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ASSESSING THE IMPACT OF WEATHER ADAPTATION MEASURES ON THE PERFORMANCE OF THE FOOD CROP MARKETERS: AN EXAMPLE FROM SOUTHWEST, NIGERIA

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ABSTRACT

This study investigates the impact of weather adaptation measures on the profitability of food crop marketers in Southwest Nigeria. A multistage sampling procedure was used to select 390 respondents, categorized into adopters and non-adopters of climate adaptation strategies. An endogenous switching regression model was employed for data analysis. Key determinants of adaptation decisions include access to climate information, participation in training, proximity to markets, and association membership. While adopters experience higher profitability, inconsistent rainfall continues to adversely affect income, revealing limitations in current adaptation practices. Conversely, rising temperatures are associated with increased income among adopters, indicating successful mitigation of heat stress. The average treatment effect on the treated (ATT) is estimated at ₦279,000, demonstrating substantial income gains for adopters. Similarly, the average treatment effect on the untreated (ATU) is ₦108,200, implying that non-adopters could benefit significantly from adaptation. The study recommends investments in infrastructure and targeted financial support to enhance adaptive capacity, especially for marketers in rural areas.

Keywords: Climate adaptation, Food marketing, Profitability, Weather variability, Endogenous switching regression.

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1. INTRODUCTION

A significant portion of the population in developing countries relies on agriculture and agricultural products for sustenance and economic livelihood (Workie et al., 2020; Ahmadzai et al., 2021). Agriculture in sub-Saharan Africa (SSA) is highly sensitive to changes in climate due to the region's dependence on rain-fed farming systems and the limited use of modern agricultural technologies (Darko et al., 2020; Nwafor et al., 2021; Omotoso et al., 2023). The Intergovernmental Panel on Climate Change (IPCC) has repeatedly warned that the region is one of the most vulnerable to climate change, primarily due to its high dependence on agriculture, inadequate infrastructure, and the limited adaptive capacity of smallholder farmers (Onyeaka et al., 2024; Opiyo et al., 2024). In Nigeria, agriculture contributes about 22% to the national GDP, and the country is one of the world's largest producers of crops such as cassava, yam and maize (FAO, 2020). However, the increasing frequency of extreme weather events, such as floods, droughts, and irregular rainfall, has posed significant challenges to agricultural production, thereby affecting the broader agri-food supply chain, including food crop marketers (Adetunji et al., 2020).

Weather patterns, including temperature, rainfall, and extreme weather events, directly impact crop yields, which in turn influence market prices, supply chains, and the overall profitability of agricultural enterprises (Adetunji et al., 2020; Malik et al., 2022; Rahman et al., 2022). Like other SSA countries, agriculture in Nigeria is highly vulnerable to the vagaries of weather (Olutumise, 2023a, b; Onyeaka et al., 2024). According to the Nigerian Meteorological Agency (NIMET, 2022), recent years have seen increasing variability in weather patterns, with significant deviations

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in rainfall distribution and temperature extremes. This unpredictability poses challenges for food crop marketers, who rely on consistent and predictable crop yields to plan their business activities. Consequently, these marketers must navigate fluctuating supply levels, price volatility, and changing consumer demand patterns, all of which are influenced by weather conditions. Again, weather patterns, including rainfall variability, temperature fluctuations, and extreme weather events such as droughts and floods, profoundly impact crop yield and quality (FAO, 2020). These climatic factors directly affect the supply chain, from planting to harvest, thereby influencing market dynamics and the profitability of food crop marketers. For instance, inconsistent rainfall can lead to either drought or flooding, both of which can devastate crops and disrupt market supply, leading to price volatility (Ogundipe et al., 2019).

Also, the climatic conditions in Nigeria, especially the southwestern region, are favorable to the cultivation of staple crops such as cocoa, yam, cassava, maize, and oil palm (Adetunji et al., 2020). These crops are vital not only for local consumption but also for export, particularly cocoa, which contributes significantly to Nigeria's foreign exchange earnings. Despite the generally favorable climatic conditions, Nigeria (Southwest) has been experiencing increasing climate variability in recent years, characterized by irregular rainfall patterns, extended dry spells, and occasional extreme weather events such as floods (Ogundipe et al., 2019; Olutumise, 2023a). These climatic changes have disrupted agricultural cycles, leading to reduced crop yields and market instability. For instance, prolonged dry spells during the wet season can result in drought conditions, adversely affecting the growth of water-dependent crops like maize and cassava. Conversely, excessive rainfall can lead to flooding, which not only destroys crops but also hampers the transportation of goods to markets, leading to supply chain disruptions (Nwafor, 2021).

Food crop marketers play a pivotal role in connecting farmers with consumers. These marketers facilitate the sale of agricultural produce from farms to local and regional markets, ensuring the availability of staple food items (Kangile et al., 2020; Milford et al., 2021). The activities of these marketers are influenced by various factors, including market demand, transportation infrastructure, and, critically, weather conditions (Olutumise, 2020; Oderinde et al., 2022). During periods of favorable weather, when crop production is abundant, marketers often face the challenge of price volatility due to surplus supply (Kangile et al., 2020; Ali et al., 2023). Conversely, adverse weather conditions such as droughts or floods can lead to shortages in supply, resulting in higher prices and increased profitability for marketers but with potentially negative implications for food security (Ogundipe et al., 2019).

In many parts of Nigeria, food crop marketing is a dynamic and often informal activity, with marketers navigating various challenges to maintain the flow of goods between rural production areas and urban markets (Adeosun et al., 2022; Adeosun et al., 2023). These challenges include poor road infrastructure, high transportation costs, and limited access to credit facilities (Ogundipe et al., 2019). However, one of the most significant challenges faced by marketers in the region is the unpredictability of weather patterns, which affects both the quantity and quality of produce available for sale. For example, during the rainy season, poor road conditions exacerbated by flooding can make it difficult for marketers to transport goods to urban markets, leading to delays and increased spoilage rates. On the other hand, during the dry season, reduced crop yields due to drought can result in higher prices but also reduced volumes of trade, limiting the overall profitability of marketing activities (Adetunji et al., 2020).

