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Socio-Economic Factors Affecting Profitability of Sorghum Farming in Siaya County, Kenya

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Abstract

Despite the nutritional benefits of sorghum and its ability to thrive in the low and unpredictable rainfall conditions in Siaya County, farmers in the area have not widely adopted it as a viable enterprise. In this paper, we study profitability of sorghum production and its determinant factors in Siaya County, Kenya. By randomly sampling 310 farmers, the paper shows that sorghum farming in Siaya County is profitable, with an average gross margin of Kshs. 4,286 per acre and the most profitable farm having a gross margin of Kshs. 24,000 per acre. Moreover, the factors such as the age and education level of the household head, household size, household income, access to extension services, the number of crops intercropped with sorghum, and the nature of farming have significant impacts on gross margins.

Thus, the study recommends improving extension services; encouraging farmers to embrace sustainable farming practices such as mixed farming; and incentivizing farmers into sorghum farming.

Keywords: Sorghum; Farming; Profitability; Siaya.

JEL Classification: N5, O13, Q1.

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1. Introduction

Sorghum is an essential crop in several parts of the world. It is the fifth grain globally in terms of annual production (Mundia et al, 2019). Sorghum provides a range of benefits in three main forms, as fiber, as grain, and as fodder (Frederiksen and Smith, 2000). Sorghum thrives in warm climate, and it is grown in the tropical and sub-tropical regions of Sub Saharan Africa and Asia. The crop matures within a shorter period of time and also produces relatively higher food levels per unit of energy spend compared to other crops. Currently, more than 90% of the total global sorghum harvested areas are found in Africa and Asia with Africa accounting for 61% of the areas where sorghum is harvested and 41% of the total sorghum production in the world (Mundia et al, 2019).

A report by Njagi et al (2019) noted that Kenya has an estimated 240,000 small scale sorghum farmers with land sizes of between 0.4 and 0.6 hectares spread in different parts of the country. The sorghum producing regions, especially Siaya and Makueni usually experience poor yields or total failure of maize crops during seasons of low rainfall. Consequently, the major concern for agricultural stakeholders in the sorghum subsector in Kenya has always revolved around increasing the yields and productivity of the crop, enhancing the ability of sorghum varieties that are more resistant to droughts, pests and diseases, as well as improving the commonly grown in Siaya, Migori, Homabay, Busia, Makueni, Tharaka Nithi, Meru efficiencies along the sorghum value chains.

In Siaya County, sorghum is one of the important food crops. Traditionally, Siaya residents used sorghum to cook porridge and ugali. Farmers have focused more on maize despite the low returns from maize. Fluctuations in rainfall, drought, and the changing climatic conditions have negatively affected maize yields in the County. However, farmers have continued to devote more of their land parcels to maize than sorghum even though the former can do well even in hostile climatic conditions. According to a study carried out by Akuno et al (2015), only 10% of farmers in Siaya County have fully embraced sorghum with the remaining 90% still focusing on maize as their preferred crop. At the same time, increased demand for sorghum by the alcohol-based companies such as the Kenya Breweries has increased the market outlets and commercial value of the crop. According to Obiero (2013), Siaya is a food deficit county because the county meets its food requirements for an average of four months only every year. There is a need to boost the production of sorghum to improve food security in the county.

In this study, we examine gross margin of sorghum production in the Siaya County and identify the socioeconomic, institutional, and policy factors that affect it. Thus, the rest of the paper structured as following. Next section covers brief literature review on sorghum farming and its profitability. The section 3 describes data and methodology. Section 4 presents results of the study and the last section concludes.

2. Literature Review

The extant literature shows that sorghum has multiple applications. Apart from food, sorghum can be used to provide fuel and also as animal feed. According to a study carried out by Janssen and Rutz (2012), using sorghum to produce biofuel can significantly increase the gross margins from the crop, especially if a well-organized management regime for the crop is executed. However, Njagi et al (2019) note that sorghum farming in Kenya has mainly been subsistence in nature. A study on sorghum done in Western Kenya and Eastern Uganda by Amusala et al (2012) find that the yield from sorghum is less than 1 ton/acre, and this is expected to drop even further owing to the present climate change and unpredictable rainfall patterns in the region. The low yield implies that sorghum production and productivity has not reached the optimal levels in Siaya County.

