International Journal on Food, Agriculture, and Natural Resources
Volume 04, Issue 02, Page 33-39
ISSN: 2722-4066
http://www.fanres.org

*Original Paper*

# Factors Affecting Sorghum Production in Western Ethiopia: Evidence from Smallholder Farmers

*Kifle Degefa[1*],Galmesa Abebe[1], Getachew Biru[2]*
*1) Bako Agricultural Research Center, Bako, Ethiopia*
*2) Oromia Agricultural Research Institute, Finfinne, Ethiopia*
**Corresponding Author email: kifledegu2002@ymail.com*

Received: 19 July 2022; Revised: 05 June 2023; Accepted: 19 June 2023
DOI: *https://doi.org/10.46676/ij-fanres.v4i2.109*

***Abstract*--Sorghum is the most important cereal crop in Sub-Saharan Africa including Ethiopia. The productivity and production of the crop are not increased as expected due to many limitations in the generation of demand-driven technologies and innovation upscaling in integrated and impact-oriented approaches to sorghum production. The study was focused on sorghum production systems and factors affecting sorghum production for sorghum producers. For this study both purposive and random sampling techniques were applied to select 123 households. OLS regression was used to analyze factors affecting sorghum productivities. In the study areas, the majority of the farmers used the local sorghum variety. Only 17.89% of sample households used improved sorghum varieties including lalo, chemeda, and gemedi varieties. The technology attributes improved sorghum varieties were better performance than the local variety. The regression model revealed that variables including sex, age, education, improved variety, soil slope and fertility, TLU, and extension services affected sorghum productivity positively and significantly at 10%, 5%, and 1% significance levels. Respective experts (BoANR, research centers, NGOs, and Universities) should be advised and support sorghum producers to enhance sorghum productivity.**

***Keywords*-- *Constraints and opportunities, Factors, OLS, Smallholder, Sorghum***

## I. INTRODUCTION

Sorghum is the world's fifth-largest and most important cereal grain crop after wheat, maize, rice, and barley [1]. It is the second most important cereal crop after maize in Sub-Saharan Africa [2]. It is used as human food, and it is a staple food for more than 100 million people in Eastern Africa [3]. Besides, the crop is also used as animal feed and industrial raw material [4]. Ethiopia is the largest producer of sorghum in Africa after Nigeria and Sudan and the second after Sudan in the Common Market for Eastern and Southern Africa member countries [5], [6]. Sorghum is a major staple food crop that ranks second after maize in total production as well as the third-largest crop in productivity after wheat and maize and area coverage after tef and maize [7]. The crop is one of the most widely grown cereal crops in a wide range of agro-ecologies between 400m and 2500m altitudes [8] and a staple food crop for millions of poor Ethiopians whose food insecurity is rambling [4].

Sorghum is the third most important crop in the Oromia zone next to tef and maize and also in western Oromia [7]. Since sorghum is a staple crop of particularly subsistence farmers, increasing productivity and production is often considered a means of improving the incomes and food security of poor farmers especially, in the East Wollega and West Shewa zones of Oromia [9,10]. While sorghum research was conducted in the last five decades by different research centers including Bako Agricultural Research Center with many success stories [8, 49].

Though the productivity and production of the crop are not increased as expected due to many limitations in the generation of demand-driven technologies and innovation up-scaling in an integrated and impact-oriented style [11, 48]. Therefore, to bring an integrated and impact-oriented approach to sorghum production identifying major intervention areas by assessing sorghum production systems and factors affecting sorghum production are very essential.

However, there is no information about production status, constraints, and opportunities to boost sorghum production and productivity as well as for further study in the study areas. Therefore, this study tried to answer the research and development intervention gaps by investigating the major sorghum production systems and factors affecting sorghum production by smallholder farmers.

## II. RESEARCH METHODOLOGY

### A. *Description of the Study Areas*

This study was conducted in West Shewa, East Wollega, and Bunno Bedelle Zones. In all sampled districts a mixed crop-livestock production system is the main agricultural practice performed by the majority of the farmers. More than 90% of the population of the study districts are depend on agriculture for their livelihood with maize, tef, rice, sorghum, and sesame leading crops.

From West Shewa zone two districts namely Ilu Gelan and Dano districts were used. Ilu Gelan district is located at 215 km to west of Finfinne, the capital city of Ethiopia and the geographical coordinates of the district is 08059'51''N,

37019’49’’E, and 1812 meter above sea level, latitude, longitude, and elevation, respectively. The annual rainfall and temperature of the districts are 1351 mm and range 13.8-32 0C, respectively [12], [13]. Danno district is located 260 km west of Finfinne with geographical coordinates latitude ranges from $08^0$34’-$08^0$56’, $37^0$08’-$37^0$29’ and 1600-1880 meters above sea level latitude, longitude, and altitude, respectively. The agro-ecology of the district was highland (5%), midland (75%), and lowland (20%) with the average monthly varying from 900-2400 mm annual rainfall. The monthly average temperature of the district varies from 18-30 $^0$C [14].

East Wollega Bonaya Boshe and Wayu Tuka districts were used from East Wollega zone. Bonaya Boshe district is located 307 km to the west of Finfinne and geographical coordinates of the district is 8054’ N, 3700’ E, and 1766 m above sea level latitude, longitude and elevation, respectively while Wayu Tuka is located at 323 km to the west of Finfinne. The rain falls of Bonaya Boshe and Wayu Tuka are range 850-1250 mm, and 1400-2400 mm, respectively [15].

