i - \mu_i \quad (3)$$

Secondly, based on the frontier analysis carried out, we predict the technical efficiency scores of the individual farmers. Note that the $0 < TE_i \leq 1$. If TE = 1; *100 percent efficient*; If TE Values are close to 1; *highly efficient*; If TE Values are close to 0; *highly inefficient.* There may be cases where the TE values are greater than one or less than zero. These may have to do with data collection or misspecification biases during the research process.

The production systems considered for this purpose were the rain-fed system, irrigated system, combined irrigation system, no fertilization system, organic systems, inorganic systems, combined fertilization system, monocropping system, mixed cropping system, intercropping system, the use of local seeds, the use of improved seeds, the no-till systems and the conventional tillage system).

**4. Linking various socioeconomic drivers to technical efficiency**

To link wheat farmers' socioeconomic drivers to the estimated technical efficiency, we employ the Beta Regression Analysis. Several previous empirical studies have used this method for such analysis (Ruzhani & Mushunje, 2025; Aravindakshan et al. 2022; Lachaud, 2017; Djokoto et al. 2016;). The choice of this analysis was done with respect to the fact that the mean TE scores are a ratio of probability-like index constrained between 0 and 1 (Ruzhani & Mushunje, 2025). The model can be specified as follows;

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$g(\mu)_i = \log\left(\frac{\mu_i}{1-\mu_i}\right) = x_1\beta_1 + x_2\beta_2 + x_3\beta_3 + x_4\beta_4 + x_5\beta_5 + x_6\beta_6 + x_7\beta_7 + x_8\beta_8 + x_9\beta_9 + x_{10}\beta_{10} + x_{11}\beta_{11}$

Sc are the demographic variables (and include gender, age, marital status, income level, educational level, wheat farming experience, household size, farm size, off-farm employment, main purpose of cultivating wheat as well as main uses of cultivated wheat). $k$ represents the number of production systems used by farmer i, $v_i$ are the random error not under the control of the farmer, while $\mu_i$ is the technical inefficiency term.

***Variable description in the Beta Regression model***

Here, the study explores the various socioeconomic determinants (independent variables) and the mean predicted technical efficiency (dependent variable). Based on Table 2, the socioeconomic determinants (such as gender, age, marital status, income level, educational level and wheat farming experience.) influence the level of technical efficiency in wheat farming (the dependent variable). The various variables are described on table 2

**Table 2: Variable description in the Beta Regression model**

| **Dependent Variable** | **Definition** |
|---|---|
| Mean technical efficiency | Predicted from the frontier analysis. |
| **Independent variables** | **Definition** |
| Gender (1=male) | Farmers sex or gender identity |
| Age | The age of the farmer (in number of years) |
| Marital status (1 = unmarried) | The current marital status of the farmer |
| Income level | The estimated monthly income of the farmer (from both on-farm and off-farm sources) |
| Educational level (1=uneducated) | The highest level of education attained by the farmer |
| Wheat farming experience | The amount of wheat cultivating experience by the farmer |
| Household size | The number of members in farmers' household |
| Farm size | The size of the wheat farm (in ha) |
| Off-farm employment (1= no off farm employment) | Whether the wheat farmer has an off-farm employment |
| Main purpose of cultivating (1= commercial purposes) | Representing the main purpose of cultivating wheat by the farmer |
| | |

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## III. Results and Discussions

