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The 2020 Maize Production Failure in Ghana: A Case Study of Ejura-Sekyedumase Municipality

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Abstract: This paper examines the causes of widespread maize production failure in Ghana during the 2020 minor growing season. A mixed-methods approach was used to study smallholder maize farmers in the Ejura-Sekyedumase Municipality to provide a holistic understanding of the factors behind the maize production failure and to inform policy interventions. The results show that the decline in maize grain yield was caused by the failure of the minor season rains and, more importantly, the destruction of maize plants by fall armyworms. Other factors including poor soils and inadequate farm inputs contributed minimally to the observed maize failures. The agronomic practices adopted by the farmers to mitigate crop failures were undermined by their inability to master the onset and cessation of rainfall, the ineffectiveness of pesticides to control the fall armyworms and financial challenges. It is recommended that the government promotes and supports rainwater harvesting to address the impacts of drought and pests on food crop production. Furthermore, to ensure sustainable food production, a combination of indigenous knowledge and scientific farm practices are crucial to accurately forecast the weather and to control the fall armyworms.

Keywords: agronomic changes; climate change; fall armyworm; farmers' resilience; safety nets; Ghana

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1. Introduction

Sub-Saharan Africa (SSA) is at the center of the threats posed by climate change to agriculture due to production challenges such as low uses of technology and irrigation, slow progress in drought risk management, and land degradation. The poor economic performance and prospects of many countries in the sub-region are related to the constraints to agricultural production [1]. These challenges have a huge impact on agricultural productivity [2]. Food insecurity caused by crop failures is growing rapidly in many SSA countries, leading to famine, and environmental and financial crises, which can undermine the region's commitment to achieving the UN Sustainable Development Goals (SDGs) by 2030, especially SDG 1: End poverty in all its forms everywhere and SDG 2: End hunger, achieve food security and improved nutrition and promote sustainable agriculture [3].

Similar to many countries in SSA, agriculture is the main source of livelihood for millions of people in Ghana, providing the food and economic needs of rural and urban households. Agricultural production is predominantly structured on a smallholding basis, characterized by low input and low technology use, high rain-dependence and a low adoption of irrigation. The total arable land under irrigation in Ghana is reported to be less than 2% [4]. Thus, the over-dependence on rainfall for agriculture in Ghana exposes production to rainfall and its variability.

Maize (*Zea mays*, L.) is an important crop grown in Ghana, occupying over one million hectares, and constituting 50–60% of the country's cereal production. Maize is grown in almost every part of the country, but the major growing regions are the Forest–Savannah transition zone, accounting for more than 80% of the total maize grains produced in Ghana [5]. Maize grains are a major staple for many households, an ingredient for poultry feed and an important industrial commodity in Ghana. While its production provides the economic livelihood for millions of smallholder farmers in the country [6], the crop is frequently affected by rainfall variability. Frequent maize crop failures could potentially affect farmers' incomes, make them vulnerable to poverty, and worsen nationwide food insecurity.

Given the enormous importance of maize to Ghana's economy, both government and non-governmental interventions have been implemented over the last three decades to improve maize grain production. Examples of government programs to improve maize yield include fertilizer subsidies, mechanization, and buffer stock schemes, as well as increased tariffs on the importation of maize grains. From 1979 to 1997, and 2000 to 2008, the Ghana Grains Development Project and the Food Crops Development Project, respectively, introduced and encouraged the cultivation of early maturing, drought-tolerant and high-yielding maize varieties. In addition to the government's efforts, non-governmental organizations such as Masara N'Arzikialso provided inputs into credit and extension services to improve yield.

Despite the efforts to improve maize yield, challenges such as fall armyworm (*Spodoptera frugiperda*) infestation and extreme rainfall events have debilitated productivity in recent years. For instance, in 2016, a severe El Niño led to a drastic reduction in maize yield [7]. Similarly, between late 2020 and the middle of 2021, Ghana went through a serious maize grain crisis emanating from the 2020 minor season crop failure. The phenomenon led to shortages and spikes in the prices of maize grains and maize-based animal feeds. Moreover, the shortage led to an increase in maize grain prices on the local market, which affected household food security and the national economy at large. What we know is that extreme weather events may be the underlying cause of maize crop failure, but the frequency and severity of the impacts are unclear. This study sought to answer the following questions: (i) Why are crop failures becoming so frequent in recent years? (ii) What can be done to build the resilience of smallholder maize farmers in Ghana? The study aims to better understand the drivers of frequent maize production failures, which will be an important step towards establishing robust interventions to mitigate future crop failures in Ghana.

2. Methodology

2.1. Study Area

The study was conducted in three communities in the Ejura-Sekyedumase Municipality (longitudes 1°5 W and 1°39 W and latitudes 7°9 N and 7°36 N), located in the Forest–Savanna transition zone of mid-Ghana. The communities were Ejura, which is the municipal capital, Kasei and Anyinasu (Figure 1). The communities were selected in collaboration with the Municipal Agriculture Directorate to obtain a wider geographical spread covering major maize production hubs. The transitional agroecological zone coincides with Zone C in the Ghana Meteorological Agency's (GMet) agroecological classification scheme. The municipality has a land area of about 1782.2 square kilometers.

Vegetation in the Ejura-Sekyedumase Municipality is predominantly characterized by semi-deciduous forest. Mean annual rainfall totals range from 1200 to 1500 mm and decrease from south to north following the general rainfall distribution in Ghana. Rainfall in the municipality has a bi-modal pattern. The major rainy season spans late March/early April and mid-July, which is interspersed by a short dry spell from mid-July to mid-August, followed by the minor rainy season in September/October. The long dry season, also called the "harmattan", runs from November through March. The bi-modal rainfall pattern allows two growing seasons, especially for cereals and legumes under rain-fed agriculture, which is widely practiced in the transition zone. The mean monthly temperature ranges from 21 to 30 °C. The months of January through April are the warmest whereas July and August are the coolest. During the rainy season, humidity is relatively high, peaking at 90% in June and dropping to roughly 55% in February.