Moreover, extreme weather events such as floods and droughts have been shown to exacerbate market instability by disrupting supply chains and increasing the costs of transportation and storage (Tchonkouang et al., 2024; Çevik, 2024). Marketers, particularly those operating in informal markets, often lack the financial and logistical resources to mitigate these disruptions, leading to reduced profitability and market access (Oderinde et al., 2022). In response to these challenges, there has been growing interest in exploring adaptive strategies that can help food crop marketers cope with the effects of climate variability (Dapilah et al., 2020; Rijal et al., 2022; Tunio et al., 2024). These strategies include the use of improved storage facilities, diversification of marketing channels, and enhanced access to climate-related information (Magesa et al., 2020).

The relationship between climate variability and agricultural systems is well documented (Rijal et al., 2022; Omotoso et al., 2023; Onyeaka et al., 2024), but there is a dearth of information on how weather behaviour affects market performance, especially in Nigeria. Several studies have highlighted the direct impact of weather patterns and climate change on agricultural production, market supply, and price volatility by focusing on the producers' perspective (FAO, 2020; Malik et al., 2022; Alhassan & Haruna, 2024; Tunio et al., 2024). Further, it is well established that any significant deviations from normal weather patterns can have far-reaching effects on the entire agri-food value chain, from production to consumption (Ogundipe et al., 2019). For instance, erratic rainfall patterns can delay planting and harvesting periods, resulting in mismatches between supply and market demand. This, in turn, leads to price volatility, which can affect both farmers' incomes and the affordability of food for consumers. However, there is limited information on how marketers specifically adapt to weather behaviors and their impact on their market performance. Therefore, the study makes significant contributions by identifying adaptation strategies tailored to food marketing and marketing activities. Likewise, use an endogenous switching regression model to depict the observable and unobservable factors responsible for the adoption of weather adaptation measures following previous studies on impact analysis (Abdulai, 2016; Khanal et al., 2018; Oparinde and Olutumise, 2022; Khan et al., 2022). Thus, effective market strategies and adaptive measures are essential to mitigate the adverse effects of weather variability. Hence, a need to examine the impact of weather adaptation measures on the profitability of food crop marketers in Southwest, Nigeria. Specifically, the research examines the perceived effects of weather parameters on market activities, identifies weather adaptation measures tailored toward marketing, and determines the impact of adapting to weather patterns on the profitability of marketers in the area.

2. MATERIALS AND METHODS

2.1. Description of the Study Area

2.1.1. Location: The study was conducted in Southwest Nigeria (Fig. 1). The location lies between Longitudes 2^0 31^1 and 6^0 00^1 East and Latitudes 6^0 21^1 and 8^0 37^1 North, with a land area of 76,852 square kilometres and a population of approximately 58.2 million (Worldometer, 2024). It is made up of six States (Ogun, Osun, Ondo, Oyo, Lagos and Ekiti) as one of the geopolitical zones that make up Nigeria, and equally bounded in the North and East by Kwara and Kogi States, in the West by the Republic of Benin and in the South by the Atlantic Ocean.

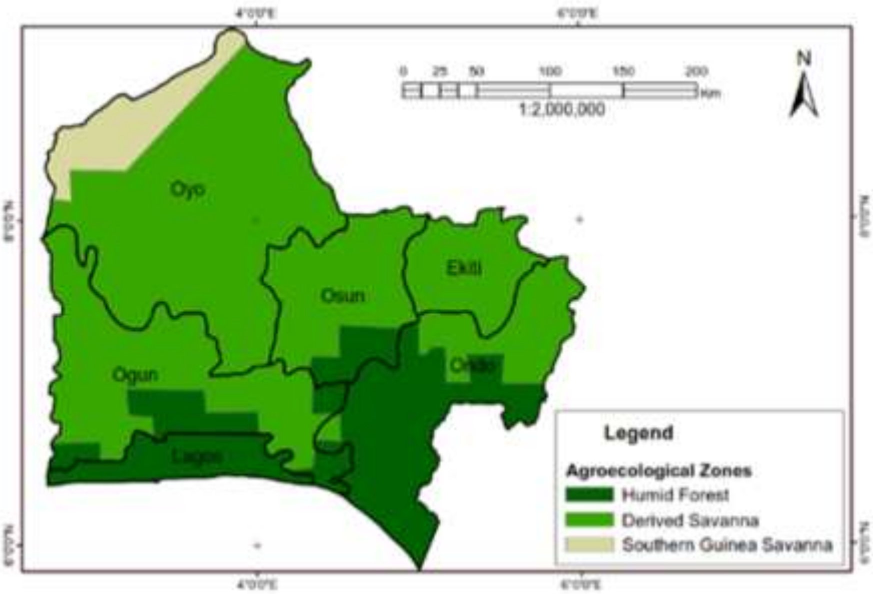

Fig. 1: Map of Southwest, Nigeria. Source: Adopted from Olutumise (2023a).

2.1.2. Climate: The area experiences a tropical climate marked by a wet season from April to October and a dry season from November to March. The wet season is characterized by heavy rainfall, averaging between 1500mm and 3000mm annually, which is crucial for the cultivation of staple crops. Temperatures in the region range from 21ºC and 34ºC, providing a conducive environment for agriculture (marketing) (NIMET, 2022). However, climate variability, including irregular rainfall patterns and occasional extreme weather events like floods, poses challenges to farming activities and market stability (Adetunji et al., 2020).

2.1.3. Food crop marketing: The marketing value chain plays a critical role in bridging the gap between farmers and consumers. They deal primarily in crops such as beans, yams, cassava, maize, and oil palm, which are staples. These marketers are highly dependent on the seasonal crop yields influenced by the climate. It is important to mention that this study takes into consideration the World Meteorological Organization's current climatological reference period (1991 – 2020) as a baseline period (Driss, 2021).

2.2. Source of Data Collection

The research utilized primary data sources, which were collected between July and November (5 months), 2023. The data were collected from food crop marketers' surveys and interviews with key informants. The primary methods of data collection included a well-structured questionnaire and face-to-face interviews, supplemented by private observations. The household survey featured an instrument with open and closed-ended questions, initially in English and then translated into Yoruba as needed. Informed consent to participate was obtained from all respondents included in the study, while the researchers oversaw the survey. The administration of the questionnaire was done through a well-trained enumerator from the State Agricultural Development Program (SADP). The instruments were thoroughly checked by experts in the fields of Agricultural Economics at Adekunle Ajasin University, Akungba-Akoko. A test-retest method was used to determine instrument reliability, and a Cronbach's Alpha coefficient of 0.811 was obtained, indicating high internal consistency (George & Mallery, 2003).