### 1. Demographic distribution of wheat farmers

The demographic results reveal that 58.75 percent of the wheat farmers were female, with 41.25 percent being male. Also, results reveal that 30 percent of the wheat farmers were married while 61.75% of the farmers were unmarried. Furthermore, 3.25 percent of the farmers were divorced while 20 (5 percent) of these wheat farmers were widow(er)s. The findings reveal that 12 farmers (3 percent) had no formal educational background. 42 (10.5 percent) of the farmers had attained primary educational levels, 9.5 percent of the farmers had attained secondary educational levels, 38.5 percent of these farmers attained university (undergraduate) levels, 17.5% attained postgraduate levels, while 21 percent obtained vocational training. Further findings reveal that 81.75% of the wheat farmers were engaged in other activities apart from wheat farming while 18.25% were fully dependent on wheat farming for the income. Additionally, our results reveal that for 81.5 percent of the wheat producers, their aim of cultivating wheat was for commercial purposes. For 0.75 percent of the farmers, wheat was cultivation for home cultivation. However, 14.75 percent of the farmers, they engaged in wheat cultivation for the dual purpose of both home consumption and commercial purposes. 2.25 percent of the farmers engaged in wheat cultivation due to reasons such as research, help and others. Lastly, 36 percent farmers revealed that their main use of the cultivated wheat was for home consumption, 3.75 percent of the farmers revealed their cultivated wheat was used as raw material for the production of animal feed, 8.25 percent of the farmers revealed that their cultivated wheat was processed to make wheat flour, while 1.5 percent used their cultivated wheat for other purposes such as commercialisation, seed etc. 18.25 percent of these farmers cultivated wheat for the dual purpose of home consumption and animal feed, 0.75 percent of the farmers engaged in wheat production for the dual purpose of home consumption and processing of wheat flour, 18 percent of the farmers cultivated wheat for the dual purpose of animal feed and wheat flour production while 48 farmers while 12 percent of the farmers cultivated wheat for the purposes of consumption, animal feed and wheat flour production. Further results indicated that farmers had an average experience of 5.9 years (or approximately 69 months) in wheat farming. The findings also reveal that the wheat farmers had an average household size of approximately 4 persons. Furthermore, results show that the wheat farmers had an average monthly income of approximately 32967.25FCFA. This includes proceeds from wheat farming. Based on the survey results, the farmers had an average farm size of 1.069ha. This farm size includes their entire land area used for wheat cultivation. Lastly, the wheat farmers had an average age of 29.403 or approximately 29 years. This implied that wheat farming was mostly carried out by the working population. Table 3 summarizes this result.

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**Table 3: Socioeconomic distribution of wheat farmers (descriptive variables)**

| Socioeconomic variable | Description | Frequency | percentage |
|---|---|---|---|
| Gender | Male | 165 | 41.25 |
| | Female | 235 | 68.75 |
| Marital status | Married | 120 | 30.00 |
| | Unmarried | 247 | 61.75 |
| | Divorced | 13 | 3.25 |
| | Widow (er) | 20 | 5.00 |
| Level of education | None | 12 | 3.00 |
| | Primary | 42 | 10.50 |
| | Secondary | 38 | 9.50 |
| | University (undergraduate) | 154 | 38.5 |
| | University (postgraduate) | 70 | 17.50 |
| | Vocational training | 84 | 21.00 |
| Other occupation apart from wheat farming | Yes | 379 | 94.75 |
| | No | 21 | 5.25 |
| Main purpose of cultivating wheat | Commercial purposes | 96 | 24 |
| | Home consumption | 84 | 21 |
| | Both | 212 | 53 |
| | Others | 8 | 0.02 |
| Experience in wheat farming (in years) | Mean Value/ SE | 5.904 | 0.269 |
| Household size | Mean Value/ SE | 3.900 | 0.129 |
| Monthly income | Mean Value/ SE | 32967.25 | 2435.671 |
| Farm size (in hectares) | Mean Value/ SE | 1.069 | 0.060 |
| Age | Mean Value/ SE | 29.403 | 0.660 |

### 2. Predominant production systems in the Western Highlands

The findings reveal that 12.75 percent of the farmers focused on rain-fed system only (depended entirely on rainfall), 2.25 percent used only artificial irrigation in their farms, while 85 percent employed both rain-fed and artificial irrigation to their wheat cultivation process. Based on the fertilization systems, 1.5 percent of the farmers applied no fertilizers or manures, 48 percent farmers applied organic manures, 5.25 percent applied inorganic manures while 45.25 percent applied a combination of both organic manures and inorganic fertilizers. Further results on the cropping system revealed that 81.5 percent of the farmers employed monocropping system where only wheat was cultivated, 13.75 percent employed a mixed cropping system where the wheat was cultivated alongside (confined) farm animals, 3.75 percent employed an intercropping