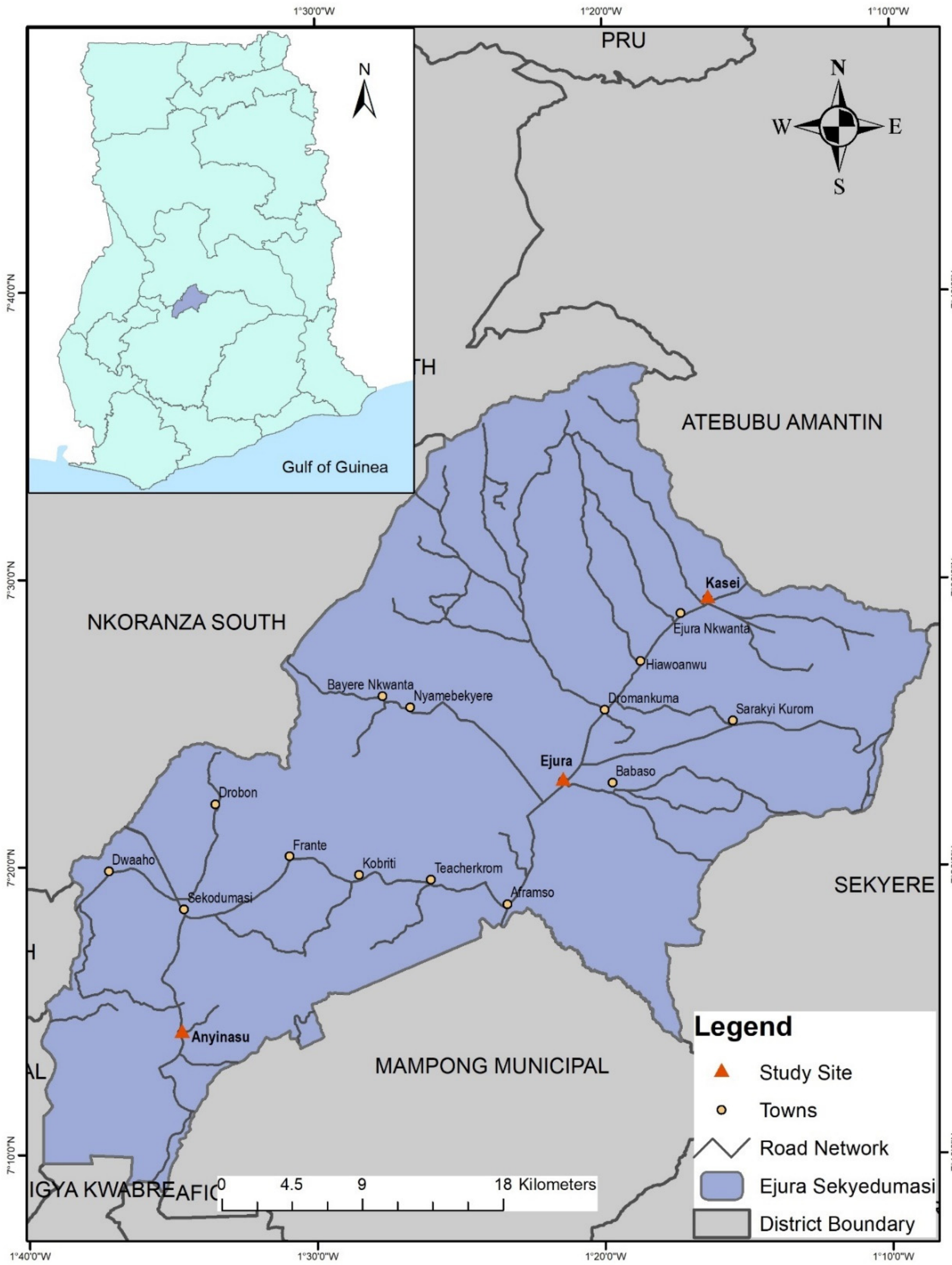

Figure 1. Map showing the study communities. Source: Authors' construct.

Soils in the Ejura-Sekyedumase Municipality fall under the Forest and Savanna ochrosols. Characteristically, the soils have a deep profile, are light in color, are well aerated with a moderate supply of organic matter and plant nutrients, and have good water-holding capacity. The climatic conditions together with vegetation and soil offer suitable conditions for agriculture, especially maize production. According to Cossar, et al. [8], maize production accounts for about 41% of the total cropped area in the municipality. The high contribution of the municipality to maize grain production in Ghana makes it suitable for studies on maize failures.

The municipality had a population of about 121,765 in the year 2020. Agriculture employs about 60% of the labor force and serves as the main source of livelihood for most people in the municipality. Furthermore, agriculture in Ejura-Sekyedumase Municipality is predominantly smallholding and includes crop production and livestock rearing. Besides maize, farmers in the municipality produce cowpea (*Vigna unguiculata*, (L.) Walp), groundnuts (*Arachis hypogaea*, L.), rice (*Oryza sativa*, L.), cassava (*Manihot esculenta*, Crantz), yam

(*Dioscorea* spp.) and vegetables mostly for commercial purposes. The most common farm animals raised include cattle, goats, sheep and poultry.

2.2. Data Collection

A mixed-methods approach, involving the collection of both quantitative and qualitative data, was used in this study. The data were sequentially collected through focus group discussions (FGDs), questionnaire surveys, and stakeholder interviews. Due to the lack of official data on the number of maize farmers in the communities, the researchers relied on information provided by key contact persons who were identified in each community. These key contacts also assisted the researchers in the selection of key maize farmers in their respective communities. To ensure the spatial representation of the populations in the communities, the key maize farmers were selected from different neighborhoods in the communities. The farmers identified were grouped into male and female groups for focus group discussions (FGD). Each group comprised 9 to 12 participants, who had mixed socio-economic characteristics such as age, education, and farm characteristics. The mixed characteristics ensured a representative sample of the study population. Furthermore, the gender-based and small-sized focus groups allowed active participation during the interviews. In total, four male and four female FGDs were conducted in the study communities (Ejura, 4; Kasei, 2; and Anyinasu, 2), with a total of 82 participants.

In addition to the FGDs, questionnaires were administered to approximately half of the farmers who participated in the FGDs. A similar approach to that described by Obour, et al. [9] was used in selecting the respondents of the questionnaire. Thus, the respondents targeted in each study community were those who were more experienced and knowledgeable about the 2020 minor season maize failure than the average farmer and were willing to participate. In total, 40 questionnaires were administered (Ejura: 19; Kasei: 9; Anyinasu: 12).