2.3. Sampling Procedure and Sample Size

Following Cochran's (1977) formula for determining sample size for an infinite population to achieve a certain level of confidence and precision, approximately 390 sample sizes were adopted by this study. Thus, the formula becomes:

$$n_0 = \frac{Z^2.p.(1-p)}{e^2} = \frac{1.95^2.(0.5).(1-0.5)}{0.05^2} = 385 \approx 390\, marketers$$

Where:

n_0 is the sample size for an infinite population, Z is the Z-score (e.g., 1.96 for a 95% confidence level), p is the estimated proportion of the population (often set at 0.5 for maximum variability), e is the desired margin of error (expressed as a decimal, e.g., 0.05 for 5%). Thus, a margin of error of 5% was considered acceptable for this study, given the confidence level of 95%. This allowed for a sample size of 390 respondents while maintaining statistical validity. Specifically, three States were randomly selected from the region, and they are Ekiti, Osun and Oyo. The second stage involved a purposive selection of Local Government in the State capitals of each State because there is a greater concentration of food crop marketers and their significant market activities, especially with prominent agricultural and market dynamics. One Local Government Area dominated by rural households was also selected from each State, making two LGAs from each State and six for the study. The third stage involved a random selection of five markets from each LGA, making thirty markets for the study. It is worth noting that only one market was randomly selected in a community. The last stage involved a snowballing approach to select 13 food crop marketers from each market, making a total of 390 respondents. This technique effectively identified experienced food crop marketers by leveraging referrals from initial participants. It also minimized logistical costs and challenges across multiple markets.

2.4. Method of Data Analysis

2.4.1. Endogenous Switching Regression Model (ESRM): The decisions marketers make when faced with a dyadic choice, such as whether to adjust to weather conditions or not, can have a significant impact on household net income. This choice can be modelled within an optimization framework. Let us assume that marketers are categorized as adapters and non-adapters, denoted by G_{ia} and G_{in}, respectively. While the researcher is aware of the adaptation status, other factors such as household net income and preferences remain known only to the marketers. The unobserved net benefits for marketers can be represented by the equation (1):

$$G_i^* = G_{ia} - G_{in} \qquad (1)$$

Here, the latent net income from adaptation to weather conditions is modelled as a function of household explanatory variables (Xi) in a latent variable framework as shown in equation (2):

$$G_i^* = X'_i\, \alpha + \varepsilon_i,\ G = 1[G_i^* > 0] \qquad (2)$$

In this study, G_i is a binary variable, with Gi = 1 for food crop marketers who adopt adaptation measures, and Gi = 0, otherwise. The vector X encompasses all observable factors that influence adaptation, such as access to market information, geographical location, distance, experience, education, and perceived climatic characteristics. The term alpha (α) represents the vector of parameters to be estimated, while ε is the error term accounting for measurement errors and unobserved variables, with a mean of zero and variance σ_ε^2.

Given that one of the primary objectives of this study is to examine the impact of weather adaptation strategies on the net income of food crop marketers, a conceptual model is constructed to reflect the marketer's decision to adopt adaptation strategies. This model assumes that the outcome variables are a linear function of the explanatory variables (Xi) and the binary adaptation status (Gi) (Abdulai, 2016; Oparinde & Olutumise, 2022) as presented in equation (3). The relationship can be expressed as:

$$NI_i = Z_i'\, \beta + G_i\, \gamma + \mu_i \qquad (3)$$

Where NI_i represents a vector of outcome variables, Z_i' is a vector of market and climatic characteristics, Gi indicates the household's adaptation to weather conditions, μ_i is the random error term, and β and γ are the parameters to be estimated.

As outlined by Abdulai (2016), selection bias can occur when the error terms of both the outcome equation (μ) and the choice equation (ε) are influenced by unobservable factors. This results in correlated error terms, leading to biased estimates from ordinary least squares (OLS) regression. According to Asfaw et al. (2012), selection bias can

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be addressed using randomized controlled trials (RCTs), where individuals are randomly assigned to treatment and control groups.

Previous studies have sought to identify the effect of adaptation status on various outcomes by estimating separate production or supply functions for those marketers who adopt adaptation strategies and those who do not. However, as Awotide et al. (2015) pointed out, this approach assumes that all marketers are homogeneous, which can be a significant limitation. Furthermore, the issue of endogeneity arises, given that adoption decisions are typically voluntary, with wealthier, better-informed, more educated, or more productive marketers more likely to adopt adaptation measures. Consequently, self-selection into adaptation is a key source of endogeneity in this analysis.

To address the endogeneity issue, the study employs an Endogenous Switching Regression Model (ESRM), which corrects for potential sample selection bias stemming from other interventions that provide multiple services to marketers beyond weather adaptation (Freeman et al., 1982; Madala, 1983; Heckman, 1990). The ESRM is an econometric model that describes a decision process and the associated regression models for each decision option, helping to account for self-selection and estimate treatment effects in the presence of non-random allocation of subjects to treatment groups (Alene & Manyong, 2007). By simultaneously estimating the determinants and effects of adaptation, the ESRM efficiently accounts for both observable and unobservable factors. This method was further refined by Lokshin and Sajaia (2011), allowing for an evaluation of the direction and magnitude of non-random selection and selection bias inherent in OLS estimates.

2.4.2. Empirical Specifications of the Endogenous Switching Regression Model (ESRM): In this study, the ESRM was employed to analyze the two-stage decision-making process regarding food crop marketers' adaptation to weather conditions. This approach is consistent with recent applications of ESRM in agricultural adaptation studies (Alhassan & Haruna, 2024; Tunio et al., 2024). The first stage involves estimating the selection equation, which identifies the factors influencing the adoption of weather adaptation strategies. In the second stage, the model captures the effect of adaptation on net income, separating the results into two distinct regimes: adapters and non-adapters as presented in equations (4a) and (4b). The equations for the two regimes can be expressed as:
Regime 1 (Adapters):

$$NI_{ia} = Z_{ia}' \beta + \mu_{ia} \text{ if } G_i = 1, \quad (4a)$$

Regime 0 (Non-adapters):

$$NI_{in} = Z_{in}' \beta + \mu_{in} \text{ if } G_i = 0, \quad (4b)$$

Where NI_{ia} and NI_{in} represent the net income outcomes for adapters and non-adapters, respectively. The vector Z includes household, climatic, and market-level characteristics, β is a vector of parameters to be estimated, and μ is the error term.