Njagi et al (2019) finds that a typical Kenyan sorghum farmer who does not use improved sorghum seeds and fertilizers could make a negative gross margin of Kenya Shillings 17,440 while a commercial oriented sorghum farmer who uses both fertilizer and improved seeds could make gross margin of up to Kenya shillings 13,700 per acre. The huge variation in gross margin between farmers who farm their crop without fertilizer and improved seeds vis-à-vis those who use such inputs shows that a lot of study needs to be done to understand the socioeconomic factors which influence the gross margin among small holder sorghum farms.

Zalkuwi et al (2015) shows that the gross margins from sorghum production in Nigeria and India are found to be Rs. 17354.30 (about Ksh. 26,031.45) and Rs. 20642.10 (about Ksh. 30,963.15) per acre respectively. The output from sorghum production is found to be 17.68 QTLs and 18.14 QTLs in India and Nigeria respectively. According to Kilambya and Witwer (2013) the average sorghum yield in Kenya has been 0.8 tons per hectare for the last two decades with the peak production being experienced in 2005 when production averaged 1.2 tons per hectare. These yield levels are still very low considering the fact that with proper

field management regime certified improved seeds have the capacity to produce between 2 and 5 tons per hectare per season of production. Consequently, there is need to determine the gross margins from sorghum for sustainable food security in Siaya County and other parts of Kenya.

Despite the increasing need for farmers to embrace sorghum production to supplement maize, the adoption of the crop has been rather low. According to County Government of Siaya (2018)¹, only 28.96% of total land under crops was dedicated to Sorghum. The productivity of local maize in Siaya County stands at 632.3 Kg/ha during the long rains and 599.5 kg per acre during the long rains while hybrid maize seeds produce 681.9kg/ha during the short rains and 780.5 kg/ha during the long rains (Obiero, 2013). This is quite low when compared with other regions in Kenya where farmers get up to 8.8 tons/ha (Nyataya, 2014).

Despite the fact that sorghum has unique characteristics, its adoption in Siaya County has been limited. Instead, most farmers prefer to grow maize, even though sorghum is better suited to the severe and unpredictable weather conditions in Siaya County. The insufficient uptake of sorghum in Siaya County is partly responsible for the county's persistent food shortages, as Kange et al.'s (2014) study has shown. There is a lack of information on why most households in Siaya County do not grow sorghum, despite the crop's ability to thrive with minimal rainfall. It is surprising that previous research has not extensively investigated the economic benefits of sorghum in Siaya County. Rather several studies focus on determinants of sorghum productivity. For instance, Okeyo et al (2020) investigate productivity of sorghum in Siaya County, Kenya by randomly sampling 300 smallholder households. Their OLS model documents that farm size under sorghum, labour, farm gate price, serena and seredo seed varieties are significant determinants of sorghum productivity in the study area.

The determinants of sorghum production were researched in other regions of Africa as well. For instance, Sadiq et al (2020) study variations in sorghum production in Nigeria during 1961 and 2008. They document that sorghum production has low growth during analysis period and the chief determinant of sorghum production appears to be area expansion rather than its productivity.

Gebre et al (2021) examine determinants of sorghum producers' commercialization in Ethiopia using questionnaire among 543 farmers. Their Tobit model results indicate that sex of household head, educational level of household head, land under sorghum production, non/off-farm income, sorghum quantity

¹ Siaya County Spatial Plan 2018-2028. Available at <https://repository.kippira.or.ke/handle/123456789/2031>

produced, credit amount receive, and oxen significantly influence the degree of sorghum commercialization.

Semakula (2022) analyses determinants of sorghum productivity in Uganda by sampling 272 smallholder households. As a result, he observes that undertaking efforts to promote and encourage sorghum production among older farmers; promoting marriage among farmers that are single/never married; designing and implementing initiatives to promote sorghum productivity targeting male headed households as well as adopting agricultural productivity improvement campaigns targeting farmers with low levels of education have positive impacts on sorghum productivity in long-term. Moreover, he also documents that household size enlargement—by encouraging households to produce more children (source of cheap labour) to improve not only sorghum but the entire agricultural productivity; the encouragement of household heads to engage themselves in activities that can increase household incomes as well as encouraging farmers to allocate more land to Sorghum production.