Chewaqa district was used from Bonno Bedelle zone.m The district is located at 403 km to the west of Finfinne with the geographical coordinates of 7040’ N, 36050’ E, and 900-1400 m above sea level latitude, longitude, and altitude, respectively. The annual rain falls and temperatures of the district range 1000-1200 mm and 37-40 0C, respectively [16].

### *B. Data Sources and Methods of Data Collection*

Both primary and secondary data types were used for this study. The primary data was collected from sample sorghum producers and key informant interviewers by using a semi-structured questionnaire and checklist during the 2019/20 cropping seasons. Secondary data was collected from published and unpublished sources for a rational conclusion of the finding.

### *C. Sampling Techniques*:

A three-stage sampling technique was employed to select appropriate sample respondents. Five sorghum potential districts were selected purposively based on sorghum production extent and accessibility from Bunno Bedele, East Wollega, and West Shewa zones in the first stage. In the second stage, nine kebeles were selected randomly from sorghum producers’ kebeles and selected districts. In the third stage, 123 sample sorghum producers were selected randomly using probability proportional to sample size [17]. According to this formula the sample size was determined as follow; where: n = sample size, N = total number of tef supply to market, and e = precision level (0.09):

$$n = \frac{N}{1+N(e)^2} = \frac{12{,}700}{1+12{,}700(0.09)^2} = 122.27 \approx 123$$

TABLE I. SAMPLE DISTRICTS AND HOUSEHOLDS

| Zones | Districts | Female sample | Male sample | Total sample |
|---|---|---|---|---|
| West shewa | Danno | 5 | 20 | 25 |
| | Ilu Gelan | 4 | 15 | 19 |
| East Wollega | Bonaya Boshe | 6 | 22 | 28 |
| | WayuTuka | 3 | 11 | 14 |
| Bunno Bedelle | Chewaqa | 8 | 29 | 37 |
| Total | | 26 | 97 | 123 |

### *D. Methods of Data Analysis*

In this study, both descriptive statistics and econometric models were used to analyze the data. The first objective was analyzed using descriptive statistics such as mean, standard deviation, frequency distribution, and percentages, and the third objective was analyzed using the Ordinary Leas Square (OLS). This OLS model is applicable if and only if all sample households participate in sorghum production. In this study, all sampled households produced sorghum. This model is also used for its simplicity and practical applicability [18], [19]. Econometric model specification of sorghum production function is given below:

$$Y_i = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \cdots + \beta_n X_n + \varepsilon_i$$

Where; Y= Observed sorghum production, $\beta_0$, $\beta_1$, $\beta_2$, $\beta_3$, $\beta_4$……. $\beta_n$= Coefficients of explanatory variables and $\varepsilon_i$= Error terms

## III. RESULTS AND DISCUSSION

### *A. Household Socio-demographic Characteristics*

Household demographic characteristics was summarized in Table 2 and 3. The average age of the sampled household head was 42.92 years with a standard deviation of 12.20 years. This implies that the age of sorghum producer in the study areas was mainly practiced by the middle-aged farmers which is similar with [20], [21] results.

The average family size of the household was about 6.47 persons. This number of members of a household points to the availability of labor for agriculture and off/non-farm activities which makes it easy to implement farm activities and more received income from off/non-farm activities to invest in productivity enhancing-activities like purchase high yielder variety and other inputs. This result is in line with [22], [23] results.

The sampled household head had 4.61 years of sorghum farming experience with a standard deviation of 10.08 years. The farmers with more experience are better at a position with adapt high yielder variety and have been engaged in better sorghum field management which is in line with [24], [25] results.

TABLE II. HOUSEHOLD DEMOGRAPHIC CHARACTERISTICS (CONTINUOUS VARIABLES)

| Variables | N | Min | Max | Mean | Std. Dev. |
|---|---|---|---|---|---|
| Age of household | 123 | 22 | 80 | 42.92 | 12.20 |
| Household size | 123 | 1 | 18 | 6.47 | 2.85 |
| Sorghum experience | 123 | 1 | 50 | 17.45 | 10.08 |
| Education level | 94 | 1 | 12 | 5.50 | 2.96 |

Table 3 result shows that about 76.42% of respondents attained a minimum of one year of schooling. The average education level of the household head was 5.50 years with a standard deviation of 2.96 years while only about 23.58% of the household heads surveyed were illiterate. From the result, about 78.86% of respondents were male heads while 21.14% of households were female heads. Regarding the marital status of the household heads, about 94.31% were married, 3.25% were widowed, and 2.44% were not married.

TABLE III. HOUSEHOLD DEMOGRAPHIC CHARACTERISTICS (CATEGORY VARIABLES)

| Variables | | N | Percent of household |
|---|---|---|---|
| Educated households | | 94 | 76.42 |
| Gender | Male | 97 | 78.86 |
| | Female | 26 | 21.14 |
| Marital status | Married | 116 | 94.31 |
| | Widowed | 4 | 3.25 |
| | Single | 3 | 2.44 |

### *B. Socio-economic Characteristics of Household*

Among the households sampled over 96.75% of household heads had their landholding for engaged agriculture. The average total own land used for agriculture of respondents was 2.13 hectares' a range of 0.25-13 hectares while the average cultivated land of the respondent was 2.65 hectares with a range of 0.50-14 hectares. The total cultivated land that includes all the land used under the control of the farmer own, rented in and shared in which used for agriculture (Table 4).