The ESRM framework permits overlap between the variables in the selection equation (Equation 2) and the outcome equations (Equations 4a and 4b). However, for identification purposes, at least one variable in the selection equation must be excluded from the outcome equations. Therefore, the selection equation was estimated using the same variables from the net income equation, supplemented with an additional identifying instrument. A valid instrument influences the adoption of weather adaptation measures without directly affecting net income. In this study, access to climate information and participation in climate-related training were chosen as instruments. These variables are considered relevant and valid because they influence the decision to adopt adaptation strategies while being independent of the direct determinants of net income.

Additionally, to account for observable selection bias, the explanatory variables in Z in Equations 4a and 4b reflect only observable factors. The ESRM is also capable of addressing selection bias arising from unobservable factors, particularly in cases of omitted variable bias. Following Heckman's (1979) approach, the inverse Mills ratios (also known as selectivity terms) from the selection equation, represented as λ_a for adapters and λ_n for non-adapters, are incorporated into the outcome equations to yield, as shown in equations (5a) and (5b):
Regime 1 (Adapters):

$$NI_{iS} = Z_{ia}' \beta + \sigma_{a\varepsilon} \lambda_S + \theta_{ia} \text{ if } G_i = 1, \quad (5a)$$

Regime 0 (Non-Adapters):

$$NI_{iR} = Z_{in}' \beta + \sigma_{n\varepsilon} \lambda_R + \theta_{in} \text{ if } G_i = 0, \quad (5b)$$

Here, the selectivity terms λa and λn correct for selection bias due to unobservable factors. The terms θ_{ia} and θ_{in} represent error terms with conditional zero means. Lokshin and Sajaia (2011) note that the two-stage approach, while useful, can produce heteroskedastic residuals, complicating the calculation of consistent standard errors. To address this issue, they propose the use of a full information maximum likelihood (FIML) method, which was adopted in this study. This method has been applied in previous studies by Abdulai (2016) and Oparinde and Olutumise (2022).

The empirical estimation of the ESRM in this study included a function of weather adaptations, modelled through

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a probit regression, and a net income function for food crop marketers. The decision equation for the study was specified as follows:

2.4.3. Dependent Variables

Outcome variable: NI = Net income (in Naira)
Selection variable: G = Adoption of weather adaptation measures (1 = adapters, 0 = non-adapters)

Explanatory Variables

X_1 = Education (years of formal schooling)
X_2 = Marketing experience (years of experience in food crop marketing)
X_3 = Distance to the nearest market (km)
X_4 = Market location (1 = rural, and 0 = urban)
X_5 = Access to credit (1 = access and 0 = no access)
X_6 = Access to market information (1 = access and 0 = no access)
X_7 = Perceived change in rainfall (1 = decrease, and 0, otherwise)
X_8 = Perceived change in temperature (1 = increase, and 0, otherwise)
X_9 = Participation in climate-related training/workshops (yes = 1 and 0 = no)
X_{10} = Access to climate information (1 = access and 0 = no access)
X_{11} = Log of Labour cost (in Naira)
X_{12} = Log of Transport cost (in Naira)
X_{13} = Membership in a farmers' association (1 = member, and 0 = non-member)

Thus, the empirical model enables the study to evaluate how various factors, including access to market information, education, experience, and participation in climate-related training, affect the likelihood of adopting weather adaptation measures and how these decisions impact net income.

3. RESULTS & DISCUSSION

3.1. Demographic Features of the Sampled Respondent

The results of the summary statistics of the selected variables used in the regression are presented in Table 1. The variables of the sampled respondents were divided into non-adopters and adopters of weather adaptation measures, with a statistical comparison between these groups. The t-test was conducted on the continuous variables, while the Chi-square test was performed on the nominal variables as presented in the last column of the Table.

Table 1: Stages of Sampling Procedures

Stage 1: Simple random sampling technique for the State	Stage 2: Purposive sampling technique for the 2 LGAs each	Stage 3: Simple random sampling technique for the 5 communities (markets) each.	Stage 4: Snowball sampling technique for the marketers	Total
Ekiti	Ado & Gbonyin	5	13	130
Osun	Osogbo & Iwo	5	13	130
Oyo	Ibadan North & Ibarapa North	5	13	130
				390

The results indicate that adopters of weather adaptation measures have, on average, significantly higher levels of education (mean of 9.91 years) compared to non-adopters (mean of 6.71 years). This suggests that educational attainment may positively influence the decision to adopt adaptation strategies. The role of education is further substantiated by the higher experience levels among adopters (14.07 years on average) compared to non-adopters (9.84 years), with a statistically significant difference of 4.23 years. These results align with the findings by Alhassan and Haruna (2024), who reported that education and farming experience significantly influence awareness and the adoption of climate-smart practices in Sub-Saharan African markets. The increased exposure to knowledge and skills associated with higher education and experience may equip marketers with a better capacity to respond to climate and weather variability through adaptation. Again, credit access and market information show limited variation between adopters and non-adopters, with absolute differences of 0.09 and 0.03, respectively, and no statistical significance. This suggests that both groups have relatively equal access to marketing and financial resources. Training and access to climate information show significant differences between adopters and non-adopters. Adopters report significantly higher levels of participation in climate-related training (0.49) than non-adopters (0.22). Additionally, climate information access is higher among adopters (mean of 0.88) compared to non-adopters (0.69), with a statistically significant difference of 0.19. These findings imply that training and access to reliable climate information may foster greater awareness and readiness to implement adaptation strategies. The significant differences in training and information access underscore the importance of targeted training programs and

