

## SOCIOECONOMIC CHARACTERISTICS OF SMALL-SCALE FARMERS AND SUSTAINABLE MAIZE PRODUCTION: EVIDENCE FROM THE SEMI-DECIDUOUS FOREST AND COASTAL SAVANNAH AGRO-ECOLOGICAL ZONES IN GHANA

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### Abstract

*Maize plays a crucial role as a staple cereal crop in Ghana, mainly grown by smallholder farmers who often face low yields. The study investigated the reasons behind low maize yields among smallholder farmers in Ghana's Semi-deciduous forest zone (SDFZ) and coastal savannah zone. It focused on identifying challenges and assessing factors affecting the adoption of sustainable farming practices. Researchers gathered data through focus group discussions, surveys (structured questionnaire) with 360 farmers, field observations during a transect walk and analysed the findings using SPSS version 20. The findings highlighted significant constraints faced by farmers in maize production, including widespread use of landraces (65% in the SDFZ and 26.7% in the CSZ), farmer saved seeds only (56.1% in the SDFZ and 45% in the CSZ), non-use of fertilisers (over 50% in either zone), climate variability (at least 33% of respondents ranked drought first in the SDFZ and poorly distributed rainfall first in the CSZ), lack of access to farming credit (on average, only 10% had access to credit), and unsuitable tenure arrangements (on average 33% of farmers were sharecroppers). The study emphasises the importance of grain quality in storage, consumer preferences as well as cooking attributes as being crucial for the acceptance of new maize varieties. It recommends supporting smallholder farmers by assisting them to establish cooperative associations to facilitate easier access to credit and inputs, and improve output prices to expedite new technology. Decision-makers should provide a policy framework that enhances land ownership, or leasing terms. The fertiliser subsidy programme should be revived. Additionally, extension workers should be resourced to reach a greater number of farmers; researchers should investigate the perception of inferior taste and poor storage quality associated with improved maize varieties and proffer solutions for enhanced acceptability.*

### Introduction

Maize is a vital staple cereal that serves as a key source of energy and supports the livelihoods of people around the globe. Many smallholder farmers and agricultural workers rely on maize cultivation for their income (Tanumihardjo et al., 2020). In Ghana, maize is increasingly recognized as an important economic crop, providing essential food and cash for farming families. Approximately 70% of the total maize produced in the country is cultivated by smallholder farmers, contributing over 20% to their incomes (Acquah and Kyei, 2012; MOFA, 2013). This makes maize one of the essential crops in Ghana's agricultural sector and crucial for food security, especially for smallholder farmers. In 2015, an estimated net consumption of 1,285,335 metric tons of maize was recorded (MOFA, 2016), with around 1,000,000 metric tons marketed annually in Ghana (Darfour and Rosentrater, 2016). Therefore, improving maize productivity could boost food self-reliance, particularly within rural communities across various agro-ecological zones.

However, maize production systems face several challenges, including climate variability (Mumo et al., 2018; Shi and Tao,

2014), declining soil fertility, land ownership challenges and low utilisation of vital inputs such as improved seeds and fertilisers (Agyare et al., 2014). These factors contribute to low yields, despite the significance of maize in the Ghanaian economy. The shortfall in local maize production for human consumption, livestock, and poultry feedstuff is often mitigated by importations (Codjoe, 2007; FAO, 2013; Gage et al., 2012). One major cause of soil nutrient depletion on smallholder farms is the continuous cultivation of the same land without replenishing its nutrients, leading to declining soil fertility. Additionally, local maize landraces have been reported to yield significantly less than improved varieties (Ewool et al., 2016; Kpotor, 2012; Marfo-Ahenkora et al., 2025). Consequently, it is crucial to enhance smallholder productivity by implementing sustainable approaches such as use of improved maize germplasm, effective Soil nutrient management, and better crop management strategies. The incorporation of manure and/or mineral fertilisers has been shown to maintain soil productivity and significantly improve maize yields (Quansah, 2010; Uwah and Eyo, 2014; Zingore, 2011). However, excessive application of fertiliser and not

adhering to the recommended rates could be detrimental to the soil thereby compromising soil health. The substitution of landraces with advanced open-pollinated varieties (OPVs) has largely resulted in a 100% increase in global grain yields (Pixley et al., 2009). In Ghana specifically, Kpotor (2012), has reported that improved OPVs can yield 32% to 45% more than landraces.

Saidou et al. (2004) emphasised the importance of understanding the socioeconomic factors that influence smallholder farming systems when developing agricultural technology. This understanding is essential for incorporating local realities into the development and dissemination of technology. Thus, it is vital to analyse the constraints faced by smallholder farmers to better comprehend their perspectives (Roling et al., 2004) and to explore why certain proven recommendations for maize production are often not implemented. Numerous studies have examined the factors influencing the adoption of agricultural practices or technologies for sustainable maize production (Acevedo-Siaca and Goldsmith, 2020; Ehiakpor et al., 2021; Martey et al., 2021; Mensah-Bonsu et al., 2011; Ragasa et al., 2013). However, the adoption of these technologies can vary by location (Baiyegunhi et al., 2019; Kassie et al., 2015; Sinyolo, 2020), as key factors, including socioeconomic characteristics and resource endowments, differ across districts and regions. The goal was to ascertain factors influencing sustainable maize production in Ghana. The specific objectives of the study were:

1. To ascertain the socio-economic and socio-cultural traits of smallholder maize producers as well as their input use and practices in the Coastal savannah and Semi-deciduous forest agro-ecological zones of Ghana.
2. To analyze the relationship between farmers' socioeconomic characteristics and the adoption of new technology in maize farming systems.
3. To explore the relationship between technical and biophysical factors and maize productivity.

### Conceptual Framework

Sustainable maize production entails the creation of a production system such that productivity and profitability are high but has minimum negative impact on the environment and society. It can be conjectured that sustainable maize production is directly dependent on socioeconomic, biophysical and technical factors. At the same time socioeconomic variables indirectly influence sustainable maize production through their influence on technical and biophysical factors. The socioeconomic factors include age, gender, household size, land tenure arrangements, credit, income and wealth of farmers. The biophysical factors include maize seeds, climate, and geography which may be reflected in the soils, rainfall amounts and distribution, temperature, pest and diseases found in an area. The technical factors include inorganic fertiliser, manure, and cultural practices such as row planting, crop rotation and weed control.