The livestock ownership which converted Tropical Livestock Unit (TLU) was used as opposed to headcount to enable comparison across divides. The result showed that a high percentage of sampled households had own cows and oxen which implies that cows and oxen are the key important in rural livelihoods. The average total livestock holding of household was 6.51 which range 0.03-20.13 TLU. Analysis of the herd size shows that heifers, bulls, calves, shoats, equines, and poultry were kept for the purpose of crop production, income generation, and act as a symbol of prosperity purposes. Besides, using manure is also an important variable for the rural household's land productivity enhancement by improving soil fertility which is in line with [26] result.

TABLE IV. SOCIO-ECONOMIC CHARACTERISTICS OF HOUSEHOLD

| Variables | N | Percent | Min | Max | Mean | Std. Dev. |
|---|---|---|---|---|---|---|
| Total own land (ha) | 119 | 96.75 | 0.25 | 13 | 2.13 | 1.91 |
| Total operated land (ha) | 123 | 100 | 0.50 | 14 | 2.65 | 1.84 |
| Total TLU | 119 | 96.75 | 0.03 | 20.13 | 6.51 | 4.43 |

### *C. Institutional Characteristics*

Table 5 sought to establish the different types of institutional charactestics like extension and credit services. The result indicated that among the agricultural-related information fields pest management, crop rotation, and sorghum improved varieties information were the highly accessed information to the farmers (Table 5). Information on the market access on output and input marketing were the least accessed rate on crop produced by farmers (Table 5). This agricultural extension service is the delivery of inputs information to farmers on inputs like seed, fertilizer, chemicals for disease and insect control, and price of commodity forecasts and speeding technology adoption. This result is in line with [27], [28] results. This result shows that the contact frequency of extension service ranges from 1.77 to 2.32 times per year. The high extension contact ratio agent diffusion of knowledge to farmers which boosts agricultural productivity growth which is in line with [29] result. These extension service providers are the office of agriculture experts, DAs, NGOs, unions, and research centers.

Table 5 also shows that only 32.52% of sample households utilized credit from microfinance and moneylender for input purchase, non-farming activities, and buy ox purposes while 67.48% of sample households were not utilized credit due to collateral, fear risk, and high-interest rates. This implied that utilizing credit is one best option whereby smallholders could be instigated in diversifying their economic base and increase financial resources to purchase agricultural inputs which in line with [30], [31] results.

Recording selling sorghum, almost 49.59% of sampled households sold sorghum grain at the farm gate, village market, and district/main market (Table 5). The main sorghum buyers of sample households were consumers, collectors, and retailers with poor market information which is in line with [32] result.

TABLE V. INSTITUTIONAL SERVICES CHARACTERISTICS

| Variables (n = 123) | | N | Percent | Mean | Std. Dev. |
|---|---|---|---|---|---|
| Extension services | Varieties | 72 | 58.54 | 2.12 | 1.00 |
| | Pest management | 80 | 65.04 | 2.17 | 0.87 |
| | Crop rotation | 93 | 75.61 | 2.06 | 0.90 |
| | Marketing | 51 | 41.46 | 1.82 | 0.63 |
| Credit used | | 40 | 32.52 | | |
| Sorghum sold farmers | | 61 | 49.59 | | |

### *D. Crop production Pattern of Farmres*

Sampled households planted main six types of crops. The majority of sampled households planted sorghum and maize crops with 100% and 95.12%, respectively (Table 6). The next important crop was tef which was grown by 47.15% of respondents (Table 6). Pulse crops like nug, soybean, and sesame were planted by limited farmers (Table 6). The result shows that both cereal and pulse crops are the most important in terms of area coverage in the study areas. Among major grown crops maize and sorghum were the first and second ranking in terms of both production and productivity of the study areas. The mean of maize and sorghum productivity was 3.04 and 1.97 tons, respectively (Table 6).

TABLE VI. MAJOR CROPPING PATTERN WITH THEIR PRODUCTIVITY

| Crop | N | Percent (%) | Area (ha) | Production (ton) | Productivity (ton) |
|---|---|---|---|---|---|
| Sorghum | 123 | 100 | 0.46 | 0.91 | 1.97 |
| Maize | 117 | 95.12 | 0.92 | 2.80 | 3.05 |
| Tef | 58 | 47.15 | 0.60 | 0.57 | 0.95 |
| Nug | 18 | 14.63 | 0.74 | 0.68 | 0.92 |
| Soybean | 7 | 5.69 | 0.34 | 0.52 | 1.52 |
| Sesame | 14 | 11.38 | 0.46 | 0.28 | 0.60 |

### *E. Sorghum Input Used*

Over 82.11% of the sample households used local seed and only 17.89% of the sample households were used improved varieties of sorghum (Table 7). Improved seeds who fulfill the quality requirements have a positive impact on the productivity of land which is in line with [33], [34] results. Amongst the improved varieties adopted by farmers are lalo, chemada, and gemedi. This result implies that improved seed with appropriate recommendation increase the productivity of the crop who is in

line with [35] result.