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information dissemination efforts, which could further encourage adaptive behavior. This aligns with the study by Magesa et al. (2020), who emphasized that training and access to agricultural market information are critical enablers of climate adaptation among smallholder farmers and marketers. Labor costs present a statistically significant difference between adopters and non-adopters, with non-adopters incurring higher labor costs (mean of 203.1 thousand Naira) compared to adopters (mean of 109.1 thousand Naira). The reduced labor cost among adopters could indicate enhanced operational efficiencies, potentially due to climate-resilient practices or technologies. However, transport and total costs do not vary significantly between groups, indicating that while adaptation may influence labor demand, it does not necessarily impact other operational expenses. Again, adopters report higher average total revenue (6557.9 thousand Naira) and net income (880.9 thousand Naira) compared to non-adopters, whose net income averages 601.8 thousand Naira. The difference in net income (279.1 thousand Naira) is statistically significant, suggesting that adaptation measures positively impact profitability. This finding supports the hypothesis that adaptation strategies contribute to enhanced resilience and profitability for food crop marketers. Higher profitability among adopters may result from improved resource allocation, reduced labor costs, and enhanced decision-making abilities linked to education, experience, and climate information access. These results align with the findings of Tunio et al. (2024), who identified a strong link between the adoption of climate-smart agricultural practices and improvements in profitability and resilience of weather-affected farm markets. However, the findings through the mean differences have confirmed the presence of an endogeneity problem in the sampled respondents. It is an indication that confounding factors are not controlled by the mean differences, and the conclusion from the findings might be misleading. This is the justification for more robust and rigorous analytical tools (e.g., endogenous switching regression model) that accounts for the endogeneity of marketer's characteristics while measuring the impact of weather adaptation strategies on the performance of food crop marketers in the area (Khanal et al., 2018; Khan et al., 2022).

3.2. Perceived Effects of Weather Patterns on Market Activities

Table 2 presents the perceived impacts of weather patterns on market activities among food crop marketers using a 4-point Likert rating scale and ranked mean. The perception effect that changing weather patterns have led to reduced crop availability in markets was the most strongly agreed, with a mean score of 3 .92, ranking 1st. This finding aligns with recent studies indicating that irregular rainfall and temperature extremes disrupt crop growth cycles, reduce yields, and limit market availability (Adetunji et al., 2020; Malik et al., 2022).

Table 2: Demographic features of the sampled respondents

Variable	Pool sample		Non-adopters		Adopters		Absolute Difference
	Mean	SD	Mean	SD	Mean	SD	t-test/chi2
Education (years)	7.91	4.62	6.71	4.29	9.91	5.20	3.20*
Experience (years)	11.22	9.10	9.84	7.22	14.07	9.02	4.23*
Distance (km)	12.12	11.23	12.46	10.81	11.99	10.21	0.47
Credit (access)	0.54	0.41	0.58	0.39	0.49	0.51	0.09
Market information (access)	0.64	0.37	0.53	0.39	0.56	0.37	0.03
Location (rural)	0.50	0.50	0.50	0.50	0.50	0.50	0.00
Perceived rainfall (decreased)	0.49	0.21	0.51	0.43	0.50	0.39	0.01
Perceived temperature (increased)	0.76	0.57	0.79	0.54	0.80	0.45	0.01
Training (yes)	0.37	0.57	0.22	0.34	0.49	0.50	0.27*
Climate information (access)	0.85	0.55	0.69	0.46	0.88	0.36	0.19*
Labour (₦) '000	109.1	87.23	203.1	109.33	99.1	72.3	104*
Transport cost (₦) '000	147.6	138.8	143.2	101.21	151.3	100.2	8.1
Total Cost (₦) '000	5670.2	4198.0	5708.7	4831.1	5677.0	4981.3	31.7
Total Revenue (₦)	6511.5	4536.2	6310.5	5832.4	6557.9	4829.9	247.4
Net income (₦) '000	841.3	638.2	601.8	452.3	880.9	691.7	279.1*

* mean statistically significant at a 5% probability level.

Seasonal changes were perceived to influence consumer preferences for specific crops, as shown by a mean score of 3.85 (ranked 2nd). This highlights the role of seasonality in consumer demand patterns, which aligns with findings by Nwafor (2021) on climate-driven shifts in market demand. Adverse weather conditions were reported to increase the difficulty of transporting food crops to markets (mean score of 3.81, ranked 3rd), while leading to higher spoilage rates before crops reach their destination (mean score of 3.79, ranked 5th). These issues are due to the logistical challenges posed by weather extremes, such as flooding and poor road conditions, which exacerbate delays and spoilage. This finding is consistent with Oderinde et al. (2022), who noted that transport disruptions often result in increased operational costs and lower market efficiency for food crop marketers. Marketers perceived a rise in storage and preservation costs due to weather-related issues, with a mean score of 3.80, ranked 4th. This points to the

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need for improved storage facilities to counteract the effects of humidity and temperature on crop preservation, as reported by Magesa et al. (2020). Higher storage costs are likely to reduce profit margins, which could have negative effects on the food supply chain. Frequent changes in weather patterns were reported to complicate long-term marketing strategies, with a mean score of 3.76, ranked 6th. This perceived effect aligns with the unpredictability noted in recent climate reports (NIMET, 2022). The inability to forecast and plan long-term strategies can hinder marketers from optimizing inventory levels, setting stable prices, and managing supply chain partnerships, all critical factors in sustaining profitability. Profit reductions during extreme weather events were also notable, with a mean score of 3.67 (ranked 7th), as marketers incur higher operational costs due to scarcity and price volatility. This confirms the findings by Malik et al. (2022), who highlight how extreme weather can inflate marketing costs and erode profit margins. The perception that extreme weather events drive up food crop prices was ranked 8th, with a mean score of 3.45. This indicates that marketers believe weather and climate extremes, such as droughts or floods, reduce crop supply, leading to higher market prices. This aligns with recent studies showing that weather-induced scarcity drives price volatility, as limited crop availability due to adverse conditions inflates prices, impacting both marketers' operational costs and consumers' access to affordable food (Adetunji et al., 2020; Ali et al., 2023). Changes in customer demand for specific types of food crops in response to weather patterns were perceived by respondents with a mean score of 3.33, ranking it 9th. This suggests that certain weather conditions may drive consumers to seek alternative food crops based on seasonal availability, quality, or affordability. This finding supports the study of Kangile et al. (2020), who observed similar shifts in consumer preferences influenced by climate variability, implying that marketers need to adapt to these demand changes by adjusting their product offerings based on prevailing weather conditions. Thus, these findings affirm that food crop marketers in the area face several challenges that influence both supply-side pricing and demand-side consumer behavior, driven by weather variability.

