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Socio-Economic Factors Influencing the Adaptation Strategies of Tomato Producers' to Climate Change in North West, Nigeria[A]

Ibrahim MAHARAZU[1], Olugbenga Omotayo ALABI[2*],
Ayoola Olugbenga OLADELE[3], Jeremiah Samuel ALUWONG[4]

Abstract: This work evaluated socio-economic factors influencing the adaptability strategy of tomato producers to climate change in the North West, Nigeria. Primary data utilized were based on well-designed questionnaire distributed to 100 tomato producers. Data were analyzed using descriptive statistics, using an adaptability strategy use index, multinomial Logit model, and principal component model. The outcome shows that the average age of tomato producers approximates 44 years. They are literate with an average of 12 years of school education. About 51% of tomato producers had access to credit, and they are smallholder farmers with an average of 0.81 hectares of farm land. The major climate change adaptation strategies used by tomato producers and their corresponding indexes include the planting of heat and drought tolerant crops (0.9725), use of improved seeds (0.9682), mulching (0.8981), soil and water conservation technique (0.8321), and use of organic manure (0.7931). The significant predictors influencing the choice of low climate change adaptation strategy users include years of school education, age, experience in tomato farming, and income earned from tomato farming. The significant predictors influencing high climate change adaptation strategy users include years of school education, and income earned from tomato farming. The major challenges faced by tomato producers and

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* **Sorumlu yazar/Corresponding Author:** [2]Olugbenga Omotayo, ALABI, Department of Agricultural Economics., Faculty of Agriculture, Universitiy of Abuja, PMB 117 Gwagwalada Abuja, Nigeria, omotayoalabi@yahoo.com, OrcID 0000-0002-8380-977

[1] Department of Agricultural-Economics, Faculty of Agriculture, Kaduna State University, (KASU), Kaduna State, NIGERIA. maharazu_ibrahim@kasu.edu.ng, OrcID 0000-0002-0968-6112

[3] Department of Agricultural Extension and Management, Federal College of Forestry Mechanization, PMB 2273 Afaka, Kaduna, Kaduna State, NIGERIA. oladeleayoola2007@gmail.com, OrcID 0000-0001-8831-5979

[4] Department of Agricultural-Extension and Management, School of Agricultural Technology, Nuhu Bamali Polytechnic, Zaria, Samaru Kataf Campus, Kaduna State, NIGERIA. jeremiahaluwong1@gmail.com, OrcID 0000-0001-8462-538X

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their corresponding Eigen values include a lack of improved seeds (8.6935), lack of technology (5.93660), lack of processing and storage facilities (3.9274), and lack of capacity building for producers (3.5173). Improved seeds, irrigation facilities, and farm technologies should be made available to tomato producers to combat threats of climate variability and increase productivity.

Keywords: Adaptability Strategy, Climate Change, North West, Socio-Economic Factors, Tomato Producers, Nigeria.

Jel: B23, C01, C40, D20, D51

Kuzey Batı Nijerya'daki Domates Üreticilerinin İklim Değişikliğine Uyum Stratejilerini Etkileyen Sosyo-Ekonomik Faktörler

Özet: Bu çalışma, Kuzey Batı Nijerya'daki domates üreticilerinin iklim değişikliğine uyum stratejisini etkileyen sosyo-ekonomik faktörleri değerlendirmiştir. Çalışmada kullanılan birincil veriler, 100 domates üreticisi ile yapılan anketlere dayanmaktadır. Veriler, tanımlayıcı istatistikler, uyum stratejisi kullanım endeksi, Multinomial Logit ve Temel Bileşen modelleri kullanılarak analiz edilmiştir. Sonuçlar, domates üreticilerinin ortalama yaşının yaklaşık 44 ve ortalama 12 yıllık eğitime sahip olduklarını göstermektedir. Domates üreticilerinin yaklaşık %51'inin krediye erişibildiği ve bunların ortalama 0,81 hektarlık tarım arazisine sahip küçük üreticiler olduğu belirlenmiştir. Domates üreticilerinin kullandığı başlıca iklim değişikliğine uyum stratejileri ve bunlara karşılık gelen endeksler arasında sıcaklık ve kuraklığa dayanıklı ürünlerin ekimi (0,9725), ıslah edilmiş tohum kullanımı (0,9682), malçlama (0,8981), toprak ve su koruma tekniği (0,8321) ve organik gübre kullanımı (0,7931) yer almaktadır. Düşük iklim değişikliği uyum stratejisi kullanıcılarının seçimini etkileyen önemli belirleyiciler arasında eğitim süresi, yaş, domates yetiştiriciliğindeki deneyim ve domates yetiştiriciliğinden elde edilen gelir yer almaktadır. Yüksek iklim değişikliğine uyum stratejisi kullanıcılarını etkileyen önemli belirleyiciler arasında eğitim süresi ve domates tarımından elde edilen gelir yer almaktadır. Domates üreticilerinin karşılaştığı temel zorluklar ve bunlara karşılık gelen Eigen değerleri arasında ıslah edilmiş tohum eksikliği (8,6935), teknoloji eksikliği (5,93660), işleme ve depolama tesislerinin eksikliği (3,9274) ve üreticiler için kapasite geliştirme eksikliği (3,5173) yer almaktadır. İklim değişikliği tehditleriyle mücadele etmek ve verimliliği artırmak için ıslah edilmiş tohum, sulama tesisleri ve tarım teknolojileri domates üreticilerinin kullanımına sunulmalıdır.

