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Smallholder Maize Farmers’ Perception of Weather Variability and its Influence on Sustainable Adaptation Strategies in Anambra state, Nigeria.

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Abstract

The effect of weather variability was severe on poor households lacking mitigation capability. Adaptation was easy and cheaper, but documentation about its adoption was low, thus this study examined maize farmers’ perception and use of sustainable adaptation practices. A multi-stage sampling procedure was used. In all, 120 farmers were randomly selected. A structured questionnaire was used to collect data on farmers’: perceived climatic factors; sustainable adaptation practices; the effect of climate change and farmers’ adoption constraints. Data were analyzed using descriptive statistics multinomial logit. The result showed perceived high temperature (74.0%) high relative humidity (58%), high intensity of sunlight (64.2%) and low wind velocity (57.5%). Strategies adopted by farmers in mitigating climate change showed that 95.0% of the farmers mitigated against weather variability. The majority mitigated climate variability with the adoption of organic manure (60.2%), cover cropping (86.0%), planting resistant varieties (87.0%) and mixed cropping (83.5%). The influence of weather variability on farmers’ adaptation strategies results showed that farmers are proactive in adapting against rainfall ($P<0.01$), wind ($P<0.01$) and temperature ($P<0.01$), and not sunlight ($P<0.1$). The marginal effects showed that rainfall, wind, and temperature have the likelihood of increasing the adaptive measures taken by the farmers. Constraints to the adoption of mitigating strategies included inadequate training standard deviation (SD) = 0.24, lack of awareness (SD = 0.47), access to credit (SD = 0.35), extension contact (SD = 0.27), farms’ income (SD=0.4) and educational level (SD = 0.35). Sustainable adaptation practices mitigated weather variability and enhanced output increase. Farmers should be trained in using sustainable adaptation practices to mitigate weather variability.

Keywords: Climate change, farmers, mitigation, strategies,

Introduction

Agriculture is the major source of livelihood in rural communities in Africa, about 65 percent of the African population depends on agriculture for employment and more than 15 percent of their Gross Domestic Product (GDP) is from agriculture, Africa Agriculture Status Report (2015); Organization for Economic Co-operation and Development (OECD) (2015); FAO (2016).

Maize is an important global staple food, more than 15 percent of global calorie intake is from maize, rice and wheat (World Atlas, 2017). Maize ranks second most important cereal crop after sorghum in Nigeria, based on the number of people it feeds (Enyisi et al., 2014; Komolafe and Adeoti, 2018). Maize is a multipurpose crop providing food and fuel for man, feed for poultry and other livestock. Smallholder farmers that are scattered all over the country produce the bulk of the maize grains in Nigeria. These farmers depend majorly on the weather for their production with little or no irrigation (Mubiru et al. (2017). Therefore, smallholder farmers are vulnerable to climate change. Globally, policymakers are confronted with climate change challenges that seem to be the most serious environmental obstacle in fighting hunger, disease, malnutrition and poverty due to its devastating impact on agricultural yield (Amusa, 2012). Ensuring food security is being challenged amid the climate change scenario and is now a complex situation that demands urgent attention. (Kim et al., 2017). Climate change is a major socio-economic and developmental obstacle to economic growth and development. It is a fact that human activities are mainly responsible for climate crises (IPCC, 2013). Even though Africa contributes just a little above 3% to greenhouse gas emissions (GHG) their economies were the most hit by this menace, (Dube et al., 2016). The continent bears the brunt of climate variability because their agriculture is weather dependent and their capabilities to mitigate against climate change are very low (Nwafor 2007; FAO, 2016). Consequently, mitigating against climate variability and reduction of agriculture's contribution to (GHG) emissions is key to reducing climate change.

The negative effect of climate variability will be severe on poorer households due to their lower capability to mitigate climatic change (Adger, 2003; Adeoti et al., 2016) Climate variability threatens all sectors of agriculture. Visible evidence of the effect of climate change on agriculture in Nigerian included the drought of 1972-73, in the northeastern where 300,000(13%) livestock, in the region, were lost, while agricultural output decreased to between 12% and 40% of the annual averages (Adeoti et al., 2016). In Nigeria, smallholder farmers are facing the effects of climate change that arise as a result of farmland degradation, low yield, desertification, biodiversity loss, flood and reduction in farm income (Herrick et al., 2013). Despite these, there are fewer empirical studies in Nigeria on the economic effect of climate change on smallholder maize farms as well as the capacity of these farmers to adapt and mitigate against it adequately.