Magino et al (2004) study profitability of sorghum-cowpea and sorghum-groundnut intercropping practices and comparing the profitability of the intercrops and there component sole crops. They surveyed 150 randomly selected farmers and using OLS technique, they find out that gross margin of the two intercrops were significantly higher than those of the component crops. It was concluded that, sorghum-cowpea and sorghum-groundnut were equally profitable and advantageous.

Thus, we think the profitability of sorghum by analyzing its gross margins should be thoroughly examined in the region. Therefore, in this study, we investigate the socioeconomic and institutional factors that influence the profitability of sorghum.

3. Data and Methodology

3.1. Data and Data Collection

The study is carried out in Siaya County which is located in the south-western part of Kenya. The county has a total land size of 2,530km² which comprises of highlands, wetlands, and agricultural lands. The county borders Busia, Kakamega, Vihiga and Kisumu counties to the north, northeast and southeast respectively. The county is positioned on latitude 0° 26' to 0° 18' north and longitude 33° 58' east and 34° 33' west. It has a total area of 2, 496.1 square kilometers. The average land size per household in Siaya County is about

1.02 Hactares in Alego and Ugenya, and about 3.0 hectares in Bondo. The soils are diverse which includes the red well drained clay soils mostly referred to as nitisols which are mostly found in Uyoma areas of Bondo Sub County. The areas along river Yala have alluvial soils while most parts of Alego, Ugenya and Gem Sub County have loam and clay soils with moderate levels of fertility².

Data on socioeconomic characteristics of the household such as income, education level of household head, age and gender of household head, size of the household, institutional factors such as agronomic practices like intercropping and nature of farm ownership, and policy factors such as access to extension, and access to credit are provided by the household head. Also, the various variable costs used in the production process such as cost of seeds, land preparation, planting, weeding, harvesting, and fertilizer as well as information about the quantity and prices of sorghum produced by farmers are all collected from the respondents by using structured questionnaires. We utilize the questionnaire methodology, because it is a more efficient, effective and economical tool in terms of time and cost of collecting data.

The study uses a multistage sampling method, with 300 participants being drawn from Alego-Usonga Sub County to represent the research population. Alego-Usonga Sub County is selected purposefully due to its high poverty level and a substantial number of sorghum farmers in Siaya County. Within the sub-county, the participants are chosen using a simple random sampling method, which ensured that all farmers had an equal opportunity of being selected for the study. This approach is deemed appropriate as it eliminated any bias in the selection of respondents (Okeyo et al, 2020).

3.2. Methodology and the Model

The study simple focuses on Gross Margin Analysis and Ordinary Least Squares methodologies.

The Gross margin is the difference between total revenue and total variable cost. The algebraic expression of gross margins is represented as:

$$GM = TR - TVC \quad (1)$$

Where GM is Gross Margin, TVC is Total Variable Costs, and TR is Total Revenue which is generated by the product of prices and quantity. The TR is computed by the formula $P_i * Q_i$; where P_i is the price per quantity (kilogram) of sorghum produced, Q_i is the quantity of sorghum produced. The quantities used in this study included both the number of products

² Siaya County Spatial Plan 2018-2028. Available at <https://repository.kippra.or.ke/handle/123456789/2031>

sold, the amount of the produce consumed, and the amount used for other purposes such as donations to churches or relatives. In terms of the values of the gross margin, a positive gross margin value where $GM > 0$ would show that sorghum farming is profitable while a negative gross margin value, $GM < 0$ would imply that sorghum farming in Siaya county is not profitable. Finally, a gross margin value of zero, $GM = 0$, would mean that sorghum farmers in Siaya County merely break – even, and they neither make profits or losses.