The key elements of sustainable production, profitability, and

productivity could be influenced specifically by land tenure systems, credit, and gender and therefore generally by socioeconomic factors. Similarly, profitability and productivity could be influenced by technical factors including fertiliser use and cultural practices. To the extent that socioeconomic factors influence the use of productivity enhancing inputs and practices, we can deduce that they also indirectly influence sustainable maize production.

In this study the farmers' socioeconomic characteristics, input use and practices are described. Also, complementarities in the use of inputs such as fertiliser and practices such as row planting are explored. Next, the association between socioeconomic factors and biophysical, technical and maize productivity are investigated. Farmers' perception of the influence of climate variables, and other broad factors on maize production and productivity are assessed.

## Materials and Methods

### Study Areas

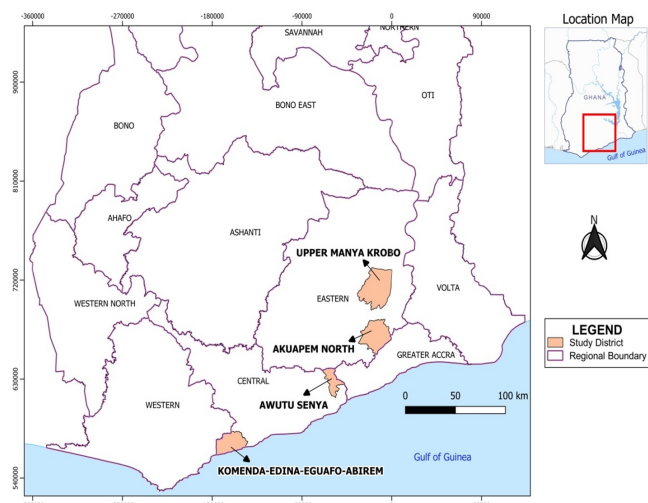
This study was carried out in the Coastal Savannah Agro-ecological Zone (CSZ) - parts of the Central Region and the Semi-Deciduous Forest Agro-ecological Zone (SDFZ) parts of the Eastern Region, Ghana. Two districts were selected from the Central Region: Awutu Senya (-5°20'N, 5°42'N, -0°25'W 0°37'W) and Komenda-Edina-Eguafo-Abirem (-5° 05' N, 5° 15' N, -1° 20' W, 1° 40' W). Two districts were also chosen from the Eastern region: Upper Manya Krobo (-6.2 - 6.5°N, -0.3 - 0.0° W) and Akuapem North Municipal (-5° 51' 6° 10' N, -0° 00' E and 0° 20' E). Figure 1 displays a Ghana map showing the study districts.

Three settlements were selected from each district. The study area all of which were farming communities primarily comprised smallholder farmers. Table 1 shows the districts, their 3 selected communities, Global positioning system (GPS) and elevation of the study sites. All chosen districts experience a bimodal precipitation pattern. Typically, the primary rainy season commences in April and concludes in July, followed by a brief dry period in August. The secondary rainy season begins in September and completes in November. The districts undergo an extended dry period from December to February, occasionally stretching into March. The Eastern Region experiences average yearly precipitation of 900 to 1500 mm, while the Central region's rainfall varies from 500 to 1200 mm annually. Mean temperatures in both regions are generally similar, ranging from 21°C to 32°C.

There are variations in soil types across the two regions. Soils in the two districts within the SDFZ mainly consist of Dystric Fluvisols, Cambic Arenosols, Humic Acrisols, and Umbric Leptosols. In the two districts of the CSZ, the predominant soil types include Dystric Leptosols, Haplic Lixisols, Ferric Lixisols, and Ferric Acrisols. These soils were characterized by the CSIR-Soil Research Institute at the Accra centre, using the FAO soil classification system.

**Table 1.** The Districts, Communities, Global positioning system and Elevation of the study areas

Agro-ecological zone	District	Community	Location (GPS)	Elevation (m)
Semi-deciduous forest zone	Akwapim North Municipal	Mankrado/Otareso	6°0'29.9"N, 0°8'87.7"W	190
		Okyerekrom	6°3'91.6"N, 0°8'43.6"W	285
	Upper Manya Krobo	Ahenkorase	5°56'39.9"N, 0°12'77.0"W	271
		Akateng Manya	6°30'10.2"N, 0°8'36.5"W	93
		Dzomoa	6°20'56.4"N, 0°8'35.3"W	338
Coastal savannah zone	Awutu Senya	Mensah Dawa	6°19'11.4"N, 0°7'53.1"W	229
		Awutu Bontrase	5°35'5.2"N, 0°33'27.6"W	141
		Akufful Krodua	5°42'30.3"N, 0°31'3"W	115
	Komenda-Edina-Eguafo-Abirem Municipal	Awutu Ofaso	5°42'55.7"N, 0°33'30.7"W	139
		Eguafo	5°9'40.1"N, 0°21'42.7"W	72
		Kissi	5°5'45.1"N, 1°31'7.8"W	31
Abirem Agona	5°11'17.8"N, 1°25'39.8"W	73		

**Figure 1.** Portions of the Ghana map illustrating the study sites.

## Sampling, Data Collection and Data Analysis

### Sampling procedure

A multistage sampling method was used to choose the project sites. In the first phase, two regions were purposively selected: one in the semi-deciduous agro-ecological zone and the other in the coastal savannah zone. In the second stage, two districts notable for maize cultivation were chosen from each region. In the third stage, three communities were chosen at random from each of the four districts, resulting in a total of 12 communities from the chosen districts in the two agro-ecological zones (AEZ).

Next, a sampling frame was obtained for maize farmers in each selected community across the districts: Upper Manya Krobo, Akuapem North, Awutu Senya, and Komenda-Edina-Eguafo-Abirem in the semi-deciduous agro-ecological zone of the Eastern Region, and in the coastal savannah zone of the Central Region respectively. Farmers who cultivated maize as a mono-crop in addition to their intercrops were purposively chosen with the assistance of Agricultural Extension Agents (AEAs). Finally, an approach using simple random sampling was employed to select thirty (30) farmers within each of the project communities.