Adaptation to climate change is modifications by nature or human systems in reaction to either actual or expected climatic stimuli which reduces harm or exploits beneficial opportunities IPCC (2014). Farm-level adaptation involves a change in capital or behaviour by actors (government, firm and household) in reducing harm or increasing potential benefit from climate change. The study of adaptation strategies for climate change is an integral part of climatic change effects assessment and it is an important policy option in combating climate change impacts Adeoti et al. (2016). From the literature we realized that adaptation methods are functions of the institutions, customs and policies; therefore, it is expected that there will be differences in the degree of adaption between agroecological zones in a country. Where directed policy responses are lacking, farmers select their adaptation strategies based on their household and farm characteristics. The awareness that is, perceiving climate change challenges and the potential gain of mitigation is the key determinant in the use of agricultural technologies to mitigate against climate change Hassan and Nhemachena, (2007); Adeoti et al., (2016). Leaving climate change, without mitigation is generally hazardous to the agriculture sector; but with adequate adaptation methods in place, vulnerability can be adequately checked (Smit 2002; Adeoti et al., 2016). Although research works have been done to assess the effects of climate change on agriculture in Nigeria (Fonta et al., 2011; Adeoti et al., 2016), only a few examined the role of adaptation strategies. Thus the adaptation and mitigation measures available to policymakers are scarce. There is a handful of research on the impacts of climate change and adaptation (Chen et al., 2018; Wilson et al., 2018), but studies on adaptation with smallholder farmers at the center of research is limited. This study, therefore, addressed this research gap by analyzing smallholder maize farmers' perceptions and adaptation strategies to mitigate climate change in Anambra State. Therefore, the following research objectives were addressed:

1. identify the perceived climatic factors that affect maize production and the adaptive strategies adopted by farmers in mitigating weather variability;
2. estimate the influence of weather variability on farmers' adaptation strategies; and
3. identify the constraints faced by farmers in adopting mitigation strategies.

Methodology

Sampling Technique

A multi-stage sampling method was used. Anambra Agricultural Development Project (ADP) frame was adopted. Agricultural Development Programmes zones: Aguata and Onisha were purposively selected due to the high dominance of maize farmers. One block was randomly selected from each selected zone. Two cells each were purposively selected based on their high maize production level. A total of 120 farmers were randomly selected proportionate to the cell's size. A structured questionnaire was used to collect data on farmers': perceived climatic factors (high; medium and low) sustainable adaptation practices; perceived effect of climate change and farmers' constraints to adopt mitigation methods. Data were analyzed using descriptive statistics, inferential statistics-multinomial logit and Likert-scale.

The Multinomial Logit (MNL) Model

The multinomial logit (MNL) model was used to 1. estimate the influence of weather variability on farmers' adaptation strategies. According to Kurukulasuriya and Mendelsohn (2006), this method can be used to analyze the choice of methods adopted to mitigate the negative impacts of weather variability. The advantage of the MNL is that it permits the analysis of opinions across further than two orders, allowing the determination of choice chances for different orders Wooldridge (2002. also, Koch (2007) emphasizes the utility of this model by describing the ease of interpreting estimates from this model. To describe the MNL model, let y denote a random variable taking on the values {1, 2...J} for J, a positive integer, and let $\mathbf{x}$ denote a set of conditioning variables. In this case, y denotes adaptation options and $\mathbf{x}$ contains weather variability. The question is how changes in the elements of $\mathbf{x}$ affect the response probabilities P (y $= j / x$), j =1, 2 ...J ceteris paribus. Since the probabilities must sum to one, P (y $= j / x$) is determined once we know the probabilities for j = 2...j. Let x be a 1× k vector with the first element unity. The MNL has response probabilities:

P (y=j / x) = exp (xβ) / [1+$\sum_{h=1}^{j}\exp(x\beta h)$, j = 1 …j] equation (1)

Where βj is k×1, j = 1……. j
Following Kurukulasuriya and Mendelsohn (2006); Seo and Mendelsohn, (2006); Deressa et al. (2009) the adaptation options for this study were selected. These were soil conservation, planting of improved variety, changing planting date, diversification to non-farm activity, and changing farm size. The adaptation methods for this study are based on asking farmers about their perceptions of climate change and the actions they take to counteract the negative impact of climate change. The explanatory variables for this study include rainfall, temperature sunlight and wind.