TABLE VII. SORGHUM INPUT USED INTENSITY OF HOUSEHOLDS

| Inputs | | N | % of hhs | Amount used (kg) | Seed/ha (kg) |
|---|---|---|---|---|---|
| Types of seed | Local | 101 | 82.11 | 10.18 | 15.13 |
| | Improved | 22 | 17.89 | 5.35 | 10.50 |
| Inorganic fertilizer | Urea | 10 | 8.13 | 35.00 | 76.09 |
| | NPS | 19 | 15.45 | 32.20 | 70.00 |
| Chemicals (lit) | Herbicide | 16 | 13.01 | 0.66 | 1.43 |
| | Insecticide | 12 | 9.76 | 0.56 | 1.22 |

*F. Sorghum Varieties Characteristics*

The sampled households were asked to score their preferred traits for sorghum varieties. The scores were coded as very poor with a score of 1 and very good with a score of 5. The result presented in table 11 preferred traits of sorghum varieties. Overall improved varieties score above 4 were chemeda and gemedi with average scores of 4.14 and 4.01, respectively. All of the improved sorghum varieties reported were above average and local varieties. Production, market/demand, and consumption attribute sorghum improved varieties were reported as superior to local variety except lalo by lodging and both chemada and gemedi by bird susceptible. This implied that in most of the attributes improved sorghum varieties are better than local seeds. Farmers search for several of attributes when selecting sorghum varieties to grow besides yield which is in line [33] result.

The sorghum varieties also preferred based on crop residue. The sorghum residue is an important indicator of among other things, the crop-livestock competition at the farm level. The result presented in Table 9 showed that a big percentage of crop residue from sorghum went to livestock feeding with 25.91%. 90.24% of sampled households used sorghum residue for livestock as feed. Over 19.22% of sorghum residue was used as firewood with all sampled households' participation. While only 9.33% of sorghum residue went to income generation (sold), 17.08% was burnt in the field. Comparatively smaller quantities of sorghum residue with 15.82% and 12.64% were used for soil fertility improvement and construction, respectively

TABLE VIII. PREFERRED TRAITS OF SELECT SORGHUM VARIETIES

| Variables | Sorghum traits | Local | Lalo | Chemeda | Gemedi |
|---|---|---|---|---|---|
| Production characteristics | Grain yield | 3.06 | 4.08 | 4.25 | 4.00 |
| | Stover yield | 2.96 | 3.50 | 3.75 | 3.50 |
| | Palatability | 4.00 | 3.73 | 4.00 | 4.00 |
| | Lodging tolerate | 2.80 | 2.50 | 4.00 | 4.00 |
| | Pest tolerate | 3.10 | 3.70 | 4.00 | 3.65 |
| | Early maturity | 3.01 | 3.62 | 4.00 | 3.67 |
| | Uniformity maturity | 3.06 | 3.58 | 4.00 | 4.33 |
| | Grain size | 3.22 | 3.58 | 3.75 | 3.75 |
| | Head size | 3.27 | 3.82 | 4.25 | 4.00 |
| | Bird tolerance | 2.75 | 3.25 | 2.50 | 2.50 |
| Market/demand characteristic | Marketability | 3.24 | 3.36 | 4.33 | 3.31 |
| | Grain color | 3.21 | 3.14 | 3.75 | 4.33 |
| | Grain price | 3.13 | 3.60 | 3.67 | 3.43 |
| Consumption characteristic | Storability | 2.71 | 3.40 | 3.67 | 4.00 |
| | Taste | 3.47 | 3.36 | 4.00 | 3.67 |
| Overall average | | 3.36 | 3.73 | 4.14 | 4.01 |

TABLE IX. SORGHUM RESIDUE UTILIZATION OF SAMPLE HOUSEHOLDS

| Utilization | N | % of hhs | % of total utilized |
|---|---|---|---|
| Burnt in field | 83 | 67.48 | 17.08 |
| Used as firewood | 123 | 100.00 | 19.22 |
| Soil fertility | 76 | 61.79 | 15.82 |
| Feed for livestock | 111 | 90.24 | 25.91 |
| Used for construction | 42 | 34.15 | 12.64 |
| Sold | 5 | 4.07 | 9.33 |

*G.* Factors Determining Sorghum Production

To identify the impact of variables on sorghum production and productivity a regression model was used. Some basic assumptions tests were carried out. To test multicollinearity among explanatory variables the Variance Inflation Factor (VIF) test was conducted. The VIF result indicated that there was no series multicollinearity problem among the explanatory variables with an average value of VIF 9.231 average VIF which is in line with [36]. The problem of heteroscedasticity or no-equality of error variance was tested using robust command and obtaining robust standard errors. The test fails to reject the null hypothesis of constant variance. So, there is no problem with heteroscedasticity who is in line [37] result.

According to the regression result shown in Table 10, the sex of the household head was significant at a 5% significance level. Thus results showed that there is a difference in sorghum productivity among male-headed and female-headed households. The result indicates that sorghum productivity was higher for male-headed households than for female-headed households by 15.36% which in line with [38] result who stated that maize productivity of male-headed households with overall 44.3% that female-headed households.

The age household head was significant at a 10% significance level (Table 10). The result indicated that, holding other variables constant, as the household age increases by a year, the sorghum production increases by 14.83% because the majority of the sampled households were categorized as young (productive) age. This implies that the older the head of the household, the more experience he/she has in managing the land which in line with [39] result.

The improved seed was also another significant variable of the regression model. The result indicated that farmers who utilized improved seeds got 9.85% more sorghum production compared to farmers who use local varieties (Table 10). The improved seed has a positive impact on the productivity of land which in line with [33], [34] results.

The education level of the household head was significant at 1% significance level. Hence, as farmers' education level increase by a year sorghum productivity increases by 21.04% (Table 10). This implies that the more educated the household head, the more experience he/she has in handling the sorghum land and the result is in line with [40] result.