### Data collection

The Participatory Rural Appraisal (PRA) technique was utilized to identify community challenges, and specific commodity-related issues, and to understand the community-level economics and cultural dimensions within the community. A comprehensive approach was taken in data collection, integrating both qualitative and quantitative methods. Qualitative data were gathered using Focus Group Discussions (FGDs) conducted with semi-structured interview guidelines, whereas quantitative data were gathered by means of a structured survey tool. Furthermore, additional qualitative insights were gathered through transect walks within the communities and visits to selected farms.

### Focus Group Discussions (FGD)

Semi-structured interview protocols were crafted to facilitate the data gathering for the focus group discussions. The FGD took place before the structured survey (questionnaire administration) and was instrumental in developing the systematic questionnaire for the subsequent phase of the study. Executed over the months of July and August 2015, the FGD involved chosen research locations and had an estimated 11 farmers participating in each group. Agricultural Extension Agents (AEAs) responsible for the operational areas facilitated the engagement of small-scale maize producers for the deliberations. Every cluster comprised both male and female participants, along with community influencers and community insight providers.

During the discussions, farmers addressed variety of topics, covering land ownership systems, maize varietal options, soil enhancement strategies, produce marketing and storing solutions, agricultural inputs applied, access to financing options, and the roles of men and women in maize cultivation within their localities. The focus group discussion additionally sought to gather insights on major challenges in production, economic and social dynamics, farm organization and strategies for managing maize cultivation. Twelve (12) focus group discussions were held (one in each community). The number of males and females were almost equal at each group discussion. With farmers' consent, audio files of all proceedings were made, alongside written notes taken in field notebooks.

### Survey (Structured Questionnaire Administration)

The sample frame was made up of some maize farmers in the selected districts (Upper Manya Krobo, Akuapem North, Awutu Senya, and Komenda-Edina-Eguafo-Abirem) in the semi-deciduous agro-ecological zone of the Eastern region and the coastal savannah zone in the Central region. Farmers cultivating maize in a mono-crop alongside their intercrops were deliberately chosen with the assistance of Agricultural Extension Agents (AEAs). Subsequently, a random sampling technique was employed to select 30 (thirty) individuals from each of the research communities.

A survey was carried out to assess farmers' socio-economic and cultural profiles, agronomic practices, access to agricultural inputs, resource allocation, access to extension and biophysical features including climatic factors influencing maize cultivation using a systematically structured questionnaire. Evidence on farmers' use of improved maize varieties was also collected.

Enumerators, primarily Agricultural Extension Agents, were coached to conduct the survey. The questionnaire was piloted in both the SDFZ and CSZ regions on individuals and communities not included in the main study but closely resembling the target respondents in terms of geographic location, socio-economic background, and cultural attributes. A finalized questionnaire was developed after addressing all issues identified during the pre-testing phase. This finalized survey was then carried out with thirty farmers from the 12 communities during the months of September and October 2015. A total of 360 maize farmers participated in the interviews; 180 farmers from each of the agro-ecological zone.

### Data Analysis

The feedback from the FGD (focus group discussions) was included in the results and discussion section. The principal data gathered from the 360 participants were evaluated and through descriptive statistical methods such as frequency tables, percentage breakdowns, averages and visual representations like graphs as well as inferential techniques, including Chi-square analysis. Data processing and statistical evaluation were performed using IBM SPSS software, version 20.

## Results and Discussion

### Questionnaire Return Rate and results of Focus Group Discussions (FGD)

The results of the study are based on data collected from 360 maize farmers from the Coastal savannah agro-ecological zone and the semi-deciduous forest zone. Equal number of farmers were randomly selected from each of the zones. All respondents contacted answered the questionnaires. Results from the survey are augmented with findings from the Focus Group Discussions during which participants discussed their challenges and opportunities.

### Socioeconomic Characteristics of Farmers

Sixty percent of all respondents were males and the rest females. More males were sampled in the SDFZ (64%) than in the CSZ (56%) (Table 2). The male dominance in maize farming observed in this study aligns with findings from [Ankrah et al. \(2020\)](#). This predominance of males in both agro-ecological zones may be attributed to the perception that farming is primarily a men's job in many agricultural communities. However, during Focus Group Discussions (FGDs), it was noted that women played significant roles by assisting with pre-harvest, harvesting, and post-harvest activities. Similarly, a report from Kenya indicated that although there are more men maize farmers, women contribute the greater portion of labour ([World Bank, 2006](#)). However, ([Hauwa et al., 2022](#)) found that women provided the most labour (72%) for planting or sowing in maize production in the case of Nigeria. Furthermore, it has been observed that Ghanaian women ([Morris et al., 1999](#)) account for a substantial portion of the overall labour needed on farms and have full control over the disposal of the harvest. The FGDs conducted in this study further confirmed the significant contributions of women in maize production. [Palacios-Lopez et al. \(2017\)](#) noted that female labour share in Sub-Saharan Africa was 40 percent with no significant variations across crops but with some variations across countries.

The observed male dominance in maize farming within both agro-ecological zones may also be linked to the land inheritance systems present in the communities studied. [Acheampong et al. \(2019\)](#) reported similar findings in the Atebubu-Amantin district and Techiman municipal area, stating that men's prominence in farming was often due to women's limited ownership of farmland, as land was typically bequeathed to males. [Ankrah et al. \(2020\)](#), however, noted that while women did own land, men tended to be the primary users, which may explain the male dominance in maize farming in this area.

The majority of respondents in both agro-ecological zones fell within the age range of 41 to 60 years, comprising 55.6% of those in the SDFZ and 52.3% in the CSZ (Table 2). A small percentage of respondents, only 6% in the SDFZ and 11.5% in the CSZ were aged 21 to 30 years. Additionally, respondents over the age of 60 accounted for 16.7% in the SDFZ and 15.6% in the CSZ. These results indicate that young farmers (ages 21-30) are underrepresented among the maize farmers interviewed compared to the other age groups (Table 2). This trend suggests that fewer young individuals, who are typically more energetic, are engaged in maize production in the surveyed locations, which could have implications for sustainable maize farming. Having fewer young people in maize production may lead to less willingness to experiment with new technologies and a shortage of labour and energy for farming operations. Additionally, young individuals often face difficulties in adopting technologies that require significant initial capital, as they may lack the necessary resources ([Akudugu, 2012](#)). This is also corroborated by [Ankrah et al.](#)