3.3. Weather Adaptation Measures among Food Crop Marketers

According to Table 3, the breakdown of weather adaptation measures adopted by food crop marketers in the area is presented. These strategies reflect efforts to mitigate the impacts of climate and weather variability on marketing activities, aiming to sustain profitability and ensure market resilience. About 69.7% of marketers utilize community-based marketing to combat weather variability. This adaptation measure was the most adopted, and the probable reason might be that community-based marketing enables collaborative efforts, pooling resources and sharing information to minimize losses due to unpredictable weather. This strategy supports findings from Dapilah et al. (2020), who emphasize the role of social networks in building adaptive capacity among marketers in climate-vulnerable areas. Approximately 68.3% of marketers adopted improved storage and preservation methods, highlighting the need to counteract the effects of humidity, spoilage, and quality degradation caused by adverse weather conditions. Effective storage solutions reduce post-harvest losses and help stabilize supply despite seasonal production fluctuations, a critical factor for food security and income stability, as suggested by Magesa et al. (2020). About 63.7% of marketers diversified their product sales, a strategy that helps mitigate risks associated with crop failure or low supply of certain foods. By diversifying, marketers can offer alternatives to consumers when primary crops are affected by adverse weather, reducing their reliance on any single crop and spreading market risk. This finding aligns with studies by Kangile et al. (2020), which highlight the importance of diversification as a climate adaptation strategy. Nearly 57.1% of the sampled respondents adopt technology and weather forecasting strategies. The strategy reflects marketers' reliance on technology to anticipate weather changes, helping them make informed decisions about inventory, transport, and pricing. Access to accurate weather information can improve operational planning and reduce unexpected losses, as noted by Magesa et al. (2020), who argue that technology plays an important role in climate adaptation. Again, improved supply chain management was adopted by nearly 51.5% of marketers. This involves optimizing the logistics of crop movement from farms to markets, especially when weather extremes impact transportation. Efficient supply chain management helps minimize delays and spoilage, contributing to consistent market supply and profitability even during adverse weather. Oderinde et al. (2022) found similar trends, noting that well-managed supply chains enhance resilience in climate-affected regions. Around 46.2% of marketers employed mobile market strategies, allowing them to bring products directly to consumers or adjust locations based on crop availability and demand. Mobile markets help marketers overcome barriers posed by transport and infrastructure challenges, particularly during floods or dry spells when market access can be limited. This strategy is also reported by Adeosun et al. (2022), where mobile markets provide flexible solutions to accessibility challenges. With 39.9% of marketers using flexible pricing, this strategy enables adaptation to fluctuating supply costs and consumer demand, balancing prices based on crop availability and market conditions. Flexible pricing allows marketers to manage cost pressures and maintain consumer engagement, as supported by Ali et al. (2023), who identify price flexibility as a critical strategy for adapting to climate-induced supply shocks. Approximately 37.2% of marketers adopted online platforms to reach a broader customer base, providing alternatives to physical market presence when weather extremes occur. This digital approach broadens market reach and provides a platform for

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timely updates on product availability and pricing, aligning with Ali et al. (2023), who highlight the growing relevance of digital channels in modern food marketing. Despite its potential to mitigate financial risk, food crop insurance was barely adopted (0.1%). The low adoption rate may reflect limited awareness, availability, or affordability of insurance options. Tunio et al. (2024) suggest that insurance schemes are critical for providing a safety net in climate-affected regions, but challenges related to accessibility often limit uptake.

Table 3: Perceived Effects of Weather Patterns on Market Activities

Items/ Questions	SA	A	D	SD	Mean	Rank
Changes in weather patterns have led to a reduction in the availability of food crops in the market.	197(93.8)	11(5.2)	-	2(1.0)	3.92	1st
The occurrence of extreme weather events increases the prices of food crops in the market.	146(69.5)	34(16.2)	9 (4.3)	21(10.0)	3.45	8th
Profits are lower during periods of extreme weather conditions due to increased operational costs.	174(82.9)	5(2.4)	28(13.3)	3(1.4)	3.67	7th
Changes in weather patterns affect customer demand for certain types of food crops.	146(69.5)	21(10.0)	9(4.3)	34(16.2)	3.33	9th
Seasonal weather changes influence the types of food crops customers prefer to buy.	192(91.4)	7(3.3)	8(3.8)	3(1.4)	3.85	2nd
Extreme weather conditions increase the difficulty of transporting food crops to the market.	186(88.6)	9(4.3)	15(7.1)	-	3.81	3rd
Adverse weather patterns lead to higher spoilage rates of food crops before they reach the market.	187(89.0)	6(2.9)	12(5.7)	5(2.4)	3.79	5th
Weather-related issues increase the cost of storage and preservation of food crops.	186(88.6)	9(4.3)	11(5.2)	4(1.9)	3.80	4th
Frequent weather changes make it difficult to plan long-term marketing strategies for food crops.	179(85.2)	14(6.7)	14(6.7)	3(1.4)	3.76	6th

3.4. The Impact of Adapting to Weather Adaptation Measures on the Net Income of the Marketers

The results of the endogenous switching regression validate the robustness and appropriateness of the model, indicating that weather adaptation measures have significant income benefits for adapters while accurately adjusting for selection bias and endogeneity. The significant likelihood ratio test result and the non-zero, highly significant correlation coefficients (-0.964 and -1.000) confirm that unobservable factors are driving both the adaptation decision and income outcomes, a key assumption addressed by ESRM. Without accounting for this endogeneity, an OLS model would likely overestimate or underestimate the benefits of adaptation strategies. The statistically significant standard deviations (1.439 and 1.294) suggest that the income effects for adopters and non-adopters are distinct, meaning that adaptation provides a measurable economic benefit for adopters, even when accounting for unobserved differences. The endogeneity correction and significant treatment effects suggest that adaptation strategies do indeed lead to higher income for food crop marketers. Furthermore, a statistically significant value of the Likelihood Ratio (LR) test ($\chi^2 = 213.32$) indicates that the two equations are indeed correlated, validating the presence of selection bias. This further justifies the use of ESRM for the study.