The cultivated landholding size is the determinant factor for sorghum productivity which positive significant at 5% significance level (Table 10). The result indicated that, as the cultivated landholding size increases by a hectare, sorghum productivity increases by 19.78%. In reality in the study areas, increasing cultivated land holding size is not possible. The only

possible option for farmers to increase their cultivated land holding size was only through renting and sharing the land of others which is in line with [41], [42] results.

Concerning soil slope and fertility, they were significant at 5% and 1% significance levels, respectively (table 10). This implies that as soil slope flat use increases, sorghum production increases by 31.45% which is related to soil fertility. Though farmers possess several fragmented plots in different areas, they were asked to provide the overall assessment of their plots as fertile or infertile. Thus, the result showed that farmers who rated their plots as fertile got 10.28% more sorghum production compared to plots rated as infertile which is soil improvement has a positive impact on crop productivity enhancement which is in line with [43] result.

The possession of livestock is a critical asset in rural areas. As it was hypothesized, for smooth management and on-time cultivation of land, income generation for purchase inputs. The TLU was significant at 1% significance level (Table 10). Hence, the result indicates that an additional TLU brings a 23.91% increase in sorghum production which is in line with [44] result. Besides, using manure is also an important variable for the rural household's land productivity enhancement by improving soil fertility which is in line with [22] result.

The use of extension service increases the sorghum productivity by 18.73% as the households were got more with contact of extension service during one production season of the survey period (Table 10). So, expanding and encouraging the farm household participation frequency for the use of extension program is still important for the sorghum productivity enhancement. Besides, agricultural extension service is the delivery of inputs information to farmers on inputs like seed, fertilizer, chemical for disease and insect control, price of commodity forecasts, and speeding technology adoption which is in line with [27], [28], [45] results.

TABLE X. FACTORS AFFECTING SORGHUM PRODUCTION OF SAMPLE HOUSEHOLDS

| Variables | Coefficient | Std. Err. | t-value |
|---|---|---|---|
| Sex of the household head | 0.1536** | 0.0622 | 2.4687 |
| Age of the household head | 0.1483* | 0.0713 | 2.0817 |
| Seed (improved & local) | 0.0985** | 0.0420 | 2.3451 |
| Education level of the respondent | 0.2104*** | 0.0549 | 3.8320 |
| Sorghum farming experience | 0.1956 | 0.1318 | 1.4847 |
| Household size | 0.2239 | 0.1406 | 1.5926 |
| Distance to the main market | 0.1265 | 0.1025 | 1.2347 |
| Cultivated landholding | 0.1978** | 0.0732 | 2.7039 |
| Soil slope | 0.3145** | 0.1156 | 2.7198 |
| Distance to sorghum plot | 0.2154 | 0.1504 | 1.4321 |
| Soil fertility | 0.1028*** | 0.0319 | 3.2213 |
| TLU holding | 0.2391*** | 0.0645 | 3.7085 |
| Credit utilized | 0.1355 | 0.0365 | 1.5668 |
| Extension contact frequency | 0.1873*** | 0.0564 | 3.3179 |
| Constant | 14.5463*** | 2.771261 | 5.2490 |

### *H. Major Sorghum Production Constraints*

The result presented in table 11 were major sorghum production constraints. The majority of the sampled households (98.37%) identified the price of fertilizers as a constraint in sorghum production which ranked fourth. This implied that the issue of high fertilizer prices is not only widespread in the surveyed household areas but also the most important to the farmers when compared to other constraints faced. Constraints ranked high in importance by the farmers include access to market and information which ranked first, low grain price which ranked second, and pests (insects and diseases) which ranked third. Weed infestation and poor soil fertility were the other constraints ranked fifth and sixth respectively. Untimely availability of inputs (seed & fertilizer) which ranked seventh were reported by sampled households. The result shows that over 60% of the sorghum yield gap can be decomposed into damages due to these biotic and abiotic constraints which is in line with [6], [46] results. For ensuring food demand of the fast-increasing population in developing countries including Ethiopia quantification of crop yield gaps and discovering production and marketing constraints are very crucial.

TABLE XI. MAJOR SORGHUM PRODUCTION AND MARKETING CONSTRAINTS OF HOUSEHOLDS

| Constraints (n=123) | N | % of hhs | Rank |
|---|---|---|---|
| Untimely availability of improved seed | 92 | 74.80 | 7 |
| High prices of fertilizer | 121 | 98.37 | 4 |
| Access to markets and information | 117 | 95.12 | 1 |
| Low grain prices | 123 | 100.00 | 2 |
| Floods | 30 | 24.39 | 8 |
| Pests and disease | 120 | 97.56 | 3 |
| Soil fertility | 112 | 91.06 | 6 |
| Weed infestation | 34 | 27.64 | 5 |

### *I. Major Sorghum Opportunities*

Favorable conditions, market demand, genetic variability, and the presence of institutes are the major opportunities for sorghum productivity enhancement. Favorable condition for sorghum production is an indigenous crop and is mainly grown in the western part of Ethiopia. This implies that the western part of the county is a favorable condition for sorghum production. There is a huge demand for sorghum in Common Market for Eastern and Southern Africa which is in line with [47] result. Genetic variety for developing new varieties Information: The majority of the sample households were aware of sorghum improved varieties which is in line with [9] result. This shows that improved sorghum varieties can be popularized easily using the information as an opportunity. Besides, Research Centers (Bako, Bedelle, and Nekemte Soil) and Universities (Wollega and Mattu) also support the sector by improving sorghum productivity with the quality needed by Common Market for Eastern and Southern Africa.