**Table 2.** Farmers Demographic characteristics of farmers in the study locations

Item	Agro-Ecological Zone		All (N=360)
	SDFZ (N=180)	CSZ (N=180)	
<b>Sex of farmer (%)</b>			
Male	63.9	55.6	59.75
Female	36.1	44.4	40.25
<b>Educational Level (%)</b>			
Primary/JHS	65.5	71.1	68.3
Secondary	8.9	10.6	9.75
No formal education	25.6	18.3	21.95
<b>Age group (%)</b>			
21–30	6.0	11.5	8.75
31–40	21.7	20.6	21.15
41–50	26.7	30.6	28.65
51–60	28.9	21.7	25.3
Above 60	16.7	15.6	16.15
<b>Household size (count)</b>			
1–5	58	70	64
6–10	88	101	94.5
11 and above	34	9	21.5
<b>Marital status (count)</b>			
Single	10	16	13
Married	137	135	136
Divorced	10	16	13
Widowed	21	12	16.5
Separated	2	1	1.5
<b>Experience in maize farming (%)</b>			
1–5	7.8	11.1	9.45
6–10	16.1	17.2	16.65
11–15	2.2	6.7	4.45
Above 15	73.9	65.0	69.45

Field Survey (2015)

(2020) who observed that credit constraint is eased as age increases. Yet, younger farmers are more risk-loving and more enthusiastic about trying modern technologies Mwangi and Kariuki (2015). As farmers age, they tend to reduce their workload or even cease farming altogether, which contributes to the relatively low percentage of farmers aged 60 and above (Table 1). Older farmers are often set in their ways and may be reluctant to try new technologies. Furthermore, with years of experience, older farmers might find it challenging to abandon established practices for newer methods. Simtowe (2006) made similar observations by noting that as farmers' age, they may become more hesitant to alter their farming patterns and adopt new agricultural practices or technologies which agrees with findings from Huang et al. (2020). In contrast, younger farmers are characteristically less risk-averse and are keener to try modern technologies (Mwangi, 2015). Similarly, Sappamrer and Thammachai (2021) found that younger people were more likely to adopt organic farming.

Education is generally believed to foster a positive attitude

towards the acceptance of new practices. Most respondents had only basic education, accounting for 65.6% in the SDFZ and 71.1% in the CSZ. Only 8.8% in the SDFZ and 10.6% in the CSZ reported having completed secondary education, while a little over one-fourth and about one-fifth of farmers in the SDFZ and CSZ, respectively, had never attended school (Table 2). The preponderance of respondents with low education (primary or JHS) or no formal education (leading to low literacy levels) in these study areas could hinder agricultural productivity, as such farmers may struggle to understand and adopt innovations in agriculture.

Most interviewed farmers had been engaged in farming for over 15 years: 73.9% in the SDFZ and 65% in the CSZ. About 16.1% in the SDFZ and 17.2% in the CSZ had farmed for 6 to 10 years, while relatively few farmers (7.8% in the SDFZ and 11.1% in the CSZ) had been farming for 1 to 5 years (Table 2). The majority of farmers did not use soil amendments (fertiliser and manure) and improved systems like crop rotation although they have substantial experience in maize

**Table 3.** Farm Characteristics

Characteristics	Agro-Ecological Zone		Average
	SDFZ (N=180)	CSZ (N=180)	
<b>Total maize holding (hectares, %)</b>			
0.2–0.81	33.3	49.4	41.35
0.82–1.62	38.3	41.1	39.7
1.63–2.43	20.0	7.2	13.6
> 2.43	8.3	2.2	5.25
<b>Land Tenure System (count, %)</b>			
Family	40 (22.2)	57 (31.7)	48.5 (27.0)
Sharecropping	78 (43.3)	36 (20.0)	57 (31.7)
Lease/hiring	21 (11.7)	71 (39.4)	46 (25.5)
Own land	41 (22.8)	16 (8.9)	28.5 (15.8)
<b>Row planting (count, %)</b>			
Yes	136 (75.6)	137 (76.0)	136.5 (75.8)
No	44 (24.4)	43 (24.0)	43.5 (24.2)
<b>Fertilizer application (count, %)</b>			
Yes	85 (47.2)	81 (45.0)	83 (46.1)
No	95 (52.8)	99 (55.0)	97 (53.9)
<b>Fertilizer use per hectare (count, %)</b>			
	N=85	N=81	Total N=166
61.8 kg	62 (72.9)	13 (16.0)	37.5 (44.4)
123.5 kg	18 (21.2)	44 (54.3)	31 (37.7)
185.3 kg	0 (0.0)	3 (3.7)	1.5 (1.9)
247.1 kg	5 (5.9)	21 (26.0)	13 (16.0)
<b>Manure Use (count, %)</b>			
Yes	11 (6.1)	8 (4.4)	10 (5.3)
No	169 (93.9)	172 (95.6)	170 (94.8)
<b>Crop rotation (count, %)</b>			
Yes	32 (17.8)	29 (16.1)	30.5 (17.0)
No	148 (82.2)	151 (83.9)	149.5 (83.0)
<b>Access to credit facilities (count, %)</b>			
Yes	21 (11.7)	15 (8.3)	18 (10.0)
No	159 (88.3)	165 (91.7)	162 (90.0)
<b>Access to extension services (%)</b>			
Yes	81.1	76.7	78.9
No	18.9	23.3	21.1

Source: Field Survey (2015)

production (Table 3).

Notwithstanding their long years in farming, the low literacy levels of farmers pose a challenge. Consequently, most farmers may struggle to understand, implement modern farming systems, and take up new technologies capable of improving yields, as supported by Klutse et al. (2013).

The average household size in both agro-ecological zones ranged between 6 to 10 people, with a total of 272 farmers being married. According to Ghana Statistical Service (2021), the average household size for Ghana is 3.6; this is lower than the current finding.

The majority of respondents in SDFZ (88%) did not have

access to credit. Similarly, the vast majority of respondents in CSZ (92%) did not have access to credit (Table 3). This lack of access to credit may be linked to lower production levels, as suggested by Gaisina (2010). Moreover, education was not significantly associated with access to credit, not even at the 10 percent significance level for either zone.