3.4.1. Determinants of Adopting Weather Adaptation Measures: Selection Equation: The selection equation in Table 4 (column 2) identifies key factors influencing food crop marketers' decisions to adopt weather adaptation measures. The negative and statistically significant coefficient at a 5% level for distance to the nearest market implies that marketers farther from markets are less likely to adopt adaptation strategies by 7.8%, *ceteris paribus*. This finding highlights the role of proximity to markets in facilitating access to resources, training, and market-specific climate information, which are critical for implementing adaptation measures. Marketers in remote areas face greater logistical barriers, including limited infrastructure and access to support services, making adaptation more challenging. A similar finding was reported by Adeosun et al. (2022), who observed that market distance influences adaptation in agricultural practices. The significant negative impact of market location indicates that rural marketers are less likely to adopt adaptation measures by 16.3% than those in urban areas. Urban marketers have better access to adaptive resources, such as storage facilities, that enable them to respond more effectively to climate risks. This finding aligns with the study by Oderinde et al. (2022), who reported that the resource disparities between rural and urban marketers limit rural areas' adaptation capacity. The significant negative coefficient for perceived changes in rainfall shows that marketers who perceive declining rainfall are more likely to adopt adaptation measures by 0.02%. This finding reflects the awareness among marketers of risks posed by drought and water scarcity, which can disrupt crop supply and affect profitability. Similar observations were made by Alhassan and Haruna (2024), who found that sensitivity to rainfall variation significantly motivates the adoption of climate-smart adaptation practices among rural agricultural households. The significant positive coefficient for perceived temperature suggests that marketers who observe rising temperatures are more likely to adopt adaptation measures by 19.5%. This implies that marketers are cognizant of the adverse effects of heat stress on food quality and supply, motivating investments in adaptation, such as improved storage and transport solutions. Studies by Magesa et al. (2020) similarly indicate that temperature

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changes spur adaptation to protect crop quality. The positive and significant coefficient for association membership suggests that marketers who belong to associations are more likely to adopt adaptation measures by about 19% compared with their counterparts who are not. Associations serve as platforms for resource pooling, information exchange, and shared learning, which collectively strengthen adaptive capacity. Dapilah et al. (2020) found similar effects, noting that social networks are instrumental in building resilience to climate change by facilitating access to knowledge and support. The instrumental variables, participation in climate-related training and access to climate information, have significant positive and strong associations with adaptation likelihood at a 1% probability level. It means that access to reliable climate information increases the likelihood of adopting weather adaptations by 36.4% while participation in training on climate change increases the likelihood by 25.7%, *ceteris paribus*. This relationship suggests that when marketers have consistent and reliable access to climate forecasts, historical weather trends, and seasonal projections, they are better equipped to anticipate and respond proactively to adverse weather conditions. Additionally, training provides practical skills for addressing climate risks. These results align with the study by Magesa et al. (2020), who ascertained the importance of climate-related training and information in supporting climate resilience in agriculture.

Table 4: Full information maximum likelihood estimates of the endogenous switching regression model for Marketers' Performance

Explanatory Variable	Treatment Equation		Outcome Equations			
	Adoption Status		Non-adopters		Adopters	
	Coeff	Z	Coeff	Z	Coeff	Z
Education (years)	0.0006	0.080	-0.0036	-0.34	-0.0042	-0.41
Marketing Experience (years)	0.1085	0.67	0.1631	0.86	0.3470**	2.06
Distance to market (km)	-0.0777**	-2.30	-0.12011**	2.55	-0.0834**	1.96
Market location (rural)	-0.1626**	-2.83	0.5410***	6.93	0 .6420***	8.13
Credit (access)	0.0058	0.53	-0.0988	-0.89	0.2249**	2.05
Market information (access)	0.0072	0.65	-0.0095	-0.68	-0.0079	-0.51
Rainfall (decreased)	-0.0002***	-4.24	0.0530***	-3.76	-0.1330***	-8.69
Temperature (increased)	0.1949**	2.44	-1.93e-1	-0.02	0.0001***	6.97
Membership (yes)	0.1896**	2.29	-0.2119**	-2.28	0.0801	0.8
Log_Labour (₦)	-0.6173***	-17.59	7.8267***	6.68	3.6244**	3.18
Log_Transport (₦)	-9.2982***	-7.55	3.6244***	3.18	7.8267***	6.68
Training (yes)	0.2573**	3.97				
Climate information (access)	0.3638***	7.40				
$ln\sigma_1$			1.2935***	0.0839		
ρ_1			-0.9636***	0.0103		
$ln\sigma_2$					1.4388*	0.0707
ρ_2					-1	5.67e-08
Log-likelihood	-536.22					
Likelihood ratio of Independence $X^2(1)$			213.32			

*, **, *** signify significant level at 10%, 5%, and 1%, respectively.