Finally, key informant interviews (KIIs) were held with personnel from the Municipal Ministry of Food and Agriculture (MoFA) Directorate, local agricultural extension officers in whose jurisdictions the study communities were located. The interviews were held either in English or Akan (Twi) depending on the preference of the respondents. The FGDs and KIIs were recorded and later transcribed. All data were collected following strict COVID-19 protocols, such as social distancing and the wearing of face masks. The primary data collected consisted of the stakeholders' observation of changes in climate variables, particularly rainfall and temperature, respondents' accounts of maize production in terms of changes in yield, especially during the 2020 minor season, and their narration of the probable causes of the 2020 minor season maize failure. Further, data on the farmers' practices and their opinions on how to mitigate future maize production failures were solicited. Finally, information on government preparedness to prevent the future occurrence of crop failures in the country was solicited from agricultural extension officers and personnel from the Municipal MoFA Directorate.

To corroborate the information obtained from the respondents, daily rainfall and minimum temperature data for the municipality covering the period 2015 to 2020 were obtained from the GMet. In addition, data on the grain yield of maize for the municipality covering 2012 to 2020 were also obtained from the Municipal MoFA Directorate. The climate and yield data were used to analyze trends over the past half decade, particularly in 2020, which is the focus of the study.

2.3. Data Analyses

The recorded interviews were transcribed verbatim into English. The questionnaires were cleaned, coded, and subsequently inputted into a statistical computer software, SPSS (version 20.0), for analysis. Crosstabulations were performed to examine the relationship between variables across the study communities. To determine uniformity between respondents in the different study communities, a Chi-square (χ^2) test of homogeneity analysis was performed. $p < 0.05$ was used as a criterion for statistical significance. The Friedman

Test was performed to compare the mean rank of the factors responsible for the 2020 minor season's maize production failure in the communities. When the test showed overall statistical significance, a post hoc test, a Wilcoxon signed-rank test with Bonferroni-corrected alpha level, i.e., an alpha level divided by the number of comparisons, was used to isolate factors that were significantly different. Relevant quotes extracted from the transcripts are used to emphasize key quantitative descriptions in the results and discussion sections. Rainfall, temperature, and maize grain yield data were analyzed in Microsoft Excel. The frequencies of the length of the dry spell and the longest dry spell in the major and minor rainy seasons were computed using Instat+ version 3.36. The dry spell was defined as four or more consecutive days without rain or with precipitation of less than 1 mm. The longest dry spell was computed according to Gbangou, et al. [10] as the largest number of consecutive days during which rainfall was less than 1 mm in the season. For each year, the major season was defined as April–July, and the minor season was September–October.

3. Results and Discussion

3.1. Socio-Demographic and Farm Characteristics

This section presents some key characteristics of the subset of respondents who participated in the questionnaire survey. Of the 40 respondents, 62% were females and 38% males. The ages of the respondents ranged from 20 to 75 years. More than 50% of the respondents have some form of formal education, with junior high school/middle school being the most common form of education completed by the respondents. In general, the respondents have large household sizes, with an average of seven people. The total farm size of the respondents in the last five years ranged from <2 to more than 6 ha. Average maize farm size in the last five years ranged from <2 to 4 ha. Except for vegetable production, where irrigation is practiced, the growing of crops, including maize, is done under rain-fed conditions. This probably explains why most of the farmers (88%) indicated that they do not practice irrigation farming (Table 1). The results show that, in general, there were no significant differences between the study communities in terms of the demographic and farm characteristics of the farmers interviewed. The identical demographic and farm characteristics offered an excellent platform to better understand the 2020 minor season maize production failures, impacts, and agronomic adaptations.

3.2. Maize Production and Failures

The Ejura-Sekyedumase Municipality is an important maize growing area in Ghana [11]. Production is the main source of income for farmers. In total, 53% of the farmers reported that over 60% of their income is from the sale of maize grains (Table 1). The plowing and harvesting of maize fields are often done mechanically using tractors, while sowing and weed clearance is done manually and using weedicide. Maize is grown two times a year, during the major and minor growing seasons. Major season maize is usually planted in April, during the onset of the major rainy season, and harvested in August. The minor season maize is cultivated from late August to early September when the minor season rain is expected to start, and harvested in December. The interviews revealed that the farmers use diverse agro-chemicals for controlling weeds and pests, and for replenishing soil nutrients. The most common agro-chemicals applied by the farmers included weedicides ("Condemn", Samphosate, "Round-up", "Adwumawura", "King Kong", Atrazine), insecticides (Lambda Super 2.5, "Diband and Samprifos", Lindane), and mineral fertilizers (Urea, NPK15-15-15, NPK 23-10-5, and ammonia).

Interviews with the farmers and the key informants confirmed their observations of declined maize yields in the last five years, and notably during the 2020 minor season. About 68% of the farmers reported that their maize yield during the 2020 minor growing season decreased between 40 and 70% compared to what they harvested in the previous years.

The observations of the respondents were validated by empirical data on maize production. Figure 2 shows that the cultivated area of maize slightly decreased in 2019 and 2020 compared with 2018. The maize grain yield sharply increased from 2017, and the highest was recorded in 2018. Figure 2 further shows that, compared with 2018, maize yield dropped by about 14% and 8% in 2019 and 2020, respectively, suggesting a slow recovery in 2020, which to a large extent corroborates the narrative of yield decline. However, given the lack of seasonal maize yield data, it was not possible to isolate the minor season yield to match the qualitative reports of the respondents.

Table 1. Demographic characteristics of respondents.

Characteristics	Communities			χ^2 Value	df	*p*-Value
	Ejura (*n* = 19) %	Kasei (*n* = 9) %	Anyinasu (*n* = 12) %			
Gender						
Female	34	13	15	1.999	2	0.368
Male	13	10	15			
Age						
20–45 years	13	5	10	9.584	10	0.478
46–65 years	25	13	18			
66+ years	10	5	3			
Level of educational attainment						
No formal education	38	5	5	23.969	8	0.02
Primary school	8	0	0			
Junior high/middle school	3	15	23			
Senior high school	0	3	3			
Household size						
1–5 people	10	10	3	4.966	6	0.548
6–10 people	25	8	18			
>11 people	13	5	10			
<2 hectares	18	10	0	14.374	8	0.073
2–6 hectares	20	10	15			
>6 hectares	10	5	15			
Average maize farm size in the last 5 years						
<2 hectares	28	13	8	6.422	6	0.378
2–4 hectares	15	8	13			
>4 hectares	5	3	10			
Practice irrigation						
Yes	3	5	5	1.878	2	0.391
No	45	18	25			
Proportion of income from maize grains in the last five years						
20–40%	8	8	10	11.393	8	0.180
41–60%	5	10	8			
>61%	35	5	13			

3.3. Drivers of Maize Production Failure in 2020

To understand the local knowledge of the factors responsible for the 2020 maize production failures, the impacts, and the lessons learned, the farmers were asked to identify and rank the factors responsible for the minor season maize production failures in 2020. Rainfall, pests and diseases were ranked as the major distinctive factors in all the study communities (Table 2). According to the respondents, the minor season rains in 2020 set in too late, and lasted for a much shorter time than usual. Consequently, many farmers missed the timing of the rains. Farmers who either planted early and expected the rain to come, or who planted late and expected that the rains were going to continue, experienced plant withering due to dry soil conditions. The few farmers who got the timing right suffered severe fall armyworms attacks, leading to plant damage and subsequent crop failures.