#### Technical Characteristics Related to the Farm

Table 3 presents farm characteristics in the study locations. In the SDFZ, 71.6% of respondents had maize holdings ranging from 0.20 to 1.62 hectares. In contrast, 90.5% of respondents in the CSZ reported similar maize holding sizes. Only 8.3%

of respondents in the SDFZ and 2.2% in the CSZ had maize farms larger than 2.43 hectares. This low percentage of larger maize farms, particularly in the CSZ, may be attributed to the fact that the majority (71%) of farmers in that zone acquired land through leasing or hiring (see Table 3). The cost of leasing land may be prohibitive for smallholder farmers, leading them to possibly opt for smaller farm sizes that they can afford to rent.

Respondents have small land sizes; less than 2 hectares which is the national average (MOFA, 2017). This is likely to reduce farmers' productivity as observed by Huang et al. (2020) who attributed the negative effect on productivity to challenges faced by small holders in accessing credit; a situation reflected in this study (Table 3).

In the SDFZ, about 43.3% of respondents were sharecroppers, defined as farmers who share their produce with the landowner according to an agreed percentage. Additionally, 11.7% of the 180 respondents in the SDFZ held leasehold or rented land, while 22.2% farmed on family land, and 22.8% farmed on their land (see Table 3). In the CSZ, a different scenario was observed: 39.4% of respondents had leaseholds, while only 8.9% farmed on their land, 20% were sharecroppers, and 31.7% farmed on family land.

The land tenure systems in an area can significantly affect soil fertility management. Adjei-Nsiah (2006) highlighted a connection between tenure insecurity, particularly among migrant farmers, and a lack of focus on soil fertility regeneration. In the Wenchi district, for instance, tenant farmers began heavily cultivating the land without implementing adequate soil fertility restoration measures because they wanted to maximize current returns without regard for the future. Similarly Donkor et al. (2023) observed that land tenure security promoted the use production inputs including fertilisers in cocoa production in Ghana.

The majority of respondents, 76 percent in both agro-ecological zones, practiced row planting. However, most of them used wider spacing than is advised. They attributed the use of wider planting distances to low soil fertility and considered the practice a way of going round the challenge of low soil fertility. This aligns with the observation made by Buah et al. (2009), who noted that farmers traditionally adopt low plant densities as a means to adapt to low soil fertility and moisture, as well as to minimize risk during drought conditions.

Ragasa et al. (2013) corroborates the finding that majority of farmers engaged in row planting. In their study a little over one half of the respondents planted in rows. However, the planting distance and number of seeds per hill used by farmers often deviated from research and extension recommendations. In contrast, Afful (2015) found that 82% of respondents sowed randomly, highlighting a divergence with the current findings. The significant relationship between row planting and fertilizer usage observed in this study may be attributed to the fact that row planting facilitates easier farm operations, including the application of fertilizers (Table 3). Tripp et al. (1987) also reported that planting maize in rows simplified the appli-

cation of the correct amount of fertilizer and is more likely to be associated with fertilizer use, which aligned with the observations made in the current study. Dinku and Beyene (2019) also noted that row planting is influenced by the use of improved seeds. This indicates that some row planting goes together with the use of improved seeds and fertilizers.

The application of fertilizer by respondents within the last five years is summarized in Table 3. A majority of respondents reported that they had not used fertilizer at all during this period, with 52.8% from the SDFZ and 55% from the CSZ indicating no usage. Yawson et al. (2010) noted low fertilizer usage in parts of the Central region of Ghana and concluded that factors such as small-scale production, a lack of marketing structures for farmers, and high transportation costs to remote areas contributed to this trend.

For those respondents who had applied fertilizer, they were asked to specify the quantity used per acre, which was then converted to a per-hectare basis in Table 3. In this study, a fifty-kilogram (50 kg) bag of inorganic fertilizer was referred to as one bag. The amounts of fertilizer used varied among respondents in the two study locations. While over 73 percent of farmers applied fertilizer at about 62kg ha<sup>-1</sup> (approximately one and a quarter bag per acre) in the SDFZ, about 54 percent of farmers applied about 124 kg ha<sup>-1</sup> (equivalent to one bag per acre). A few farmers in the SDFZ (5.9%) used 247.1 kg ha<sup>-1</sup> (two bags per acre), whereas in the CSZ, 26% of respondents applied the same amount.

The observation that respondents from the CSZ used significantly higher quantities of fertilizer per unit area than those in the SDFZ aligns with findings from Ragasa et al. (2013), which indicated limited fertilizer use in the forest zone compared to the CSZ, citing the relatively fertile lands in the forest zone as a contributing factor. The generally low usage of fertilizer across the agro-ecological zones (AEZs) has important implications for sustainable maize production. The recommended fertilizer application rate for maize farms in Ghana is 250 kg ha<sup>-1</sup> (Ragasa et al., 2013); cited by (Kankam-Boadu et al., 2018). Farmers' inability to purchase mineral fertilizer and failure to apply them at recommended rates when they are able to acquire some fertilizer, was observed by Mugwe et al. (2009). Although the rates of fertilizer application observed in this study are insufficient, they significantly exceed the average rate of 7.4 kg per hectare on croplands in Ghana (Benin et al., 2013).

The adoption of row planting may make operations such as fertilizer application easier and could explain why row planting is significantly associated with fertilizer application (Table 4). Additionally, the application of the right amount of fertilizer is made Tripp et al. (1987).

In both the SDFZ and CSZ, more than 90 percent of respondents did not use manure. This finding agrees with (Ragasa et al., 2013). They found that manure was used on less than 5 percent of land on which maize was growing. However, Mensah-Bonsu et al. (2011) noted that 17% of farmers interviewed in central Ghana applied animal manure, a signifi-

**Table 4.** Relationship between row planting and fertilizer use

	Practice	Fertilizer use		Total per ecozone	Chi square value	P value
	Row planting	Yes	No			
SDFZ	Yes	74	62	136	$\chi^2 = 11.537$	P = 0.001
	No	11	33	44		
CSZ	Yes	76	61	137	$\chi^2 = 25.422$	P = 0.001
	No	5	38	43		

Source: Field Survey (2015)

**Table 5.** Maize varieties cultivated by the respondents in both SDFZ and CSZ

Maize variety	Semi-deciduous zone		Coastal savannah zone	
	Frequency	Percentage	Frequency	Percentage
Obatanpa	38	21.1	35	19.4
Local white	98	54.4	47	26.1
Local white & Obatanpa	18	10.0	59	32.8
Local yellow & Obatanpa	2	1.1	5	2.8
Golden Crystal & Obatanpa	2	1.1	19	10.6
Local (white & yellow)	19	10.6	1	0.6
Obatanpa, Local white & Golden Crystal	3	1.7	14	7.8

Source: Field Survey (2015)

cantly higher percentage compared to this study and [Ragasa et al. \(2013\)](#). Despite keeping livestock, it was evident from the focus group discussions (FGDs) that farmers in these communities did not utilize farmyard manure for crop production. The practice of composting manure for maize production in these communities holds great potential. The prevailing practice of continuous cropping, coupled with limited adoption of soil fertility management methods reduces soil fertility considerably. Discussions with farmers in the study locations indicated that not much effort was made to improve soil fertility.