Differentiating equation (1) with respect to the explanatory variables provides marginal effects of the explanatory variables given as:

$$\frac{\partial pj}{dxk} = pj(\beta jk - \sum_{j=1}^{j-1} pj\beta jk$$

The marginal effects (marginal probabilities) are functions of the probability itself and measure the expected change in probability of a particular choice made concerning a unit change in the independent variable from the mean Koch (2007); Greene, (2003).

RESULTS AND DISCUSSION

Figure 1-5 presented the perceived weather variability in the study area. The majority (68.0%) perceived rainfall to be high, 20.0% perceived rainfall to be moderate and only 12.0% perceived rainfall to be low for maize production in the study area. Majority (74.0%) perceived temperature to be high, 22.0% perceived temperature to be moderate and only 4.0% perceived temperature to be low for maize production. The majority (58.0%) perceived humidity to be high, 28.4% perceived humidity to be moderate and only 14.0%. perceived humidity to be low. The majority (64.0%) perceived sunlight to be high, 26.0% perceived sunlight to be moderate and 10% perceived sunlight to be low, while 30.8% perceived wind to be high, 11.7% perceived wind to be moderate and 57.5% perceived wind to be low. The implication is that weather had a great impact on maize production as was revealed by the work of Hillel (2014), who asserted that although maize is a warm-season crop, it is more sensitive to high temperatures stress compare to other crops. At very higher temperatures maize yield tend to reduce greatly. Also, the incidence of weeds become rapid. Adejuwon, (2012), asserted that nearly 50% of maize yield is attributed to the influence of climatic factors which are precipitation, temperature, relative humidity, sunlight and wind velocity. Likewise, Madu et al, (2010) believe that variations in temperature and rainfall expose crops to new pests and diseases that multiply only at specific temperatures and humidity and pose new risks to food security. This work is also in agreement with Ozor, (2011), who discovered that Changes in the cropping pattern and calendar of planting adversely affected crop yield through long-term alterations in rainfall.

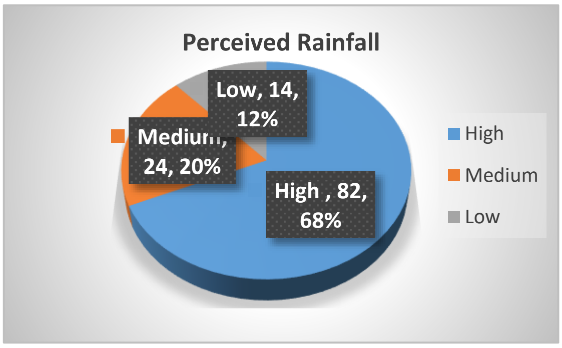


Figure 1: Perceived rainfall (Source: Field survey, 2021)

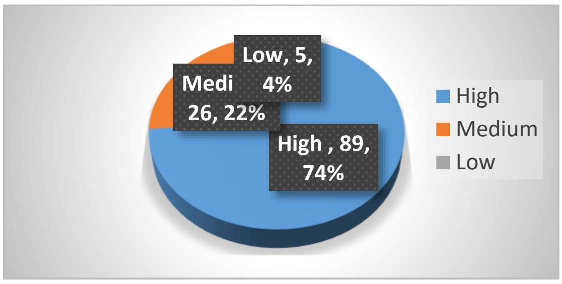


Figure 2: Perceived temperature (Source: Field survey, 2021)

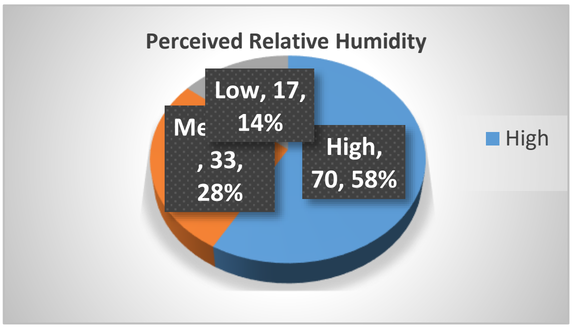


Figure 3: Perceived relative humidity (Source: Field survey, 2021)