On the other hand, the factors that influence gross margin are examined using the multiplicative regression model which is adapted from the Cobb-Douglas production model. The Cobb-Douglas production function is linearized by applying logs on both sides.

$$Y = \beta_0 \prod_{i=1}^n X_i^{\beta_i} e^{\lambda_1 Z_1 + \lambda_2 Z_2 + \lambda_3 Z_3 + u} \quad (2)$$

When you log linearize, the equation transforms to:

$$\ln Y = \ln \beta_0 + \beta_1 \ln X_1 + \beta_2 \ln X_2 + \beta_3 \ln X_3 + \beta_4 \ln X_4 + \beta_5 \ln X_5 + \lambda_1 Z_1 + \lambda_2 Z_2 + \lambda_3 Z_3 + \lambda_4 Z_4 + \mu \quad (3)$$

Here, Y is Gross Margin and $\ln \beta_0$ is an intercept of the model. The remainings are denoted as following: $X_1 =$ Household size, $X_2 =$ Area under sorghum in acres, $X_3 =$ Education level of household head, $X_4 =$ Number of crops grown, $X_5 =$ Household Income, $Z_1 =$ Access to credit, $Z_2 =$ Access to extension, $Z_3 =$ Nature of farming, and $Z_4 =$ Gender of household head and $\mu_i =$ error Term

4. Results and Discussion

4.1. Socioeconomic Attributes of the Respondents

Out of the 310 households, 176, representing 56.77% are male headed while 134, which is 43.23% are headed by females an indicator that decision making among sorghum producing households in Siaya County are male dominated with a reasonable voice of female gender. Also, our data shows that 35% of farmers are below 40 years while the rest are more than 40 years. The average age of farmers is 54 years old with the youngest being 28 and the oldest being 80 years. This shows that sorghum farming is dominated by older farmers. Younger farmers prefer to grow maize and other crops.

Most farmers have less than one acre of land under sorghum. The mean land size occupied by sorghum is found to be 0.7 acres out of an average land ownership of 2.4 acres. 72% of farmers have less than one acre of land under sorghum while only 27% have at least one acre under sorghum. This shows that scarcity of land in Siaya County limits

options available to farmers when allocating land to competing enterprises. Therefore deliberate efforts should be made to educate farmers on the special attributes of sorghum that will allow them to effectively utilize their land under difficult conditions to provision for their needs.

Our questionnaire data also documents that 82 % respondents have attained at least primary education, while those who have attained at least secondary education are 47 % respondents while only 57 respondents did not attain primary education. Overall, a higher percentage of the respondents have some basic education which points to a commendable literacy rating in the county which is critical when sorghum farmers are making farm decisions.

Access to extension and credit are important factors that influence the overall yields and profitability of most crops. However, based on the results from the research, 41.29% of respondents did not access extension services; this is a big hindrance to dissemination of technical packages to farmers. Results indicate that only 73 which represents 23.6% of farmers have accessed credit while the remaining 76.5% have not accessed credit facilities, which constraints farmers' ability to secure production inputs.

Table 1. A summary of Gross margin and key socioeconomic attributes of Farmers

Variable	Obs	Mean	Std. Dev.	Min	Max
Gross Margin per acre	310	4286.094	2898.295	-2700	24000
Household Size	310	4.174	2.132	1	10
Total Land Size	310	2.386	1.117	0.125	5
Sorghum Land (acres)	310	0.702	0.403	0	3
Household Age	310	54.223	14.452	28	80
Household Income	310	5319.516	2363.12	1800	16000
Number Intercropped	310	1.603	1.0916	0	3
Total Cost per acre	310	9600.387	701.049	7500	12000

4.2. Results of Gross Margin Analysis

The table below shows the gross margins, revenues and variable costs of sorghum.

Table 2. Sorghum Gross Margin per Acre Analysis

Revenue (Per Acre)	
Average kilograms per acre/season	405
Average Price per kg	35
Total Revenue	14, 175
Variable Costs (Per Acre)	
Land Preparation	2115
Planting	2000
Weeding	2054
Seeds	300
Fertilizer	600
Harvesting	1120
Threshing	1195
Transport	505
Storage	-
Total Variable Cost Per Acre/Season	9, 889
Average Gross Margin Per Acre/Season	4, 286

According to the results, the average gross margin for sorghum is Kshs. 4,286 which is positive. This shows that sorghum farming in Siaya County is profitable. The most profitable farm had a gross margin of Kenya shillings 24, 000 per acre while the farmer with the least profit farm had a negative gross margin (loss) of Kenya Shillings 2700. The results of this study are consistent with findings by Baiyegunhi and Fraser (2009) in three Villages of Kaduna State, Nigeria who found that sorghum production is profitable. This is also in line with Zalkuwi et al (2014) who find that sorghum farming in six states in India to be profitable. Farmers generally sale their sorghum to local traders and final consumers at an average price of Kenya shillings 35. Farmers realize an average yield of 405 kilograms (4.5 bags per acre).