More than three quarters of respondents in the two zones had access to extension services (Table 3). Although these figures show relatively high access to extension, respondents noted that visits from extension staff were infrequent, which affected productivity. Frequent access to extension services is known to positively influence adoption of new technologies. [Addai \(2011\)](#) reported that regular farmer contacts with extension agents facilitated the adoption of modern technologies. [Yaron et al. \(1992\)](#) also reported that access to extension services was critical in promoting adoption of modern agricultural production technologies. Also, [Anang et al. \(2020\)](#) found that access to extension had positive impact on adoption and income.

A cross tabulation of education and extension services showed that the two variables were not significantly associated in either of the two agro-ecological zones. Education is not significantly correlated with access to extension services probably because most respondents had low education.

## Biophysical characteristics

### Varieties of maize planted

Table 5 presents the proportion of respondents growing different maize varieties. In the SDFZ, 21.1% of respondents exclusively planted Obatanpa, while in the CSZ, this figure was 19.4%. The variety of maize planted most was local white, predominantly 'Ahomatea' and Owifonpe, while more than half of all respondents in the SDFZ planted the local white, just about half that proportion (26%) planted it in CSZ. The most widely grown maize types were Obatanpa and different types of local varieties with white colour. They were grown on their own or together with other maize types in the two agro-ecological zones (Table 5).

Overall, Obatanpa was the preferred improved variety in both zones. The preference for Obatanpa among improved maize varieties in the two zones agrees with ([Ragasa et al., 2013](#)) who found that Obatanpa remained the dominant improved variety in Ghana although many new varieties were released long after Obatanpa had been released. They suggested that the continued dominance of Obatanpa among farmers may be because of little information on newer varieties and decreased dissemination efforts.

Additionally, the prevalence of local maize varieties (both white and yellow) among farmers in the SDFZ and CSZ was also noted by [Odeno et al. \(2001\)](#). They noted that in Africa, local maize was popular and used by four-fifths of farmers, because they could be recycled for many seasons. [Almekinders et al. \(2021\)](#) observed that in West Kenya both local and improved varieties were used and this depended on cash availability in addition to other factors.

Despite the release of newly improved maize varieties, many

**Table 6.** Maize varieties cultivated by the respondents in both SDFZ and CSZ

Seed Source	Semi-deciduous zone		Coastal savannah zone	
	Frequency	Percentage	Frequency	Percentage
Own farm (FSS)	101	56.1	81	45
Own farm, family & friends	24	13.3	12	6.7
Certified Seed Growers/ Agro-input shops	35	19.5	48	26.7
Own farm, Certified Seed Growers/ Agro shops	20	11.1	39	21.6

Source: Field Survey (2015)

farmers in the study areas still favoured their local varieties, even though these typically yield less Kpotor (2012). This preference raises concerns about sustainable maize production. During the focus group discussions, some farmers expressed concerns that certain improved maize varieties, referred to locally as "agric aburo", do not store well over time. Furthermore, they reported that the cooking qualities of "agric aburo" were often subpar, with some varieties containing more fibre than usual, and that market demand for these varieties was lacking. These factors have been identified as critical for both the acceptance and long-term use of new maize varieties.

### Sources of seed maize

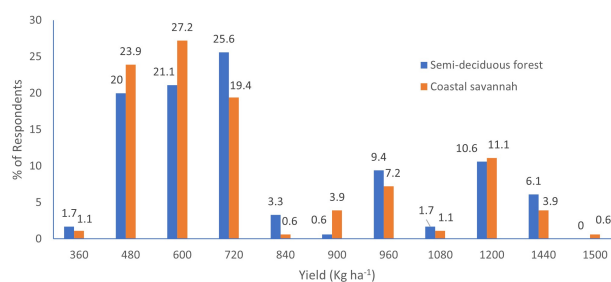
Table 6 presents the sources of seeds used by respondents. More than one half the number of farmers in SDFZ and slightly less than one-half in the CSZ indicated that they relied on materials saved from their farms for planting in the following season. These materials may be referred to as farmer saved seeds (FSS). In addition to farmer saved seeds, some farms got seeds from family and friends.

The predominance of farmer saved seeds in the study areas is considered detrimental to productivity. Farmer saved seeds comprised both local and improved varieties such as Obatanpa. The original Obatanpa germplasm is most likely contaminated, as the focus group discussions revealed that farmers have been recycling their maize seeds for several years. According to (Ragasa et al., 2013), Open Pollinated Varieties (OPVs) should ideally be used for no more than three cropping seasons before new seeds are obtained; unfortunately, this was not the case in the study areas.

About one-fifth and one-fourth of respondents obtained their seed supplies from seed growers and agro-input sellers. Yet, it is difficult to vouch for the quality of Obatanpa seeds sold in agro-input shops since there is no effective system in place for seed regulation and the seed sector in Ghana is poorly managed (Tahirou et al., 2009). According to Alhassan (2004) only 10% of seeds used by Ghanaian farmers were certified seeds produced in the formal sector, while the informal sector provides the rest. Many farmers are unable to buy certified seeds because of the cost (Tahirou et al., 2009). This situation is worsened by inaccessibility of fertilizer which must be used with improved seeds for best results (Tahirou et al., 2009). Aidoo et al. (2014) observed higher usage of certified seed by farmers (27%) in the Ejura-Sekyeredumasi Municipality.