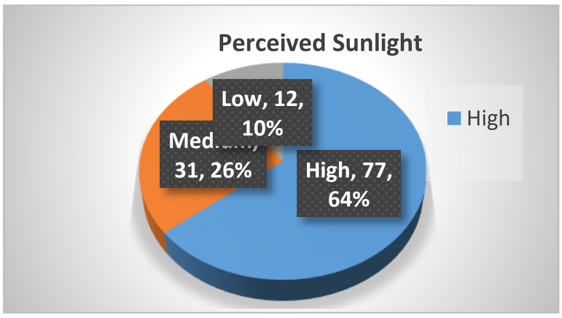


Figure 4: Perceived sunlight (Source: Field survey, 2021)

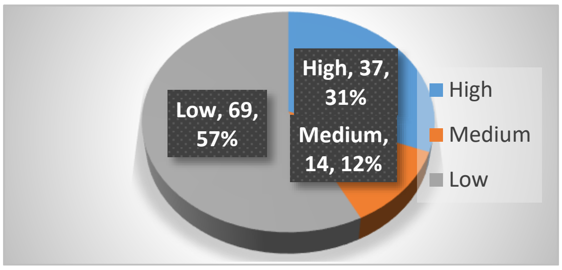
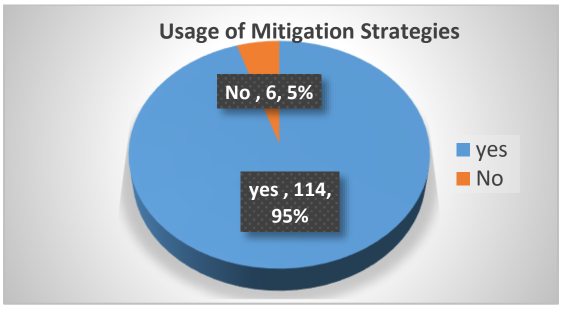


Figure 4: Perceived wind (Source: Field survey, 2021)

Figure 6 presented farmers' usage of sustainable practices to mitigate perceived weather variability. Ninety-five percent of the farmers adopted sustainable practices to mitigate against weather variability while only 5.0% did not. This implies that farmers in the area of study acknowledged the effect of weather variability and are ready to mitigate against them using sustainable farming practices.



Mean=1.08 Standard deviation= 0.264

Figure 6: Usage of mitigation strategies (Field survey, 2021)

Table 1 showed the majority (86.0%) of the farmers used cover crops to mitigate weather variability, and only 14.0% of the farmers did not adopt the use of cover crops as a means of mitigation. The standard deviation for the usage of cover crop as a mitigation method was 1.15. this indicates that most farmers in the study used cover crops to conserve soil water and delay the onset of drought when rain fails to fall as when due. Also, mulching was adopted by 84.0% of the farmers. Dickie, Streck, Roe, Zurek, Haupt, and Dolginow, (2014) in their work identified two ways of increasing carbon content in cropland soils: (1) protecting the existing carbon in the soil system by delaying the decomposition of organic matter and preventing erosion, and (2) increasing the amount of carbon in the soil. Therefore, soil carbon can be protected by planting cover crops that control erosion. A higher percentage of 85.0% of the farmers planted improved varieties of maize that were drought resistant, only 15.0% of the farmer did not plant improved varieties of maize. According to Dickie, Streck, Roe, Zurek, Haupt, and Dolginow, (2014), intensification (producing more with less) minimizes the emissions intensity of agriculture, therefore, using inputs more efficiently or adopting new inputs that address limiting factors of production is a good mitigation practice. Conventional intensification practices were planting improved varieties.