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system where wheat was grown alongside other crops. Based on the wheat seed-type used, the results indicated that 70 percent of the farmers used locally produced seeds, 24.75 percent used improved seeds, and 5.25 percent of the farmers were unsure about the types of seeds they used in wheat cultivation. Based on the tillage type, 3.75 percent of the farmers did not till their farms before cultivating wheat, 95.5 percent of these farmers tilled their farmlands before cultivation, while 0.75 percent of the farmers were unsure about what tillage system was employed. The distribution of farmers based on their choice of production system employed is summarized on Table 4

**Table 4: Distribution of production systems employed by wheat farmers**

| **Production systems** | **Percentage** | |
|---|---|---|
| | **Yes (in %)** | **No (in %)** |
| Rain-fed system | 12.75 | 87.25 |
| Irrigated system | 2.25 | 97.75 |
| Combined system | 85 | 15 |
| No fertilization | 1.5 | 98.5 |
| Organic systems | 48 | 52 |
| Inorganic systems | 5.25 | 94.75 |
| Combined system | 45.25 | 54.75 |
| Monocropping system | 81.5 | 18.5 |
| Mixed cropping system | 13.75 | 86.25 |
| Intercropping system | 3.75 | 96.25 |
| Local seed system | 70 | 30 |
| Genetically modified seed system | 24.75 | 75.25 |
| No-till systems | 3.75 | 96.25 |
| Conventional tillage system | 95.5 | 4.5 |

### 3. Predicted technical efficiency values for various production systems

The findings reveal that the use of the rain-fed system was positively and significantly associated with technical efficiency. The predicted TE value of 0.428 indicates a less than average technical efficiency as a result of the use of this production system. Similarly, production systems such as the inorganic fertilization system (predicted TE of 0.429), the combined (both organic and inorganic) fertilization system (predicted TE of 0.429) and the use of improved seeds (predicted TE of 0.427), were also positively and significantly associated with technical efficiency. However, other production systems employed by the wheat farmers were negatively and significantly associated with technical efficiency implying that their use resulted in a significant drop in technical efficiency. Such production systems include the integrated (both irrigated and

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rainfed) irrigation system (with a predicted TE of 0.428), the organic system (with a predicted TE of 0.428) and the use of locally produced seeds (with a predicted TE of 0.426). production systems that were positively but not significantly associated to technical efficiency include the no fertilization system (with a predicted TE of 0.429), the mixed cropping system (predicted TE of 0.429), the intercropping system (predicted TE of 0.428) and the no-till system (with a predicted TE of 0.429). Lastly, some production systems were found to be negatively but insignificantly associated with technical efficiency such as the irrigated system (predicted TE of 0.429), the monocropping system (predicted TE of 0.429), and the conventional tillage system (predicted TE of 0.429). The mean predicted Technical efficiency score for all the farmers and all the production systems combined was obtained as 0.428. This implies a below average level of Technical efficiency for the wheat farmers irrespective of the type of production system employed. The results of the stochastic frontier analysis and the predicted TE scores are presented on *Table 5*

**Table 5: Stochastic Frontier Analysis and predicted TE Values for various production systems**

| STOCHASTIC FRONTIER ANALYSIS (Dependent variable = log log of wheat output) | | | | |
|---|---|---|---|---|
| ***Production systems*** | ***Coef*** | ***Std error*** | ***z-value*** | ***Predicted TE*** |
| Rain-fed system (1 = yes) | 0.029*** | 0.008 | 3.66 | 0.428 |
| Irrigated system (1 = yes) | -0.004 | 0.018 | -0.21 | 0.429 |
| Integrated irrigated system (1 = yes) | -0.026*** | 0.008 | -3.33 | 0.428 |
| No fertilization (1 = yes) | 0.002 | 0.024 | 0.10 | 0.429 |
| Organic systems (1 = yes) | -0.036*** | 0.006 | -5.66 | 0.428 |
| Inorganic systems (1 = yes) | 0.037*** | 0.012 | 3.19 | 0.429 |
| Combined system (1 = yes) | 0.019*** | 0.006 | 3.23 | 0.429 |
| Monocropping(1 = yes) | -0.009 | 0.008 | -1.15 | 0.429 |
| Mixed cropping (1 = yes) | 0.005 | 0.009 | 0.49 | 0.429 |
| Intercropping (1 = yes) | 0.021 | 0.016 | 1.25 | 0.428 |
| Locally produced seeds (1 = yes) | -0.022*** | 0.007 | -3.16 | 0.426 |
| Improved seeds(1 = yes) | 0.016** | 0.007 | 2.12 | 0.427 |
| No till(1 = yes) | 0.011 | 0.016 | 0.69 | 0.429 |
| Conventional tillage (1 = yes) | -0.003 | 0.015 | -0.22 | 0.429 |