4.3. Regression Results for Factors Affecting Sorghum Gross Margin

The table 3 below presents OLS regression estimates for Gross Margin per Acre of sorghum in Siaya County, Kenya. The R-square of this regression model is documented as 0.4106 where adjusted R-squared is estimated as 0.3868. This implies that nearly 41% of gross margin of sorghum in Siaya County, Kenya, is explained by our explanatory variables.

Table 3. Regression Results for factors affecting Sorghum Gross Margin

GM/Acre	Coef.	Std. Err.	T-stat.	P.value
Education Years	3.383	0.681	4.96	0.000***
Household Size	3.791	0.766	4.95	0.000***
Sorghum Land Size	0.811	0.309	2.63	0.009***
Number Intercropped	-0.937	0.563	-1.66	0.097*
Credit Access	0.166	0.377	0.44	0.661
Access to Extension	2.229	0.713	3.12	0.002***
Household Age	-1.312	0.541	-2.43	0.016**
Membership to Farmer Group	-0.365	0.513	-0.71	0.478
Nature of Farming	1.527	0.559	2.73	0.007***
Household Income	1.764	0.744	2.37	0.018**
Total Cost per acre	-2.292	2.081	-1.10	0.271
Household Gender	-0.022	0.516	-0.04	0.967
intercept	16.545	19.648	0.84	0.400

Note: The ***, **, * signify significance at 1%, 5%, 10% level of significance.

Moreover, the results show that household age negatively affects sorghum gross margin at 1% statistical significance level. It implies that a unit increase in age of the household head would trigger a decrease in gross margin by 1.3126 units. In other words, as farmers age, they become less receptive to new ideas, innovations and technologies thus lowering chances of improving sorghum productivity. These results are in line with findings by Meijer et al (2015) on the effect of age on agricultural perceptions and adaptation. Age also affects the perception of farmers towards good farming practices such as crop rotation and organic farming.

Second, years of education of household appears to have positive impact on gross margin of sorghum at 1% statistical significance level. It implies that a unit increase in the years of schooling will increase gross margin by 3.3826 units. Thus, farmers with higher levels of education are likely to accrue higher gross margins compared to those who have lower education levels. It might be due to fact that better literacy levels improve decision making ability.

Third, the results also show that size of household has positive and statistically significant impact on sorghum gross margin implying that a 1 unit increase in household size would elicit an increase in gross margin by 3.791 units. This is consistent with Hoque (2014) who finds the size of household is positively related to the yield and profitability of

various crop enterprises. Due to the readily available labor supply, households with more members are more likely to carry out farm activities such as land preparation, planting, and weeding at the right time and more conveniently compared to those with fewer members.

Fourth, the number of crops a farmer intercropped with sorghum has a negative impact on sorghum gross margin at 10% statistical significance level. This implies that increasing the number of intercrops with sorghum on the same farm reduces the gross margin from the crop by 0.94 units. The results show that farmers who have not intercropped sorghum with other crops have higher gross margins compared to those who have intercropped the crop. This urges education of farmers in desisting from non-objective intercropping of sorghum with crops which only compete with the sorghum crop for moisture and nutrients.

Fifth, access to extension services has positive impact on sorghum gross margin at significant 1% statistical significance level. This indicates that farmers who have received services from extension providers generate more profits from their farms. Such farmers are more likely to make 2.287 units of gross margins per acre of sorghum from a unit of extension services received. This confirms findings by Hoque (2014) that access to and valuable agricultural information have a positive effect on the gross margins of rice in Bangladesh. This might be due to the fact that farmers who have interacted with extension officers are found to be better equipped with good farm management practices.