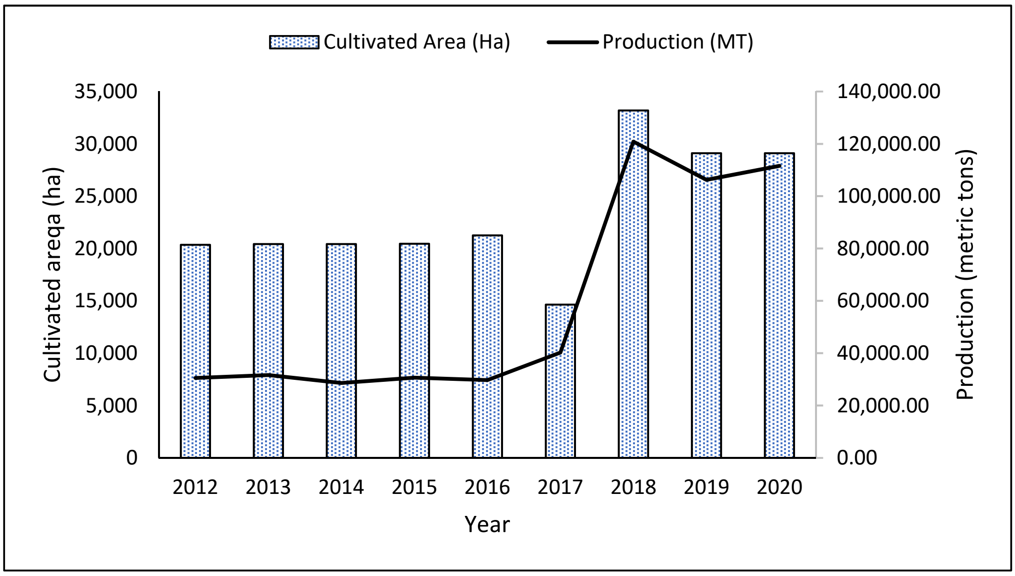

Figure 2. Maize cultivated area and production from 2012 to 2020 for Ejura-Sekyedumase Municipality.

Table 2. Ranking of factors responsible for the 2020 minor season maize production failure in Ejura-Sekyedumase municipality by farmers.

	Communities					
	Ejura (*n* = 19)		**Kasei (*n* = 9)**		**Anyinasu (*n* = 12)**	
	Rank of Factors	**Median**	**Rank of Factors**	**Median**	**Rank of Factors**	**Median**
Most important	Rainfall	10.0 [a]	Rainfall	10.0 [a]	Rainfall	10.0 [a]
	Pests and diseases	8.0 [a]	Pests and diseases	9.0 [a]	Pests and diseases	9.0 [a]
	Farm inputs	7.0 [ab]	Temperature	7.0 [a]	Soil and land degradation	7.0 [a]
	Temperature	6.0 [bc]	Soil and land degradation	4.0 [b]	Temperature	4.5 [b]
	Soil and land degradation	4.5 [bc]	Bush fires	4.0 [b]	Farm inputs	4.5 [b]
	Poor seeds	4.0 [bc]	Poor seeds	4.0 [b]	Poor seeds	4.3 [b]
	Bush fires	3.5 [bc]	Farm inputs	4.0 [b]	Bush fires	3.8 [b]
	Agric machinery	3.5 [bc]	Agric machinery	4.0 [b]	Agric machinery	3.5 [b]
	Financial	3.5 [bc]	Financial	4.0 [b]	Financial	3.5 [b]
Least important	Land scarcity and access	3.5 [bc]	Land scarcity and access	4.0 [b]	Land scarcity and access	3.5 [b]
	Friedman Test	χ^2 = 97.486, df = 9, *p*-value < 0.0001	Friedman Test	χ^2 = 46.716, df = 9, *p*-value < 0.0001	Friedman Test	χ^2 = 76.019, df = 9, *p*-value < 0.0001

Note: For each column, median values with different letters significantly differ at $p < 0.05$

Rainfall data for the municipality show fluctuations in the total monthly rainfall quantity from 2015 to 2016. It can be seen from Figure 3 that total monthly rainfall in the minor season (September–October) in 2020, in general, decreased compared to the preceding four years. To further assess the farmers' narratives about prolonged dry days in 2020, the frequency and longest days of dry spells were computed (Figure 4). For the major season, the number of dry days slightly decreased toward 2020, while the opposite was generally the case for the minor season. Furthermore, the minor season in 2020 experienced a longer dry spell (about 4–5 days more) compared to the other years. The frequency and longevity of the dry spells corroborate the qualitative accounts of the respondents of prolonged drought. According to the IPCC [12], climate change is projected to intensify rainfall variability and extreme weather events, such as dry spells, which will affect crop production. Gbangou, Ludwig, van Slobbe, Greuell and Kranjac-Berisavljevic [10] and Usman and Reason [13] indicated that the timing of dry spells relative to the cropping calendar rather than total seasonal rainfall is fundamental to crop viability and production. The authors argued that cumulative rainfall does not fully explain how rainfall variability can limit agricultural production. The reason for this is that a few heavy rainfall events may lead to the erroneous impression that the soil moisture conditions during the growing season were favorable. In other words, crops are more likely to do well under uniformly distributed "light rain" conditions over a long period compared to few "heavy" rainfall events interspersed by recurring dry spells. Owusu, Ayisi, Musah-Surugu and Yankson [7] reported that, because in Ghana maize is often cultivated under rain-fed conditions, it is extremely vulnerable to climate extremes such as prolonged droughts. Evidence from the present study shows that increased dry spells, in terms of either longevity or frequency, pose a major risk to maize production in the transition zone of Ghana, and thus threaten its status as the breadbasket of the nation. In western and southern regions of Zambia, Siatwiinda, et al. [14] found that the risk of maize failure is heightened by recurring dry conditions leading to heat stresses, but noted that production losses in the region are largely threatened by flooding conditions. In the case of Ejura-Sekyedumase Municipality, maize production losses were largely due to water stresses, but not flooding conditions.