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Findings revealed that the rain-fed system, inorganic fertilization system, and the use of improved seeds were all positively and significantly associated with technical efficiency indicating that farmers who employed these systems were likely to have higher technical efficiency than farmers who applied otherwise. Our results contradict findings by Simatupang & Nababan (2023) who observed that rain-fed based farming was found to be less efficient than irrigated farming. Our findings may be attributed to the frequent and even distribution of water across the field due to natural rainfall which may improve the water quality of the cultivated field resulting in improved efficiency. Also, the significant positive relationship between the use of inorganic fertilizers and technical efficiency aligns with findings by Zorb *et al*., (2018) and this relationship may exist because inorganic fertilizers provide readily available nutrients, increasing short-term wheat yields and technical efficiency when applied optimally. However, excessive or imbalanced inorganic fertilization can reduce nutrient use efficiency and lead to environmental degradation. Similarly, integrating both inorganic and organic fertilizers was found to significantly improve technical efficiency in wheat production. This aligns with findings by Roba (2018) who indicated that integrated nutrient management is a more sustainable and cost effective management of soil fertility and results in higher soil fertility and productivity. The findings also reveal that the use of improved wheat seeds was found to have a positive and significant association with technical efficiency. This aligns with findings by Gcaba et al. (2024) whose findings also revealed that the use of improved seeds results in a higher technical efficiency for adopters compared to non-adopters.

The integrated (both rainfall and irrigated) system as well as the use of locally produced wheat seeds were found to have a negative and significant association to technical efficiency. The use of both rain-fed and irrigated systems may be detrimental to wheat crops cultivated in the Western Highlands as it may result in waterlogging as this result is characterized by sufficient amounts and frequency of rainfall. However, our results differ from results by Makombe et al. (2011) whose stochastic frontier analysis revealed that farmers who employed the rain-fed system but also had access to irrigation had higher production frontier levels. Lastly, locally produced seeds were negatively and significantly associated with technical efficiency, indicating that farmers who cultivated using this system were likely to have lower technical efficiency than farmers who applied otherwise. This result aligns with findings by Chiona et al. (2014) who observed that locally produced seeds may have lower genetic potential compared to improved seed varieties and therefore requiring higher input usage to improve yield resulting in reduced efficiency.

The mean predicted technical efficiency value of 0.428 implies that on average, the sample of wheat farmers within the Western Highlands were operating at 42.8 percent of their feasible best practice output given their inputs in the various production systems employed. These farmers

  

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could in theory still improve their level of wheat output by 57.2 percent without adding further inputs.

### 4. Linking socioeconomic variables and technical efficiency

The link between various demographic drivers and technical efficiency indicates a positive and significant relationship for farmers whose main purpose of cultivation was for commercial purposes and technical efficiency. Contrarily, wheat farmers age, marital status, and income levels were all negatively and significantly associated with technical efficiency. Furthermore, farmers' gender and farm size were positively but insignificantly associated to technical efficiency while farmers' educational level, wheat farming experience, household size and off farm employment were negatively and insignificantly associated with technical efficiency. **Error! Reference source not found.** presents these results.