Table 1: Adaptation strategies used in mitigating weather variability (n = 120)

Adaptation strategies	Frequency	Percentage (%)	Standard deviation
Planting cover crops			1.23
Yes	103	86.0	
No	17	14.0	
Drought resistant varieties			1.22
Yes	102	85.0	
No	18	15.0	
Mulching			1.21
Yes	101	84.0	
No	19	16.0	
Green manuring			1.21
Yes	99	83.5	
No	21	16.5	
Crop rotation			1.08
Yes	72	60.2	
No	48	39.8	
Organic manure			1.08
Yes	71	59.2	
No	49	40.8	
Mixed cropping			1.05
Yes	64	53.5	
No	56	46.5	
Shifting cultivation			1.03
Yes	61	50.5	
No	59	49.5	
Minimum tillage			1.02
Yes	52	43.5	
No	68	56.5	
Alley cropping			0.8
Yes	40	33.5	
No	80	56.5	

Source: Field Survey, 2021

The majority (60.2%) of the farmers used organic manure and 3(9.8%) did not use organic manure. FAO, (2016) stated that nuclear techniques help to identify soil and water management factors capable of reducing the release of GHG from the soil thereby, mitigate climate change. Using a variety of isotopes, it can be scientifically determined the level of carbon and nitrogen accumulation and their interactions in soil organic content as a result of recently added organic manure, crop residues or wastewater. The 15N stable isotopic technique helps to identify the source of nitrous oxide production in soil, which helps using appropriate N_2O mitigation tools, such as the addition of lime to reduce the degree of soil acidity, or the addition of nitrification inhibitors to nitrogen fertilizers to delay the conversion of excess nitrogen into nitrate.

Mixed cropping was adopted by 53.5% of the farmers. This is a form of enterprise diversification that serves to prevent the total loss of a whole farming enterprise due to weather variability. This mitigates economic loss and improves food security. According to Gattinger et al. (2012), practices such as cover crops, mulching and intercropping protect soils against erosion from both run-off water and wind. Organic fertilizers and optimized crop rotations adopted by 60.2% of the farmers help the accumulation of soil organic matter which in turn improves soil characteristics, such as its water infiltration and holding capacities Zeiger and Fohrer (2009), Lorenz and Lal, (2016). They also identified a greater abundance of soil microorganisms in organically managed soils, along with more carbon and nitrogen transformation activities than in conventionally managed soils. This means that, on average, soil organic carbon sequestration tends to be higher in organic than conventional agriculture. Moreover, the higher organic matter shapes the soil as a habitat for soil life. Living soil, in turn, provides a good basis for coping with climate uncertainties, such as heavy rains or droughts, while the good soil structure of organically managed soils reduces the risk of water logging and soil erosion Lorenz and Lal (2016).

Table 2: Summary of the influence of weather variability on farmers' adaptation strategies.

	Multinomial logit Result		Marginal effect	
Variables	**Coefficient**	**P>/z/**	**Coefficient**	**P>/z/**
Rainfall	0.20	0.002	0.18	0.001**
Temperature	0.40	0.005	0.40	0.004**
Sunlight	1.00	0.040	0.99	0.040*
Wind	0.12	0.003	0.11	0.003**
Constant	s0.640	0.001	1.203	2.308

Log likelihood= 99.50, Prob> Chi2 0.00, LRChi2(4) = 52.475, Pseudo R2 = 0.354,No of obs = 120

*** 1% significant **5% significant level *10% significant level

Table 3: The constraints faced by farmers in adopting mitigation strategies. (n = 120)

Constraints	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree	Mean score	Standard deviation
Inadequate training	66 (55)	15(12.5)	8 (6.7)	18 (15)	13(10.8)	3.25	0.24
Lack of awareness	52(43.3)	49(40.8)	5 (4.2)	6(5)	8(6.7)	3.0	0.47
Credit constraint	74 (61.7)	21(17.5)	9 (7.5)	4 (3.3)	12(10)	3.2	0.35
Low extension agent contact	27 (22.5)	67(55.8)	16(13.4)	1 (0.8)	9 (7.5)	3.0	0.27
Low farms' income	65 (54.2)	22(18.3)	14(11.7)	8 (6.7)	11(9.2)	3.1	0.43
Farmers' education	51(42)	21(17.5)	13(10.8)	5(4.2)	30 (25)	2.2	0.35
Non availability of organic manure	70 (58.3)	20(16.7)	10(8.3)	8 (6.7)	12(10)	2.2	0.33

Source: Field Survey, 2021

Table 2 presented the result of the Multinomial logit model to investigate the influence of weather variability on farmers' adaptation strategies among maize farmers in Anambra State. The result showed rainfall ($P<0.01$), wind ($P<0.01$) and temperature ($P<0.01$), while sunlight ($P<0.1$). This implied that maize farmers were proactive in adapting against rainfall, wind and temperature on their farms rather than sunlight. This corroborates the findings of Ajala (2022). The marginal effects showed that rainfall, wind, and temperature has the likelihood of increasing the adaptive measures taken by the farmers.