### Maize Yields

Approximately 25.6% of farmers in the SDFZ reported a yield of 720 kg ha<sup>-1</sup> (Figure 2) compared to the 600 kg ha<sup>-1</sup> obtained in CSZ by about the same proportion of farmers (27%). The highest yield obtained in the SDFZ and CSZ were 1,440 kg ha<sup>-1</sup>, 1,500 kg ha<sup>-1</sup> respectively. However, these were achieved by only a small percentage of farmers, 6.1% in the SDFZ and 0.6% in the CSZ (Figure 2).



**Figure 2.** Estimates of grain yield (kg ha<sup>-1</sup>) realized by the respondents. Source: Field survey (2015)

Grain yields were substantially low among most respondents in the study areas. One possible reason for these low yields could be the reliance on farmer-saved seeds (FSS). The continuous use of FSS, especially improved varieties, has negative implications for sustainable maize production. All the yields reported by the respondents were much lower than the average maize yield in Ghana, which is 2.26 Mt ha<sup>-1</sup> (MoFA, 2018). This indicates that the yields of the farmers interviewed were relatively poor.

### Association between socio-economic, biophysical, technical factors and input use, improved practices and maize yields

Two key types of associations are presented in this section. The first one examines the relationship between the use of inputs or improved practices including land management, fertilizer application, and row planting and other socioeconomic, biophysical, and technical factors. The second category explores the association between maize yield or production and those same socioeconomic, biophysical, and technical factors.

### Gender and variations in access to land and total maize in hectares for maize farming

The chi-square analysis revealed that gender was significantly associated with access to land in the SDFZ ( $P < 0.01$ ), how-

**Table 7.** Relationship between row planting and fertilizer use

	Factor	Access to land		Total per ecozone	Chi square value	P value
	Gender	Yes	No			
SDFZ	Male	21	94	115	$x^2 = 8.907$	P = 0.004
	Female	25	40	65		
	Total			180		
CSZ	Male	42	58	100	$x^2 = 0.005$	P = 1.00
	Female	34	46	80		
	Total			180		

Source: Field Survey (2015)

**Table 8.** Relationship between row planting and fertilizer use

Agro-ecological zone	Factor		Gender		Total per ecozone	Chi square value	P value
	Total maize in hectares		Male	Female			
SDFZ	0.20	0.81	29	31	60	$x^2 = 23.597$	P = 0.001
	0.82	1.62	40	29	69		
	1.63	2.43	34	2	36		
	> 2.43		12	3	15		
	Total				180		
CSZ	0.20	0.81	39	50	89	$x^2 = 0.005$	P = 1.00
	0.82	1.62	47	27	74		
	1.63	2.43	10	3	13		
	> 2.43		4	0	4		
	Total				180		

Source: Field Survey (2015)

**Table 9.** Relationship between row planting and fertilizer use

Agro-ecological zone	Factor	Fertilizer use		Total	Chi square value	P value
	Access to credit	Yes	No			
SDFZ	Yes	11	10	21	$x^2 = 0.254$	P = 0.648
	No	74	85	159		
	Total			180		
CSZ	Yes	11	4	15	$x^2 = 5.308$	P = 0.029
	No	70	95	165		
	Total			180		

Source: Field Survey (2015)

ever, this was not the case in CSZ (Table 7). Female farmers have better access to farmland in the SDFZ. In contrast, [Ankrah et al. \(2020\)](#) found a strong correlation between gender and access to land, where more male farmers have considerably easier access to farmlands. Similarly, [Doss et al. \(2018\)](#) observed that access to land varied with gender with women having less access. [Akter et al. \(2017\)](#) found that gender did not matter in South-eastern Asia when it came to access to resources, including land and agricultural inputs; women had equal access.

The main inheritance system in the study locations is the matrilineal system. As a result, women hold the lineage of inheritance and, consequently, tend to have custody of a larger

share of farmland. However, due to perceptions that women are less energetic and incapable of managing large farms, the land they possess often ends up being returned to men. This may explain why more men cultivate larger areas of land than women in the study areas (Table 8). Additionally, it could clarify why there is a greater number of men engaged in maize farming in these areas as well (Table 2). In both zones, the association between maize acreage and gender was significant ( $P < 0.01$ ) (Table 8). Males operated larger farms ( $\geq 0.82$  ha) than female farmers (0.20 to 0.81 ha).

#### Access to credit facility and fertilizer use

The results indicate that respondents' access to credit was not significantly associated with fertilizer use in the SDFZ ( $P >$

**Table 10.** Farmers perception of the influence of climate variables on maize production in the study locations

Agro-ecological zone	Climatic factors	Frequency	Percent (%)	Rank
Semi-deciduous forest	Drought	61	33.9	1
	Poorly distributed rainfall (late/early)	50	27.8	2
	High winds	41	22.8	3
	Drought and high winds	18	10.0	4
	Flooding	5	2.8	5
	Flooding and high winds	5	2.8	5
Coastal savannah	Poorly distributed rainfall (late/early)	56	31.1	1
	Drought and high winds	35	19.4	2
	High winds	32	17.8	3
	Drought	31	17.2	4
	Flooding and high winds	22	12.2	5
	Flooding	4	2.2	6

Source: Field Survey (2015)

0.05), but it was significant in the CSZ ( $P < 0.05$ ) as shown in Table 9.

The significant relationship observed in the coastal savannah zone (CSZ) was likely because access to credit enables farmers to acquire fertilizer, which can enhance their farm productivity. This finding agrees with Ragasa et al. (2013) who found that access to credit was positively related to chemical fertilizer use.

#### The Relationship between Education, Fertilizer Use, and Row Planting

In both the semi-deciduous forest zone (SDFZ) and Coastal savannah zone (CSZ), the farmers' level of education did not have a significant relationship with fertilizer use, or the adoption of row planting, not even at the 10 percent significance level.

The general assumption is that education exerts a positive influence on the adoption of innovations. However, the relatively low education levels of the respondents may explain why education was not positively correlated with fertilizer use and planting in rows.

Oyekale and Idjesa (2009) confirmed that extremely low education levels can hinder technology adoption and skills acquisition among farmers. Furthermore, Sinyolo (2020) established that farmers with university or postgraduate education tend to adopt new technologies more readily than those with lower levels of education.