## IV. CONCLUSIONS

The fundamental focus of this study was to investigate the sorghum production status, factors affecting sorghum productivity, and opportunities for further investigation in the Bunno Bedele, East Wollega, and West Shewa zones of the western part of Oromia. In these areas, sorghum was the second important crop in terms of crop productivity after

maize. The limited sampled respondents have used chemical fertilizers with lower intensity of chemical fertilizer application which was below the recommended rate by researchers. The recommended amount of fertilizer per hectare for all soil types of sorghum was 100 kg of Urea and 100 kg of NPS. Hence, farmers must be aware to use fertilizer at the recommended rate. Improved variety of sorghum productivity was identified as positive significance.

The majority of the sampled households (82.11%) used sorghum local seed due to insufficient supply of seeds, lack of capital, susceptibility to the bird, and lodging problems. In all attributes (production, market/demand, and consumption) improved sorghum varieties were better than local varieties except for lodging and bird problems. Therefore, high yield and disease resistant varieties will be expected from research centers and Universities. The regression model also identifies factors affecting sorghum productivity including sex of household head, age of household head, education level of household head, soil slope and fertility, TLU, and extension contact frequency were statistically significant that affected sorghum productivity positively. This implies that a unit increase in these variables increases the sorghum productivity of the farmers. Related market aspects (inputs and output), pests (diseases, insects) were reported as major constraints in sorghum production and favorable condition, and international market (COMESA), institutions, and information were reported as major opportunities to enhance sorghum production. Therefore, all the above factors affecting sorghum production significantly positively and negatively need attention from all concerned bodies like research centers, government experts, NGOs, and private sectors who participated in sorghum production management, marketing aspects, and sorghum inputs dealers.

## ACKNOWLEDGMENT

Authors appreciate the supportive roles of native farmers in all the study areas, and agriculture experts in all districts and kebeles, express sincere gratitude to Oromia Agriculture Research Institute for logistic services during data collection.

## DECLARATION OF INTEREST

The authors have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

First, confirm that you have the correct template for your paper size.

## REFERENCES

[1] Assefa, A. Bezabih, G. Girmay, T. Alemayehu, and A. Lakew, "Evaluation of sorghum (Sorghum bicolor (L.) Moench) variety performance in the lowlands area of wag lasta, north eastern Ethiopia," Cogent Food and Agriculture, vol. 6, no. 1, 1778603, 2020.

[2] N. Nyoni, M. Dube, S. Bhebhe, B. Sibanda, M. Maphosa, and A. Bombom, "Understanding biodiversity in sorghums to support the development of high value bio-based products in sub-Saharan Africa," Journal of Cereals and Oilseeds, vol. 11, no. 2, pp. 37-43, 2020.

[3] C. Andiku, H. Shimelis, A.I.T. Shayanowako, P.I. Gangashetty, and E. Manyasa, "Genetic diversity analysis of East African sorghum (Sorghum bicolor [L.] Moench) germplasm collections for agronomic and nutritional quality traits," Heliyon, vol. 8 no. 6, p. e09690, 2020.

[4] M.M. Tasie and B.G. Gebreyes, "Characterization of Nutritional, Antinutritional, and Mineral Contents of Thirty-Five Sorghum Varieties Grown in Ethiopia," International Journal of Food Science, vol. 2020, pp. 1-11, 2020, https://doi.org/10.1155/2020/8243617.

[5] B.A. Amelework, H.A. Shimelis, P. Tongoona, F. Mengistu, M.D. Laing, and D.G. Ayele, "Sorghum production systems and constraints, and coping strategies under drought-prone agro-ecologies of Ethiopia," South African Journal Plant and Soil, vol. 33, no. 3, pp. 207-217, 2016.

[6] A. Habte, W. Worku, S. Gayler, D. Ayalew, and G. Mamo, "Model-based yield gap analysis and constraints of rainfed sorghum production in Southwest Ethiopia," Journal of Agricultural Science, pp. 1-15, 2021. https://doi.org/10.1017/S0021859621000435.

[7] G. Mengistu, H. Shimelis, M. Laing, and D. Lule, "Assessment of farmers' perceptions of production constraints, and their trait preferences of sorghum in western Ethiopia: implications for anthracnose resistance breeding," Acta Agriculturae Scandinavica, Section B-Soil and Plant Science, vo. 69, no. 3, pp. 241-249, 2019.

[8] G. Gebregergs and F. Mekbib, "Estimation of genetic variability, heritability, and genetic advance in advanced lines for grain yield and yield components of sorghum [Sorghum bicolor (L.) Moench] at Humera, Western Tigray, Ethiopia," Cogent Food and Agriculture, vol. no. 1, p 1764181, 2020.

[9] T. Menamo, B. Kassahun, A.K. Borrell, D.R. Jordan, Y. Tao, C. Hunt, and E. Mace, "Genetic diversity of Ethiopian sorghum reveals signatures of climatic adaptation," Theoretical and Applied Genetics, vol. 134, no. 2, pp. 731-742, 2021.

[10] D. Kifle, B. Getachew, and A. Galmesa, "Characterization and analysis of farming system of Cheliya and Ilu Gelan districts of West Shewa Zone, Ethiopia," Journal of Development and Agricultural Economics, vol. 12, no. 2 pp. 154-167, 2020.