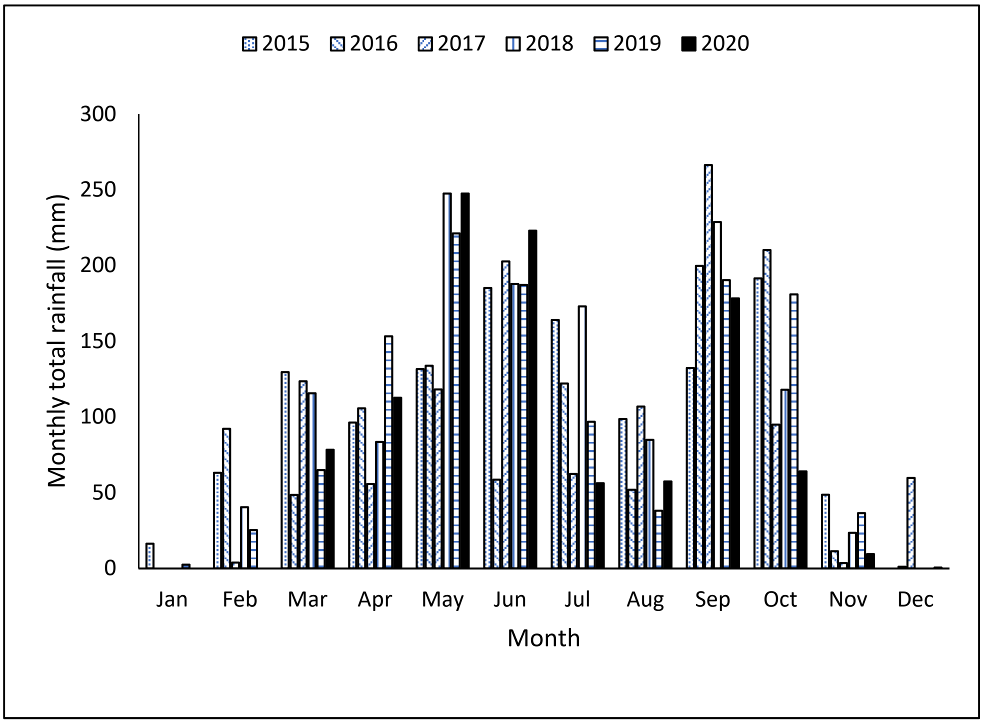

Figure 3. Monthly total rainfall in Ejura-Sekyedumase Municipality for the period from 2015 to 2020.

Minimum temperatures for the major and minor seasons for the period 2015–2020 are shown in Figure S1 (Supplementary Figure). As expected, the minimum temperature for 2015–2020 was identical, averaging ~25 °C. For lack of data on maximum temperature, the trend for the maximum temperature could not be shown.

Four main pests of maize were reported in the study communities, namely, grasshopper, stemborers, aphids and fall armyworms. However, the fall armyworm was reported as the most destructive to the maize. The farmers revealed, per their observations, that the fall armyworms become prevalent in dry and warm conditions. This is probably why the incidence of these pests was high during the drought-prone minor season of 2020. The interviews also revealed that the first fall armyworm outbreak recorded in the communities was in 2017. This was highlighted by a male respondent in Ejura as follows:

> I heard about what the fall armyworm can do to crops in other parts of Ghana in late 2016. However, it was not until late 2017 that this little but very destructive creature made its journey to Ejura and its environs. It was not a major concern initially as the damage was minimal, but it is now problematic because of the destruction, especially to young maize plants. Multiplication of the pest has been very rapid since 2020. The pest can devour several square meters of maize farm within a short time . . . Like all other farmers in the Ejura area, I have observed that the insect seems to multiply faster when the weather is dry and warm, which explains why the situation was worse in 2020 minor season because the rain did not come in time and good quantity . . . (Male maize farmer in Ejura).

The foregoing viewpoint is consistent with one researcher's account that the fall armyworm emerged in many parts of the country in 2017. Koffi, et al. [15] argues that the ability of the fall armyworms to feed in large quantities and fly over a long distance can seriously affect agricultural production, and thus poses a food security threat to the nation at large. As Bariw, et al. [16] also identified, the impact of the fall armyworm transcends the physical environment, to household social and physical resources and assets. Several factors contribute to the declining maize yield in Ghana [17]. In the case of Ejura-Sekyedumase, the results reveal that, besides rainfall and pests, other environmental and socio-economic factors, such as poor seeds, soil degradation and a lack of farm-based inputs, were reported to have contributed to the 2020 minor season maize production failures. Table 2 indicates that the rankings of these other factors limiting production somewhat differed between the communities, which could be attributed to local conditions. For example, the farmers in Ejura ranked farm inputs higher compared with those in Kasei and Anyinasu. The reason cited was that there is mostly a general scarcity of farm inputs in Ejura due to high demand during peak seasons. On the other hand, soil degradation was ranked highest in Anyinasu compared with Ejura and Kasei, because of the general report of poor soils in the community.

3.4. Alternative Income and Safety Nets for Farmers

Information on alternative sources of income and safety nets the farmers depended on during the 2020 minor season maize yield loss was solicited. Table 3 shows that the farmers relied on diverse economic activities to cushion the financial burden that arose from maize production losses. In Ejura, most of the farmers (79%) relied on the sale of animals such as goat, sheep, chicken, and cattle to earn money for household needs, while in Kasei and Anyinasu, the farmers (78 and 75%, respectively) notably engaged in non-farm activities, such as trading and the running of commercial transport. Further, in Kasei and Anyinasu, a cross section of the farmers reported that they depended on income from the sale of other crops, such as cassava and vegetables. However, there were a few of the farmers in the study communities (22% Anyinasu, 17% in Kasei and 16% in Ejura) who reported that they did nothing during the maize production failure.

In terms of social safety nets, the results show that most respondents (average of ~60%) indicated that they had none. For those who depended on safety nets, the prominent ones were support and remittances from family members and friends living in or outside the communities. Others depended on maize grains stored and income saved from the previous years. Dapilah, et al. [18] reported that diverse activities and social networks foster climate change adaptation in northern Ghana through the diversification of livelihood activities. In the present study, it was also found that family support and remittances played a valuable role in minimizing the adverse impacts of maize production failure on farmers and their households. The study also revealed that the initiatives of individual farmers and farm management practices, particularly livestock rearing, the storage of maize grains, and income from the previous years' harvest, equally played a crucial role in reducing the negative impacts of the 2020 minor season crop failure on the farmers' livelihoods.