3.4.2. Impact of Weather Adaptations on Net Income: Outcome Equation: The outcome equation in Table 4 (columns 2 and 3) analyses the factors affecting the net income of food crop marketers, with separate estimations for adopters and non-adopters of weather adaptation measures. Marketing experience has a positive and statistically significant impact on income for adopters (34.7%), indicating that seasoned marketers benefit financially from adopting adaptation strategies, likely due to their capacity to apply knowledge effectively in response to climate variability. This finding aligns with the study by Alhassan and Haruna (2024), who observed that farming experience significantly enhances adaptive decision-making and increases the likelihood of adopting climate-smart strategies in agricultural markets. However, experience is not significant for non-adopters, suggesting that adaptation amplifies the benefits of accumulated market knowledge by improving marketers' resilience to weather impacts. Distance to market has a significant negative effect on income for both adopters (8.3%) and non-adopters (12%), although the impact is more pronounced for non-adopters. This could imply that marketers further from markets, particularly those not using adaptation strategies, capitalize on local market demands or premium pricing for crops with limited urban availability. For adopters, distance may have a lesser impact on income, as adaptive strategies such as enhanced transport management. Similar observations are reported by Adeosun et al. (2022), mentioning that distance affects market access differently based on adaptation status. Market location is highly significant and positively associated with net income for both adopters and non-adopters by 64.2 and 54.1%, respectively. This implies that urban marketers, who often have access to diverse market channels, infrastructure, and support services, benefit from enhanced income, particularly when using adaptation measures. This effect suggests that adaptation strategies are more effective in urban settings due to resource availability, as confirmed by findings from Oderinde et al. (2022), which show that adaptation benefits are often amplified in urban markets due to infrastructure and resource advantages. Access to credit is positive and significant for adopters, indicating that having access to credit will increase net income by 22.5% when adapting to weather conditions. It is important to support climate adaptation investments, such as advanced storage or efficient transportation that enhance income. This supports the notion that credit facilitates adaptation, enhancing profitability among marketers who actively invest in resilience, as also reported by Adebayo and Adeola (2022) and Olutumise (2023a) in their study on credit access and adaptation in agriculture. Perceived rainfall changes have a significant negative impact on income for both adopters and non-adopters by a reduction of 13.3 and 5.3%, respectively. This finding indicates that despite adaptation strategies, adverse rainfall conditions such as drought or excess rain remain a significant constraint on income. This aligns with the findings of Malik et al. (2022), who reported that rainfall variability has far-reaching effects on crop yields and supply chain disruptions, undermining food availability across interconnected regions. For adopters, perceived temperature changes have a significant positive effect on net income, suggesting that adaptation strategies help mitigate temperature-related stress and enhance income. This result is consistent with findings by Magesa et al. (2020), who noted that adaptation practices improve resilience to heat stress, protecting profitability even in variable conditions. Again, both labor and transport costs are significant and positively associated with net income for adopters, suggesting that investment in these areas enhances profitability when combined with adaptation strategies. For non-adopters, transport also has a significant positive effect, although labor shows a stronger impact on income. These findings imply that while labor and transport investments drive income growth, adaptation enables more efficient resource use, enhancing returns on these investments. Recent studies, such as Tunio et al. (2024), also highlight that transport and labor investments are critical to profitability, especially when integrated with adaptive practices to manage climate-induced challenges.

3.4.3. Treatment Effects of the Impact of Weather Adaptation on Food Crop Marketers' Performance: The results reveal a significant Average Treatment Effect on the Treated (ATT), indicating that marketers who adopt adaptation measures achieve a significant income benefit of ₦279.0 than their non-adopting counterparts. Additionally, the Average Treatment Effect on the Untreated (ATU) is estimated at ₦108.2, suggesting that non-adopters could have achieved ₦108.2 as gains by adopting adaptation strategies. This finding indicates that adaptation measures could increase the net income of those yet to adopt the strategy. Again, the heterogeneity effects of ₦383.5 and ₦212.7 indicated that adopters consistently have higher income compared to the gains for non-adopters in the area (Table 5). The findings emphasize that adaptation measures substantial income when marketers adopt these measures. The overall Average Treatment Effect (ATE) across groups signals a broad economic advantage from adaptation. This evidence suggests that encouraging the adoption of adaptation measures could lead to more stable and resilient income levels across the sector.

Table 5: Impact of weather adaptation on expected net income (₦'000); treatment and heterogeneity effects

Treatment	Decision Regime		Treatment Effects
	Adopters	Non-adopters	
Adopters	880.8±212.2	601.8±99.5	279.0±103.7***
Non-adopters	497.3±204.2	389.1±52.9	108.2±49.2***
Heterogeneity effects	383.5±100.1***	212.7±98.3***	

Note: Values are Mean±SE. *** signifies a 1% probability level.

4. CONCLUSION

This study reveals that weather adaptation measures significantly influence the profitability of food crop marketers in Southwest Nigeria. It was concluded that weather variability was perceived to affect food crop marketing by reducing food availability, increasing costs and altering consumer demand. Thus, food marketers rely on some adaptation strategies to ensure market stability and profitability in the area. Community-based marketing, improved storage, product diversification, and technology use are the main strategies adopted by the marketers. Again, the key factors such as access to climate information, training, credit, and transportation costs are significant in enhancing adaptation measures, especially for marketers actively employing adaptive practices. The positive impact of adaptation is evident in higher net incomes among adopters, who benefit from increased efficiency in labor and resource management. Further, the study establishes that distance to the nearest market, market accessibility, and association membership are also significant in shaping adaptation decisions. However, these results identify a gap in adaptation equity where marketers in rural areas are less likely to adopt adaptation strategies, which might be due to limited access to resources and infrastructure. Again, the outcome equation reveals that adaptation significantly boosts net income for food crop marketers, particularly for those with access to credit, labor, and transport. The finding that

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adaptation amplifies the income impact of credit and transportation costs indicates that adaptive practices enhance marketers' ability to manage operational costs effectively. However, despite these positive income effects, the study reveals limitations in adaptation efficacy under extreme rainfall variability, as income remains negatively affected even among adopters. There is a significant Average Treatment Effect on the Treated (ATT) of ₦279,000, indicating that marketers who adopt adaptation measures achieve a substantial income benefit. Additionally, the Average Treatment Effect on the Untreated (ATU) is estimated at ₦108,200, suggesting that non-adopters would also experience improved income if they were to adopt these strategies. To this end, the study has provided empirical evidence on how weather adaptation measures enhance profitability in the context of food crop marketing, a perspective less examined in climate resilience literature. It highlights the role of adaptation, which is most effective when marketers have resource access (e.g., credit and infrastructure) and are situated in well-connected locations. Based on the study's findings, it can be recommended that the government should establish localized climate information centers in rural markets to provide marketers with timely, region-specific weather data. Such centers could operate through collaboration with the Nigerian Meteorological Agency and local agricultural extension offices. Additionally, expanding climate resilience training programs targeting rural and remote marketers, focusing on practical skills for rainfall management, dry-spell resilience, and temperature stress mitigation. Programs could be organized seasonally, providing marketers with timely guidance on anticipated climate conditions. The government should invest in rural road infrastructure improvements to reduce logistical barriers for marketers in remote areas. Reliable road access helps marketers transport goods efficiently, even during adverse weather, thereby minimizing spoilage and income loss. In the same vein, developing mobile extension services that deliver both climate information and marketing support to marketers in less accessible locations allows for more equitable access to adaptation resources. By collaborating with financial institutions with flexible loan repayment terms, microcredit programs specifically tailored for food crop marketers to enable them to invest in adaptive resources should be promoted in the area. Through membership association support, marketers can acquire affordable, climate-resilient storage facilities to reduce spoilage rates under varying weather conditions. This can be achieved by partnering with agricultural technology providers that could make the technology accessible at reduced costs.

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