[11] T. Begna, H. Gichile, W. Yali, and Z. Asrat, "Participatory Variety Selection of Improved Highland Sorghum on the Basis of Farmers Preference Traits in Eastern Part of Ethiopia," International Journal of Agriculture and Biosciences, vol. 9, no. 6, pp. 291-298, 2020.

[12] Z. Tadesse, E. Kelbessa, and T. Bekele, "Floristic composition and plant community analysis of vegetation in Ilu Gelan district, West Shewa Zone of Oromia region, Central Ethiopia," Trop. Plant Res., vol. 4, no. 2, pp. 335–350, 2017, doi: 10.22271/tpr.2017.v4.i2.045.

[13] B. Dessalegn, "Transitory coping strategies of food-insecure smallholder farmer households: the case of Ilu Gelan District, West Shoa Zone, Oromia Reginal State, Ethiopia," Agric. Food Secur., vol. 7, no. 1, p. 70, 2018, doi: 10.1186/s40066-018-0204-2.

[14] M.R. Wodajo, "Women and Land Rights in Western Shoa: In Case of Dano Woreda, 1941-1991," Education Research International, vol. 2022, pp. 1-11, 2022.

[15] F. T. Hailu, B. C. Chemada, L. Dagnachew, and D. L. Kebede, "On-farm evaluation and pre-scaling up of improved finger millet technologies under rainfed condition in Western Oromia, Ethiopia: A case of East Wollega Zone, Ethiopia," J. Agric. Ext. Rural Dev., vol. 13, no. 3, pp. 165–172, Jul. 2021, doi: 10.5897/JAERD2021.1241.

[16] D. R. Tefera, S. O. Sinkie, and D. Wolde Daka, "Economic Burden of Malaria and Associated Factors Among Rural Households in Chewaka District, Western Ethiopia," Clin. Outcomes Res., vol. Volume 12, pp. 141–152, Mar. 2020, doi: 10.2147/CEOR.S241590.

[17] C.S. Aweke, E. Lahiff, and J.Y. Hassen, "The contribution of agriculture to household dietary diversity: evidence from smallholders in East Hararghe, Ethiopia," Food Security, vol. 12, no 3, pp. 625-6636, 2020. https://doi.org/10.1007/s12571-020-01027-w.

[18] V. Sevinc and A. Goktas, "A Comparison of Different Ridge Parameters under Both Multicollinearity and Heteroscedasticity," Süleyman Demirel University Journal of Natural and Applied Sciences, vol. 23, no. 2, pp. 381-389, 2019.

[19] B. Adelodun, A.A. Mohammed, K.A. Adeniran, S.-U.O. Akanbi, T.S. Abdulkadir, and K.S. Choi, "Comparative assessment of technical efficiencies of irrigated crop production farms: A case study of the large-scale Kampe-Omi irrigation scheme, Nigeria," African Journal of Science, Technology, Innovation and Development, vol. 13, no. 3, pp. 293-302, 2021.

[20] H. Komatsu, H. Malapit, and M. Balagamwala, "Gender effects of agricultural cropping work and nutrition status in Tanzania," PLOS ONE, vol. 14, no 9, p. e0222090, 2019.

[21] A. Shita, N. Kumar, and S. Singh, "Determinants of Agricultural Productivity in Ethiopia: ARDL Approach," The Indian Economic Journal, vol. 66, no. 3-4, pp. 365-374, 2018.

[22] H. Ahmadzai, "How is Off-farm Income Linked to On-farm Diversification? Evidence from Afghanistan," Study in Agricultural Economics, vol. 122, no. 1, pp 1-12, 2020.

[23] S. Salam and S. Bauer, "Rural non-farm economy and livelihood diversification strategies: evidence from Bangladesh," GeoJournal, pp. 1-13, 2020.

[24] B.F. Belay and M.F. Wale, "Participatory on farm evaluation of improved sorghum varieties in North Gondar areas of Ethiopia," Cogent Food and Agriculture, vol. 7, no. 1, p. 1871809, 2021.

[25] K. Traore, D.K. Sidibe, H. Coulibaly, and J. Bayala, "Optimizing yield of improved varieties of millet and sorghum under highly variable rainfall conditions using contour ridges in Cinzana, Mali," Agriculture and Food Security, vol. 6, no. 1, p. 11, 2017.

[26] M. Marie, F. Yirga, M. Haile, and F. Tquabo, "Farmers' choices and factors affecting adoption of climate change adaptation strategies: evidence from northwestern Ethiopia," Heliyon, vol. 6, no. 4, p. e03867, 2020. https://doi.org/10.1016/j.heliyon.2020.e03867.

[27] A. Tewodros and A. Tesfaye, "Agricultural Knowledge and Technology Transfer Systems in the Southern Ethiopia," African Journal of Agricultural Research, vol. 13, no. 14, pp. 682-690, 2018. https://doi.org/10.5897/AJAR2018.12180.

[28] H. El Bilali and M.S. Allahyari, "Transition towards sustainability in agriculture and food systems: Role of information and communication technologies," Information Processing in Agriculture, vol. 5, no. 4, pp. 456-464, 2018. https://doi.org/10.1016/j.inpa.2018.06.006.

[29] A. Missiame, R.A. Nyikal, and P. Irungu, "What is the impact of rural bank credit access on the technical efficiency of smallholder cassava farmers in Ghana? An endogenous switching regression analysis," Heliyon. Vol. 7, no. 1, p. e07102, 2021.