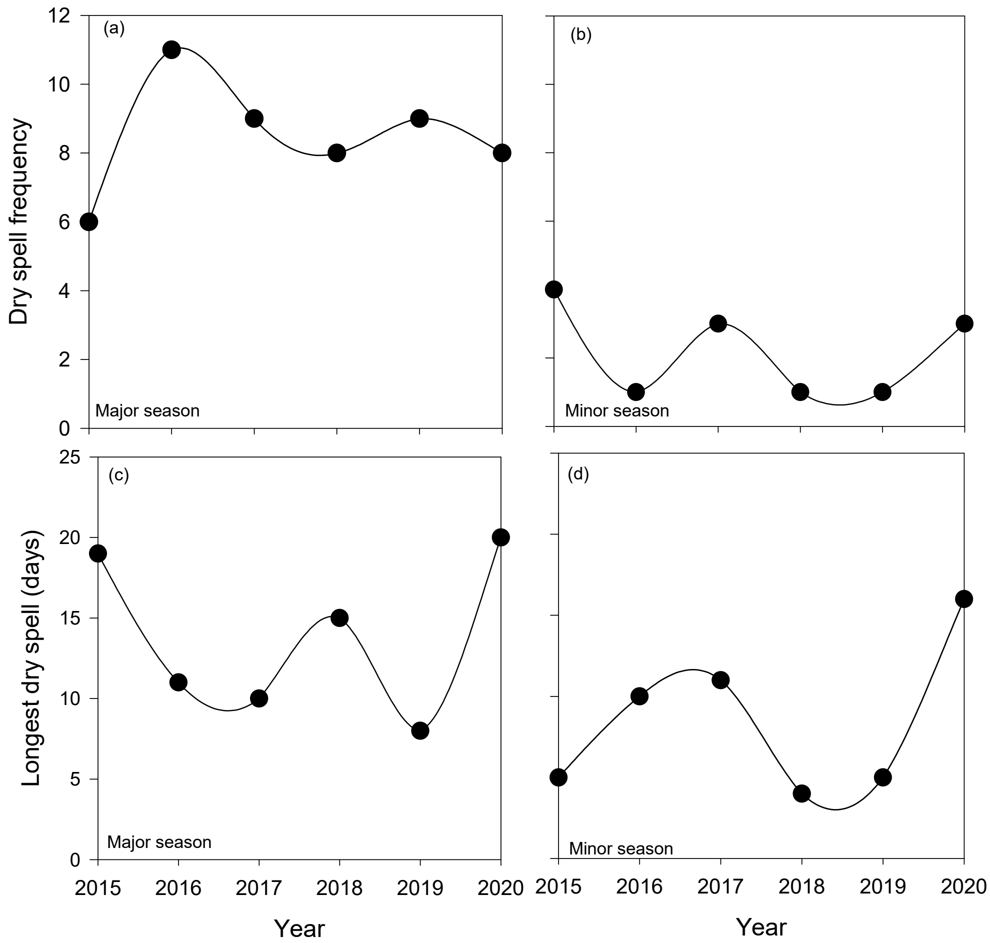

Figure 4. Frequency of dry spells for the (**a**) major and (**b**) minor cropping seasons for the period 2015–2020, and longest dry spell in days for (**c**) major and (**d**) minor cropping seasons for the period 2015–2020. A dry spell is defined as a sequence of four consecutive days or more during which precipitation is less than 1 mm.

3.5. Changes in Agronomic Practices in Response to the 2020 Maize Production Failure

The study sought information on how the experiences and lessons from the 2020 minor season maize production failure have shaped the farmers' agronomic practices. Table 4 showed that the experience from the 2020 minor season crop failure has indeed brought about some agronomic changes in maize cultivation. According to the farmers and the key informants, agronomic changes have become necessary to avert running into the same challenges experienced in 2020. Due to the difficulty for the farmers to master the onset and cessation of the minor season rain, of late, some of the farmers preferred doing early sowing of maize to take advantage of potential early rains. On the contrary, a cross section of the farmers preferred late sowing to make sure the rains are stable before planting (Table 4). However, both options are not without drawbacks because according to the Municipal Agriculture Extension Officer, in recent years, the minor season rains seemed to delay and last for a very short time when it comes. Either way it affects early and late sowing:

> The minor season rain is increasingly becoming very difficult for farmers to predict its onset and cessation. This implies that opting for only early or late sowing increases the risk of maize failure. A viable way to go is we (Extension Officers) advise farmers to do split sowing of maize so that they do not put their eggs in one basket . . . to avoid total crop failure in case the rains did not come as expected (Key informant at Ejura).

As mentioned previously, besides climate change, fall armyworms were reported to have significantly contributed to the maize production failures. In response, the farmers (53%, 44% and 58% in Ejura, Kasei and Anyinasu, respectively) reported that they have increased the use of pesticides in a bid to control the pests. The interviews revealed that the farmers have been experimenting (trial and error) with different pesticides to control the pest. The farmers reported having used at least five different insecticides, such as Lambda Super 2.5, Diband and Samprifos, ashes, Lindane, etc., in the last year in an attempt to control the fall armyworm, yet no significant impacts have been observed. Adzawla and Alhassan [19] pointed out that farmers' adaptation to climate change is important at the local level, as it helps to enhance sustainable food production. The authors reported that maize farmers in Northern Ghana are adapting to climate change by practicing row planting, mixed cropping, intercropping, and changing planting dates. The results from the present study show that the farmers are using local knowledge and farming experience to adapt to climate change, particularly unpredictable rainfall during the minor season, and to control the fall armyworm. Furthermore, the farmers in Ejura-Sekyedumase Municipality are also tackling poor nutrient status and soil degradation by using fertilizers and practicing maize rotation with leguminous crops for soil nutrient replenishment, and this way improving soil quality for crop production.

Table 3. Alternative economic activities and safety nets of respondents (multiple responses).