Inadequate financial resources, tenure insecurity, and ignorance about the advantages of using new technologies could have accounted for the low use of soil amendments, improved maize seeds, and other production strategies by respondents in the study area. This agrees with observations by Adjei-Nsiah (2006) that issues related to land, cash, credit, labour, and food security affect the use of new technologies.

#### Physical Characteristics (Climatic Factors Affecting Maize Production)

Table 10 presents farmers' perceptions of the climatic factors that negatively affect maize production. The three top climatic factors reported by farmers in the SDFZ were drought (33.9%), late or early but unsustainable (poorly distributed) rainfall (27.8%) and high winds (22.8%).

In the CSZ, late/early rainfall (31.1%), drought and high winds (19.4%) and drought (17.2%) were the major parameters which influenced maize yield negatively (Table 10). It was evident from the results gathered that the majority of farmers depended on rainfall for farming because late or early rainfall and drought were the major climatic problems they encountered in their operations. This gave credence to the notion that, in Ghana, maize farmers relied chiefly on rainfall (MoFA, 2011). Moreover, extreme weather events including prolonged droughts, floods, high winds and heat waves make crops fail (Keith et al., 2010). In both agro-ecological zones, high winds came third among weather factors influencing maize production.

#### Farmers perception of general factors responsible for low maize yields

Farmers provided various reasons for their inability to meet yield targets (Table 11). Unfavourable weather conditions were cited as the primary constraint, affecting 61 percent and 78 percent of respondents in the SDFZ and CSZ respectively. While lack of farm inputs came second among factors responsible for poor yields in the SDFZ, it came third to the CSZ. Insect pests and diseases were noted by only 0.8% of farmers in the SDFZ and did not appear to be a concern in the CSZ, while poor maintenance and general crop husbandry problems accounted for the lowest percentage in the CSZ at 2.1%.

The emphasis on unfavourable weather conditions as the main factor contributing to low yields suggests that most farmers rely heavily on natural weather conditions for maize production. This observation supports the notion that maize farming

**Table 11.** Farmers perception of factors responsible for low maize yields

Cause of low maize yield	Semi-deciduous forest		Coastal savannah	
	Frequency	Percent	Frequency	Percent
Unfavourable weather conditions	73	60.8	73	77.7
Poor or infertile soil	10	8.4	11	11.7
Lack of inputs (credit, fertilizer, weedicides, seed maize)	30	25.0	8	8.5
Poor maintenance and general crop husbandry	6	5.0	2	2.1
Insects and pests	1	0.8	–	–
Total	120	100.0	94	100.0

Source: Field Survey (2015)

in Ghana predominantly occurs under rain-fed conditions (MoFA, 2011). The majority of respondents identified unfavourable weather as the leading factor affecting low yields, yet the adoption of drought-tolerant maize varieties and improved crop husbandry practices which could mitigate the problem were undervalued by respondents in both AEZs (Table 6). The observation by La Rovere et al. (2010) drought tolerant maize varieties have the potential to improve maize yields and farmers' incomes buttresses this point. Furthermore, the importance of "lack of inputs" as an important factor limiting maize yields is shown in their relatively high ranking (second and third position in the SDFZ and CSZ respectively).

## Conclusion

The research revealed that the uptake of sustainable farming practices for maize including the utilization of improved germplasm, soil improvement agents and improved agricultural techniques was considerably influenced by cultural dynamics, socio-economic conditions, technological aspects and biophysical features within the SDFZ and CSZ study locations.

In both AEZs, men dominated maize farming. The youth (ages 21-31) represented a small minority of the surveyed maize farmers. Most respondents had only basic education or no formal education, which has implications for technology adoption. A significant challenge across all research locations was the limited availability of financial services (access to credit), which hindered farmers' capacity to acquire agricultural inputs, increase their cultivation area, and hire farm workers.

Despite engaging in continuous cropping, most farmers did not implement any strategies for improving soil productivity. Unfavourable land tenure arrangements contributed to inadequate soil fertility in these areas. A reduced crop density was noted, even among farmers implementing row planting techniques. The widespread reliance on landraces and farmer-retained seeds was evident in the study location coupled with a limited availability of certified seeds for newly released varieties. Obatanpa was the most popular improved maize variety among farmers, despite the availability of newer options. The significance of grain attributes, particularly in relation to

preservation, culinary performance, and market appeal, was identified as a pivotal factor for the adoption and continued utilization of newly developed maize varieties.

Adverse weather conditions was observed to be one of the major constraints influencing maize production especially since maize farming was primarily done under rain-fed conditions in the study areas.

Men farmed on larger acreages in both AEZs; however, more females had access to land, indicating a gendered division in land ownership.

Erratic climatic patterns, volatile commodity prices, and the potential of crop failure were key factors that discouraged many farmers from adopting innovative technologies in maize production.

Aside contributing to the literature relating to socioeconomic, technical and biophysical factors and sustainable maize production, the current study establishes differences in these factors between agroecological zones, the Semi-deciduous forest zone (SDFZ) and the coastal savannah zone of Ghana (CSZ). In particular the study finds that more females are engaged in maize production in the CSZ than in the SDFZ indicating greater gender balance in the CSZ. Yet, more females in the SDZ than in CSZ had greater access to land. Also, fewer sharecroppers were found in CSZ than in SDFZ. There were more men aged between 21 and 30 years in the CSZ than in the SDFZ. More farmers in the SDFZ than in the CSZ used land races and farmer saved seeds. However, similar proportions of farmers in both zones adopted row planting and fertilizer application.

This study suggests providing assistance to small-scale farmers in establishing cooperative associations. Such groups could provide leverage for easier access to credit with affordable interest rates. Decision-makers should enhance land ownership frameworks to develop supportive programs that will assist small-scale farmers. The study suggests that the fertilizer subsidy programmes be continued and fertilizers be supplied to key farming localities to enhance their availability and promote greater utilization.

Moreover, policymakers should facilitate the establishment of an efficient marketing framework that ensures consistent and fair maize pricing for farmers, while establishing strategies to mitigate market inefficiencies that hinder the uptake of innova-

tive technologies. Strengthening interactions between farmers and extension services is crucial for promoting the uptake of improved technologies and boosting maize productivity. Additionally, researchers should investigate and address the perception of inferior taste and poor storage quality associated with improved maize varieties, often referred to as "agric aburo" by farmers in the area.

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