**Table 6: Beta Regression indicating the link between various socioeconomic variables and technical efficiency**

| BETA REGRESSION (Dependent Variable = Mean Predicted TE ) | | |
|---|---|---|
| ***Socioeconomic Variables*** | ***Coefficient*** | ***z-value*** |
| Gender (1=male) | 0.0024 | 1.64 |
| Age | -0.0002*** | -2.86 |
| Marital status (1 = unmarried) | -0.0024** | -2.41 |
| Income level | -0.0017*** | -3.02 |
| Educational level (1=uneducated) | -0.00015 | -1.15 |
| Wheat farming experience | -0.0012 | -3.61 |
| Household size | -0.0019 | -1.41 |
| Farm size | 0.0004 | 0.64 |
| Off-farm employment (1=no off farm employment) | -0.0017 | -1.22 |
| Main purpose of cultivating (1= commercial purposes) | 0.0033*** | 3.58 |
| Constant | -0.272 | -45.60 |

Our socioeconomic findings revealed that farmers' purpose of cultivating wheat had a significant positive association with technical efficiency. This implies that farmers cultivating wheat for commercial purposes had a higher technical efficiency compared to those cultivating for consumption purposes. This result aligns with findings by Tirkaso & Hess (2018) who observed

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that farmers who cultivated for commercial purposes were technically more efficient than those who cultivated for consumption purposes.

Contrarily, farmers' age, marital status, and income level were all negatively and significantly associated with technical efficiency. Farmers' age found to be negatively associated with technical efficiency, implying the younger farmers were technically more efficient compared to older farmers. This aligns with findings by Tauer (2017) who observed that productivity increases with age, peaks mid-life and then decreases as the farmer gets older. Also, the significant negative relationship between marital status and technical efficiency implies that married farmers were less technically efficient compared to unmarried farmers. This result aligns with findings by Obayelu et al. (2016) and the reason for this may be that the family obligations of married farmers may divert their time and labour from farm to household activities thus making them less efficient. Lastly farmers' income level was found to have a negative and significant relationship with technical efficiency implying farmers with higher income levels were associated with lower efficiency and vice versa. Our findings do not align with findings by Liang et al (2023) who observed that improved incomes may result in higher technical efficiency for farmers.

## IV. Implication of Results

Despite our findings revealing how various production systems and socioeconomic factors are associated to technical efficiency, it should however be noted that these findings do not establish a causal relationship between efficiency/inefficiency and the various production systems and socioeconomic characteristics. Instead, we try to observe the existing patterns between the various systems employed and how they vary with farmers' technical efficiency. The variations in farmers' technical efficiency could be as a result of the production systems as well as other factors influencing the wheat production process. Our findings have significant theoretical, practical and policy significance. Theoretically, the contrasting effects of different production systems provide empirical grounding for theories of resource use optimization and efficiency enhancement. The focus on mathematical models such as the Stochastic Frontier Model provides theoretical grounds for conclusions derived from this research and for inferences to be made from the research findings. Practically, farmers' understanding of various production systems may lead to increased focus on best practices that enhance their efficiency and reduce random effects. Farmers' can now focus on production systems that employ inorganic fertilizers, combined fertilizers (both organic and inorganic) as well as improved seeds for higher efficiency in wheat production. Policy wise, the results of this research may inform policy makers on tailored policies that tackle efficiency-related issues that hamper wheat production in Cameroon. Such policies may focus on extension services that provide inorganic fertilizers, organic and improved seed varieties to farmers, as well as providing them guidance on how to effectively utilize these inputs and manage other risks characteristic of wheat farming. This study therefore has significant implications from both individual and macro-scale perspectives.

## VI. Conclusion

Our findings reveal clear patterns in various factors driving efficiency gaps among wheat farmers in the context of a developing economy like Cameroon. Production systems positively associated with technical efficiency include the rain-fed system, the use of inorganic fertilizers, integrated fertilization, and the use of improved wheat seeds. Also, positive socioeconomic drivers include purpose of wheat cultivation with farmers cultivating for commercial purposes having higher efficiency levels. Production systems negatively associated with technical efficiency include the integrated irrigation system, the use of the organic fertilization system and the use of locally produced wheat seeds. Negative socioeconomic factors include age, marital status and income level. The mean predicted technical efficiency of 0.428 implied that farmers have almost 57.2 percent of output they can still increase at their current level of inputs within the Western Highlands. This shows there is still a much needed room for improvement in Wheat production within the Western Highlands of Cameroon.

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