The result of the analysis presented in Table 3 showed lack of access to credit had a mean score of 3.25 which is above the average mean score of 3.0 was the major constraint. This implies that the majority of the farmers were constrained by their access to credit in adopting mitigation strategies.

This was in accordance with the work of Sangotegbe et al., 2012; Serfontein, 2016; Adeoti et al., 2016). The non-availability of organic manure with a mean score of 3.1 which is above the average mean score of 3.22 was next to access to credit constraint. This was followed by inadequate training with a mean score of 3.1 which is above the average mean score of 3.0 implying that the majority of the respondents saw inadequate training as constraints faced in adopting mitigation strategies. Farm income of the farmer with a mean score of 3.09 implies that respondents agreed that low-income generation by the farmer will constrain them from adopting mitigation strategies. This was in accordance with the work of Anne (2014), who asserted that low farmers' income hinders farmers' adoption of mitigation strategies. Lack of awareness of the farmers had a mean score of 3.0 which is above the average mean score of 3.0 implying that the majority of the farmers viewed lack of awareness as one of the major constraints in mitigating against weather variability. This is following the work of Sangotegbe et al. (2012) and Adeoti et al. (2016), who asserted that information enables farmers to determine whether or not to mitigate against climate variability. Contact with extension agents with a mean score of 3.01, implies that the majority of the farmers agreed the lack of contact with extension agents is a constraint to the adoption of mitigation strategies. This was following the work of Aidoo et al. (2021) who asserted that technology adoption is higher when extension services are available to farmers. The educational level of the farmer with a mean score of 2.17 which is below the average mean score of 3.0 which implies that the majority of the respondents disagreed with educational level as a major constraint farmers faced in adopting mitigation strategies. This is in disagreement with the work of Aidoo et al. (2021) who opined that the level of education of the farmers is a constraint to the adoption of mitigation strategies against weather variability.

Summary, Conclusion and Recommendation

Summary

This study examined smallholder maize farmers' perception and use of sustainable adaptation practices to mitigate weather variability in Anambra State, Nigeria. Multi-stage sampling method was used in selecting 120 farmers in the study area. Primary data were collected by the use of a structured questionnaire. The data collected was analyzed using descriptive and inferential statistics-multinomial logit model. The majority (68.0%) perceived rainfall to be high, 20.0% perceived rainfall to be moderate and only 12.0% perceived rainfall to be low for maize production. Majority (74.0%) perceived temperature to be high, 22.0% perceived temperature to be moderate and only 4.0% perceived temperature to be low for maize production. The majority (58.0%) perceived humidity to be high, 28.4% perceived humidity to be moderate and only 14.0%. perceived humidity to be low. The majority (64.0%) perceived sunlight to be high, 26.0% perceived sunlight to be moderate and 10% perceived sunlight to be low, while 30.8% perceived wind to be high, 11.7% perceived wind to be moderate and 57.5% perceived wind to be low. The majority (86.0%) of the farmers used cover crops to mitigate weather variability, 85.0% of the farmers planted improved varieties of maize that were drought resistant, (60.2%) of the farmers used organic manure, 53.5% of the farmers adopted mixed cropping.

The multinomial logit model to investigate the choice of adaptation strategies against climate change among maize farmers in Anambra State showed rainfall ($P<0.01$), wind ($P<0.01$) and temperature ($P<0.01$) while sunlight ($P<0.1$). This implied that maize farmers' adaptation strategies against rainfall, wind and temperature on their farms were of paramount importance than sunlight. Access to credit, non-availability of organic manure, inadequate training, low farm income, lack of awareness, contact with extension agents and low level of education were identified as constrain militating against the adoption of mitigation strategies in the study area.

Conclusion

In conclusion, the study provided empirical evidence that maize farmers' adaptation strategies against weather variability.

Recommendations

Based on these conclusions, it was therefore recommended that:

1. Farmers should be trained by extension workers on the use of sustainable adaptation practices to mitigate weather variability.
2. Credit should be provided by stakeholders to enable farmers to adopt sustainable adaptation strategies.
3. Farms should be situated close to livestock production areas to ensure the availability of farmyard manure

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