Sixth, income is another vital factor when it comes to analysis of agricultural enterprises managed at the household level. This is because income reflects the ability of farmers to purchase various inputs used in the production process. In this respect, our results find that household income has positive impact on sorghum gross margin at 5% statistical significance level. This indicates that an increase in household income by one unit increases the gross margin by 1.764 units per acre. The findings of this study corresponds with the results of a study by Obiero (2011) which find a positive relationship between household income and the yields and profitability of various crops in Siaya County. Higher incomes reflect the ability and capacity of farmers to access inputs required in the production process at the appropriate time. As such, farmers with higher incomes affirm that they are more empowered to make important production choices, including the type of crop to grow.

Lastly, the nature of farming is conceptualized in terms of whether the farmer engages in mixed farming or not. A value of 1 reflects practicing of mixed farming while a value of 0 represents crop farming alone. In this respect, our results show that the nature of farming has positive influence on sorghum gross margin at 1% statistical significance level. This might be due to the fact that crops and animals enjoy symbiotic relationship where crops get sufficient supply of organic manure while animals feed from the fiber from

the crops. In short, those who practice mixed farming enjoy a cheap supply of ready manure which helps to raise the yield.

On the other hand, the total variable cost appears to be negative, but fails to be statistically significant. Some of the cost components that are summed to reflect total cost include cost of land preparation, seeds, fertilizer, planting, weeding, and harvesting. Likewise, credit access of households, their memberships to farmer groups, as well as their gender appear to be statistically insignificant factors on gross margin of sorghum in Siaya County, Kenya.

5. Conclusion

The paper examine the gross margin of sorghum production and associated factors affecting gross margin of the crop in Siaya County using questionnaire data from random 310 farmers who are located in Alego - Usonga Sub County in Siaya County. Profitability of sorghum is measured by gross margin analysis, and determinant of factors of profitability is examined by Ordinary Least Squares (OLS) methodology using a Cobb-Douglas model.

The study finds average gross margin of Ksh. 4,286 per acre which indicates that sorghum production is a profitable venture in Siaya County. Moreover, the study documents that education level of household head, household size, household income, age of sorghum farmers, nature of farming, size of sorghum farm, intercropping and access to extension have significant impact on the gross margins of sorghum. Therefore, the county government of Siaya, the national government, research institutions, seed companies, non-governmental organizations, and all other stakeholders should educate sorghum farmers, especially on the best farming practices that would improve yields and profitability of the crop.

The study finds that mixed farming had a positive relationship with gross margins; therefore, farmers should be encouraged to practice mixed cropping and use of organic manures to enhance the fertility of the soils and optimize on sorghum yields per acre. Our findings also suggest that farmers should increase size of farming land under sorghum to enable them benefit from economic of scale.

To maximize the profitability of sorghum farming in Siaya County, farmers should only intercrop sorghum with complementary leguminous crops like beans and cowpeas, as research has shown that the number of crops intercropped with sorghum has a negative impact on gross margins. This strategy will help increase yields and profitability while preserving the soil's fertility and carrying capacity. Improving and expanding the scale of extension services provided to farmers can also boost sorghum productivity, as research

has shown that there is a positive correlation between extension services and gross margins.

In addition, farmers should diversify their income sources by engaging in other enterprises like poultry and dairy farming, as well as other businesses to increase their household income levels. This diversification will enable farmers to invest in land preparation, planting, weeding, and other farm activities in a timely manner, which will increase income levels from sorghum. Ultimately, farmers should be encouraged to increase their scale of production and adopt modern farming methods to increase their yields and incomes, and improve the food security situation in Siaya County.

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References

- Akuno, W., Osika, N.O., Akhaukwa, P.J. & Muchele, F. (2015). Community based sorghum seed multiplication as a strategy for enhancing sorghum production for improved small holder incomes and livelihoods in Siaya County. Jaramogi Oginga Odinga University of Science and Technology official institutional repository. Retrieved from <http://62.24.102.115:8080/xmlui/handle/123456789/170>.
- Amusala, G., Nyangweso, P.M, Gudu, S., Mose, J.I., Inyanje, L. & Othieno, C.O. et al. (2012). Adoption of drought tolerant sorghum in Western Kenya. *AgEcon Search*, 87-98. DOI: 10.22004/ag.econ.159386
- Baiyegunhi, L.J. & Fraser, G.C. (2009). Profitability in sorghum production in Three Villages of Kaduna State, Nigeria. *Journal of Applied Research*, 5(10), pp. 1685-1691.
- Frederiksen, R.A., & Smith, C.W. (2000). *Sorghum: Origin, history, technology, and production*. New York: Wiley.