Variable	**Communities**		
	Ejura (*n* = 19) %	**Kasei (*n* = 9) %**	**Anyinasu (*n* = 12) %**
Alternative economic activities			
Rearing and sale of animals	79	56	0
Engaged in non-farm activities (e.g., trading, running commercial transport, mechanic)	53	78	75
Nothing	16	22	17
Worked as a farm laborer	16	0	25
Cultivated and sold other crops, e.g., cassava and vegetables	0	33	42
Social safety net			
Nothing	63	56	67
Depended on remittances	37	33	0
Depended on bank loans	0	0	42
Sold stock of maize in storage	26	0	25
Depended on savings from the previous years	26	0	0
Depended on proceeds from other non-maize crops	5	22	0
Depended on support from family members	0	22	42

3.6. Building Farmers' Resilience to Maize Production Failures

Farmers' abilities to respond to changes and take appropriate actions define their resilience and adaptive capacity to climatic and non-climatic changes. Therefore, understanding farmers' indigenous practices and knowledge actions are important for timely interventions that enhance their livelihoods and food security in developing countries [20]. The present study explored ways to build the resilience of maize farmers in the study communities. According to key informants, the resilience of smallholder farmers is crucial to ensuring sustainable food production. Multiple recommendations were made by the farmers (Table 5). Many of the farmers (79% in Ejura, 67% in Anyinasu and 56% in Kasei) reported that financial constraints affect their production, and suggested making loans available and easing the modalities for acquiring loans from financial institutions in the municipality is necessary to reduce the financial burden on farmers. It was reiterated that the interest rates offered by financial institutions at the time of the fieldwork were very high. According to the farmers, some financial institutions were charging between 25% and 28% interest on loans. Besides the high interest rate, the conditions for acquiring loans were reported to be very cumbersome, which discouraged the farmers from applying for loans. The results here are consistent with previous findings by Klutse, et al. [21], who argued that the difficulty farmers face in accessing loans from a financial institution to pay for labor and purchase farm inputs have adverse impacts on food crop production in Ejura-Sekyedumase and Wenchi Municipalities. The present study has further revealed that the farmers were also reluctant to acquire loans from financial institutions largely because of the fear of defaulting, which could put them in jail. The interviews revealed that the farmers were also not interested in subscribing to farm insurance policies. At Ejura, one farmer reported that three years ago, farmers in the community tried doing business with an insurance company, but were exploited by the company leading, to the loss of their investments.

Table 4. Specific agronomic changes in response to maize production failure (in multiple responses).

Agronomic Changes	**Specific Practices**	**Farmer's Description of How Agronomic Changes Build Resilience**	**Communities**		
			Ejura (*n* = 19) %	**Kasei (*n* = 9) %**	**Anyinasu (*n* = 12) %**
Early planting	Sow maize when rain is expected to come or just after the first rainy day in the growing season	Helps respond to rainfall shifts—early sowing helps take advantage of early rains	53	44	58
Late planting	Waited until there are three to four consecutive rain events before sowing maize	Waiting until there are consecutive rainfall events ensures sufficient soil moisture	42	67	42
Nothing	-	-	26	11	8
Increase use of pesticides	Apply different pesticides at different periods	Helps control fall armyworms	26	11	0
Increase use of fertilizers	Apply a wide range of fertilizers	Ensures fast growth and gives high yields when there are rains	26	33	25
Practice crop rotation	Rotate maize with legumes, mainly groundnuts and beans	Helps conserve soil water and improve soil quality	16	22	0
Apply ashes mixed with chemicals	Apply ash solution sometimes mixed with other pesticides	Helps to control fall armyworms	0	0	8
Mixed farming	Plant both crops and rear animals like sheep, goat and chicken	Provides double benefits from crops and animals	5	0	0
Practice agroforestry	Intercrop maize plant with economic trees such as cashew and mango	Agroforestry provides shade and helps to conserve soil moisture	5	0	0
Improve soil quality	Apply organic amendments, mainly residues of groundnut and beans from the previous harvest	Enhances crop growth	0	0	17

The use of agrochemicals for agricultural production in the district has become a regular practice among farmers in the municipality in response to poor soil nutrient status, disease infestation, and the fall armyworm attack. As part of the Government of Ghana's initiatives aimed at promoting agricultural production, price subsidies on mineral fertilizers have been rolled out nationwide [11,17]. The farmers acknowledged that the subsidy has helped to reduce the price of fertilizers. Nevertheless, it was reported that high demands, particularly during the peak growing season, often led to hoarding and price increases for fertilizers. The farmers also proposed that the subsidy program be extended to include essential products, such as pesticides and weedicides, as their availability will help farmers to improve maize production. Nabavi-Pelesaraei, et al. [22] reported that the use of inputs such as biocides and farmyard manure differentiated between efficient and inefficient watermelon farmers in Iran. The authors found that there is a misconception that a high use of, for example, fertilizers can lead to inefficient production. Moreover, the low cost and inappropriate use of fertilizers can have adverse effects on crop performance and the environment [22,23]. We suggest that subsidies on prices of agro-chemicals in Ghana be accompanied by regular agronomic information on best agricultural practices to build the resilience of smallholder farmers and avert environmental externalities caused by mal-agronomic practices.

Table 5. Measures to build the capacity of maize farmers against the drivers of crop production failure (multiple responses).

Measures	Communities		
	Ejura (*n* = 19) %	**Kasei (*n* = 9) %**	**Anyinasu (*n* = 12) %**
Soft loans for farmers from financial institutions	79	56	67
Subsidize prices of agro-chemicals further	79	56	50
Development of irrigation facilities for farmers	53	67	67
Regulate the market price of maize and enforce standardization to prevent middlemen from cheating farmers	26	44	33
Promote local manufacturing of agro-chemicals to make them available	26	33	42
Manufacturing pesticides that effectively kill the fall armyworm	26	33	17
Support farmers with agricultural machinery	10	7	7
Crediting the sale of agro-chemicals	6	5	5

The interviews showed that irrigation facilities were non-existent in the municipality, and according to the farmers, developing such facilities will help reduce their dependency on rainfall for food production. They suggested that the government should consider extending the One Village One Dam (1V1D) program to their municipality. The 1V1D is a Government of Ghana flagship program initiated in 2017 to aid rainwater harvesting for domestic use and farming, especially during the harmattan season. The program is intended to increase the access to a reliable source of water for livestock watering, domestic activities, and dry season farming, all of which is intended to alleviate poverty and address the inequalities in rural and deprived communities [24]. According to the farmers, implementing the program in the Ejura-Sekyedumase Municipality will promote irrigation and reduce the risk of maize production failures.