[30] S. Sekyi, B.M. Abu, and P.K. Nkegbe, "Farm credit access, credit constraint and productivity in Ghana," Agricultural Finance Review, vol. 77, no. 4, pp. 446-462, 2017.

[31] K. Gebretsadik and A. Kiflu, "Challenges and Opportunities of Genetically Modified Crops Production; Future Perspectives in Ethiopia, Review," The Open Agriculture Journal, vol. 12, no. 1, pp. 240-250, 2018. https://doi.org/10.2174/1874331501819010240.

[32] S. Surni, H. Saediman, F. Wulandari, M. Zani, L. Yunus, and S.A.A. Taridala, "Profitability and Constraints of Small-Scale Tomato Production in Baubau Municipality of Southeast Sulawesi," WSEAS Transactions on Environment and Development, vol. 16, pp. 219-225, 2020.

[33] T.S. Dawit, J.H.M.V. Frans, and C.M. van T. Hans, "Marketing activities as critical success factors: The case of seed producer cooperatives in Ethiopia," African Journal of Business Management, vol. 11, no. 19, pp. 548-563, 2017. https://doi.org/10.5897/AJBM2016.8295.

[34] S. Jha, H. Kaechele, M. Lana, T.S. Amjath-Babu, and S. Sieber, "Exploring Farmers' Perceptions of Agricultural Technologies: A Case Study from Tanzania," Sustainability. Vol. 12, p. 998, 2020.

[35] M. Sheahan and C.B. Barrett, "Ten striking facts about agricultural input use in Sub-Saharan Africa," Food Policy. vol. 67, pp. 12-25, 2017. doi: 10.1016/j.foodpol.2016.09.010.

[36] S. Mohammadi, "A test of harmful multicollinearity: A generalized ridge regression approach," Communications in Statistics - Theory Methods, pp. 1-20, 2020.

[37] X. Guo, X. Jiang, S. Zhang, and L. Zhu, "Pairwise distance-based heteroscedasticity test for regressions," Science China Mathematics., vol. 63, no. 12, pp. 2553–2572, 2020.

[38] G.G. Gebre, H. Isoda, D.B. Rahut, Y. Amekawa, and H. Nomura, "Gender differences in agricultural productivity: evidence from maize farm households in southern Ethiopia," GeoJournal, vol. 86, no. 2, pp. 843-864, 2021. https://doi.org/10.1007/s10708-019-10098-y.

[39] A. Shita, N. Kumar, and S. Singh, "Determinants of Agricultural Productivity in Ethiopia: ARDL Approach," The Indian Economic Journal, vol. 66, no. 3–4, pp. 365–374, 2018.

[40] M.H. Ahmed, "Impact of improved seed and inorganic fertilizer on maize yield and welfare: Evidence from Eastern Ethiopia," Journal of Agriculture and Food Research, vol. 7, p. 100266, 2022.

[41] O. Mora, C. Le Mouël, M. de Lattre-Gasquet, C. Donnars, P. Dumas, O. Réchauchère, … and P. Marty, "Exploring the future of land use and food security: A new set of global scenarios," PLOS ONE, vol. 15, no. 7, p. e0235597, 2020.

[42] A.W. Degife, F. Zabel, and W. Mauser, "Land Use Scenarios and Their Effect on Potential Crop Production: The Case of Gambella Region, Ethiopia," Agriculture, vol. 9, no. 5, p. 105, 2019.

[43] W.D. Biru, M. Zeller, and T.K. Loos, "The Impact of Agricultural Technologies on Poverty and Vulnerability of Smallholders in Ethiopia: A Panel Data Analysis," Social Indicators Research, vol. 147, no. 2, pp. 517-544. 2020. https://doi.org/10.1007/s11205-019-02166-0.

[44] D.Y. Ayal and W. Leal Filho, "Farmers' perceptions of climate variability and its adverse impacts on crop and livestock production in Ethiopia," Journal of Arid Environments, vol. 140, pp. 20-28, 2017.

[45] A. Magaisa, P. Manjeru, C.N. Kamutando, and M.P. Moyo, "Participatory variety selection and stability of agronomic performance of advanced sorghum lines in Zimbabwe," Journal of Crop Improvement, vol. 36, no.3, pp. 440-460, 2022.

[46] Z. Hu, "What Socio-Economic and Political Factors Lead to Global Pesticide Dependence? A Critical Review from a Social Science Perspective," Int. J. Environ. Res. Public Health, vol. 17, no. 21, p. 8119, 2020. https://doi.org/10.3390/ijerph17218119.

[47] S. O. Okeyo, S. N. Ndirangu, H. N. Isaboke, L. K. Njeru, and J. A. Omenda, "Analysis of the determinants of farmer participation in sorghum farming among small-scale farmers in Siaya County, Kenya," Scientific African, vol. 1

[48] K. Degefa, G. Biru, and G. Abebe, "Factors Affecting Tomato Productivity in Western Oromia, Ethiopia: Evidence from Smallholder Farmers," International Journal on Food, Agriculture and Natural Resources, vol. 3, no. 2, pp. 5–10, Aug. 2022, doi: 10.46676/ij-fanres.v3i2.70.

[49] T. Tesema, "Are farmers technically efficient in growing sorghum crops?: evidence from western part of Ethiopia Gudeya Bila district," Heliyon, vol. 8, no. 7, p. e09907, Jul. 2022, doi: 10.1016/j.heliyon.2022.e09907.