- Gebre, E., Workiye, A., and Haile, K. (2021). Determinants of sorghum crop commercialization the case of Southwest Ethiopia. *Heliyon*, 7(7). DOI: 10.1016/j.heliyon.2021.e07453.
- Hoque, M.Z., and Haque, M.E. (2014). Socio-economic Factors Influencing Profitability of Rice Seed Production in Selected Areas of Bangladesh. *The Agruculturists*, 12(1), pp. 33-40.
- Janssen, R., & Rutz, D. (2012). *Bioenergy for sustainable development in Africa*. Dordrecht: Springer
- Kange, A.M., Cheruiyot, E.K., Ogendo, J.O, & Arama, P.F. et al. (2014). Pre and Post harvest factors affecting sorghum production (sorghum bicolor L. Moench) among small holder farming communities. *International Journal of Agronomy and Agricultural Research*, 5(4), 40-47.
- Kilambya D., and Witwer M. (2013). Analysis of incentives and disincentives for Sorghum in Kenya. Technical notes series, MAFAP, FAO, Rome.
- Magino, H.N., Mugisha, J., Osiru, D.S. & Oruko, O.L. (2004). Profitability of sorghum–legume cropping practices among households in Eastern Uganda. *Uganda Journal of Agricultural Sciences*, 9, pp.688-692.
- Meijer, S.S., Catacutan, D., Ajayi, O.C., Sileshi, G.W., & Nieuwenhuis, M. (2015). The role of knowledge, attitudes and perceptions in the uptake of agricultural and agroforestry innovations among smallholder farmers in sub Saharan Africa. *International Journal of Agricultural Sustainability*, 13(1), 40-54.
- Mundia, C.W., Secchi, S., Akamani, K. & Wang, G. (2019). A regional comparison of factors affecting global sorghum production: The case of North America, Asia and Africa’s Sahel. *Sustainability*, 11, pp. 1-18.
- Njagi, T., Onyango, K., Kirimi, L. & Makau, J. (2019). Sorghum production in Kenya: Farm level characteristics, Constraints and Opportunities. Tegemeo Institute of Agricultural Policy and Development technical report. Retrieved from https://www.tegemeo.org/images/_tegemeo_institute/downloads/publications/technical_reports/tr34%20sorghum%20production%20in%20kenya%20of-arm-level%20characteristics,%20constraints%20and%20opportunities.pdf
- Nyataya. J. (2014). How I harvest 40 bags of maize per acre. Daily nation, February 28, 2014. Retrieved from <http://www.nation.co.ke/business/seedsofgold/How-I-harvest-40-bags-of-maize-per-acre/2301238-2226170-qhkflez/index.html>.

- Obiero, E.O. (2013). Socioeconomic factors affecting farm yields in Siaya District, Siaya County, Kenya. Master's thesis, University of Nairobi.
- Okeyo, S., Ndirangu, S.N., Isaboke, H., and Njeru, L.K. (2020). Determinants of sorghum productivity among small-scale farmers in Siaya County, Kenya. *African Journal of Agricultural Research*, 16(5), pp. 722-731.
- Sadiq, M.S., Singh, I.P., and Ahmad, M.M. (2020). Sorghum Food Security in Nigeria. *Journal of the Faculty of Agriculture*, 15(2), pp. 166-178.
- Semakula, D. (2022). Determinants of sorghum productivity by smallholder farmers in Uganda. Master Thesis, Makerere University.
- Zalkuwi, J, Singh, R., Bhattarai, M., Dayakar, B. & Singh, O.P. (2014). Profitability analysis of sorghum production in India. *International Journal of Commerce, Business, and Management*, 3(5), pp. 2319-2828.
- Zalkuwi, J., Sigh, R., Bhattarai, M., Sigh, O.P. & Dayakar, B. et al. (2015). Production cost and returns: Comparative analysis of sorghum in India and Nigeria. *Economics*, 4(2), pp. 18-21.