In all the communities, the farmers expressed concern about how they are being cheated by the middlemen who buy maize grains. There was a general feeling that the unscrupulous practices of the middlemen seriously affect the incomes of farmers. It was reported that the middlemen come to the community with their prices, and these are often too low. For instance, at the peak of maize grain shortage in early 2021, a bag of maize was sold for about GHC 650.00 (Based on OANDO exchange rate as of January 14: USD 1 is GHC 6.1) in Accra and Kumasi, yet the middlemen bought from the farmers for between GHC 350.00 and 400.00. Additionally, it was revealed that the bags used by the buyers are often too large, compared to the approved 100 kg bag for maize grains. The farmers reported that middlemen repack the grains in standard bags before reselling them to consumers at the urban markets, which means extra grains are gained per bag. This is a modus operandi of the middlemen to make more profits at the expense of the farmers. The farmers suggested that the government should set out price regulations for maize grains and enforce the standardization of maize grains measurement across the country.

Further probing revealed that some of the middlemen prefer going into contract maize production with farmers, particularly those who are financially constrained. Often, the middlemen, i.e., the buyers support the farmers financially and in kind, such as by supplying agro-chemicals that may be needed throughout the cultivation season. In return, the farmers are bonded to sell the maize produced at the end of the season to their prospective buyers. Despite the poor pricing offered by the buyers, contract farming seems to be generally working well so far, as the farmers were able to produce enough to meet the terms of the contractual agreement. However, issues arise when maize output is insufficient to meet the demands of buyers. It was reported that the 2020 minor season maize production failure rendered several farmers indebted to middlemen. According to a male farmer in Kasei:

> At the beginning of the 2020 minor growing season, a buyer came to me from Accra ... We agreed she was going to support me financially and in kind to grow maize. Given the size of my farm, I was confident that I could supply her with at least 100 bags of maize at the end of the season. Unfortunately, nothing worked that season, the rain was a huge disappointment. On top of that, the fall armyworms devoured the maize plant ... I could not even harvest 30 bags of maize to make the buyer somehow happy ... To sum up, I am still indebted to her (the buyer).

The farmers also expressed concerns over the inability of existing pesticides on the market to fully control the fall armyworms, and suggested that the Ministry of Food and Agriculture should collaborate with research institutions in the country to explore using local materials, such as ashes, and solutions made of neem (*Azadirachta indica*, A Juss) bark or leaf to manufacture pesticides. According to the farmers, trial-and-error methods, such as using ashes, neem leaf or bark extract, or a combination of them all, seemed to reduce the rate at which the insect breeds. Guodaar, et al. [25] and Shaiba, et al. [26] found that farmers in northern Ghana used neem leaf extract in an attempt to control the spread of crop pests, particularly the fall armyworm, yet these indigenous practices have not been as effective as expected. The farmers in Ejura-Sekyedumase Municipality also face challenges, such as those related to determining the required dosage and application timing to attain optimum results. The farmers believe that integrating scientific knowledge with their indigenous practices could improve the efficiency of the locally used materials in order to effectively control the pest. Derbile, et al. [27] pointed out that, despite the importance of local knowledge in climate change adaptation in Africa, it has potential limitations. Guodaar, Bardsley and Suh [25] reported that the risks and impacts posed by climate change are complex, and therefore, there is an urgent need for climate change adaptation to support the integration of farmers' indigenous knowledge and modern scientific knowledge, and thus build the farmers' resilience.

The farmers also suggested that there is a need for the government, through the MoFA, to promote and support mechanized maize farming so as to reduce the dependency on manual labor, and thus ensure timely cultivation. Finally, a few of the farmers (8%, 6% and 6% in Ejura, Kasei and Anyinasu, respectively) proposed that agro-chemical retailers in their respective communities could supply the farmers with agro-chemicals on credit, which they could repay at the end of the growing season.

4. Conclusions and Recommendations

Although extreme weather events such as El Niño in Ghana have been linked to the failure of crops such as maize, which provides an important source of nutrition for humans and animals and contributes to the national economy, it is unclear what factors were behind the 2020 minor season maize production failure that led to a massive shortage in and price increase of maize grains. Accordingly, this study sought to advance existing knowledge by examining the factors behind the 2020 minor season crop failure at Ejura-Sekyedumase Municipality, a major maize production area in the transitional agroecological zone of

Ghana. In addition, the constraints to building smallholder farmers' resilience to crop failures, food insecurity and rural poverty were investigated.

The respondents' views and the empirical meteorological data showed the recurrence of drought during the 2020 minor growing season, which resulted in the withering and failure of the maize plant. The prevalence of fall armyworm attacks on maize plants, which was also linked to the dry and warm conditions during the growing period, contributed substantially to the 2020 minor maize production failures. According to the farmers, other factors such as poor soils, a general lack of inputs and under-resourced mechanization, may have contributed, albeit minimally, to the observed maize failure during the 2020 minor growing season.

Multiple agronomic changes are being adopted by the smallholder farmers to reduce the risk of maize production failures. The notable agronomic changes reported included administering multiple pesticides to control pests (especially the fall arm worms), taking advantage of early rains to sow, sowing later when the rainfall is stable, increasing the use of fertilizers, crop rotation, and the planting of leguminous crops to improve soil quality. However, the inability of the farmers to master the onset and cessation of rainfall, the general ineffectiveness of pesticides, financial burdens, the general high prices of agrochemicals, and the unregulated farm-gate prices of maize are constraining maize production. From the point of view of the farmers and key informants, there is a need to build farmers' capacity and resilience through, for example, making loans more accessible, extending government policy on subsidizing fertilizers to other farm inputs such as pesticides and weedicides, developing irrigation (rainwater harvesting) facilities for farmers, regulating market prices, and implementing the standardization of maize grain measurement to benefit farmers.

Based on these findings, it is recommended that the government promotes and supports rainwater harvesting through, for instance, extending the government flagship program on 1V1D to the municipality to address prolonged droughts and help reduce pest outbreaks. There is an urgent need to marry farmers' indigenous knowledge of climate forecasting and controlling the fall armyworm outbreaks with science. In the case of the former, effective collaboration between the Ministry of Food and Agriculture and the Ghana Meteorological Agency is necessary to link climate information with agronomic practice, so that seasonal climate information can be relayed to the farmers in a timely manner. There is also a need for research and field trials of existing commercial pesticides and locally used materials in order to control the fall armyworm. When doing this, the farmers' indigenous knowledge should be considered to ensure easy adoption.

Supplementary Materials: The following supporting information can be downloaded at: https://www.mdpi.com/article/10.3390/su14063514/s1, Figure S1: Average monthly min temperature of Ejura-Sekyedumase for the period 2015–2020.

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