Anahtar Kelimeler: Uyum Stratejisi, İklim Değişikliği, Kuzey Batı, Sosyo-Ekonomik Faktörler, Domates Üreticileri, Nijerya.

Introduction

Tomato (*Lycopersicum esculentum*) accounted for 14% of vegetable production, and is ranked second after potato in terms of value, production and widely cultivated vegetable crops (Mwangi et al., 2020). Tomato farming contributes to foreign exchange, income generation, employment creation, and poverty alleviation among rural populations (Singh et al.,2017). Tomato contains vitamins A and C, potassium, fibre, and lycopene (Adenuga et al., 2013). Tomato production in Nigeria in 2021 and 2022 approximately 3477981 tons and 3684566.41 tons, respectively (FAO, 2024). The yield of tomatoes in Nigeria for 2021 and 2022 was approximately 42959 100g ha^{-1} and 52 466 100g ha^{-1} respectively (FAO, 2024). The world tomato production in 2021 and 2022 was approximately 189281485.32 tons and 186107972 tons, respectively (FAO, 2024). Despite the significance of tomato, its production is very low and producers do not utilize the inputs efficiently.

Climate change is one of the major environmental threats facing mankind and sustainable development globally. Climate change has adverse effects on food security, environment, economic activities, women's health, physical infrastructure, and natural resources (Huq et al., 2006). African is one of the vulnerable continent to climate change globally. The resultant impacts of climate change include drought, flooding, changes in the length of growing seasons, disease outbreaks, pest infestation, excessive temperature which cause damage and failure to crop production, delay harvesting (Muhammad-Lawal et al., 2017). Africa (Nigeria inclusive) is highly vulnerable to the effect of climate change due to the reliance of agriculture on weather, and rain-fed agriculture. Adaptation and vulnerability to climate change are critical issues in the present food security discussion among many sub-Saharan countries (Westengen and Brysting, 2004). Responding to climate change through mitigation will take long time, responding to climate change through adaptation becomes urgent issues particularly when the potentials to adapt is low, thus without adaptation, climate change is obviously detrimental to the agricultural sector (Gbetibuou, 2009).

Climate variability threatens the achievement of sustainable development goals especially food security and reducing poverty (Antwi-Agyei et al., 2021). The climate events and extreme weather conditions such as heavy rainfall, droughts, hurricanes, floods, high temperatures, cyclones, and heat waves, are an expression of climate variability. These events and events affected by climate change such as high temperatures, droughts, heavy rainfall, precipitation patterns, hurricanes, tornadoes, floods and wildfires cause important human mortality and morbidity that influence adversely well-being and mental health, and productivity (Ebi et al., 2021). Weather means short term atmospheric conditions but climate is the weather of a specific area or region approximate over a long and specific period of time. Climate change refers to long-term changes (Ebi et al., 2021). Both weather and climate relate to local conditions (rainfall, temperature, wind strength, etc.) in a specific region or location, but the main difference the two is a matter of time. To sustain the yields of tomato and increase agricultural production, there is need for effective adaptation strategies to combat the threats of climate change in crop production which has a lot of food security significant for the country. There is no adequate data on climate change adaptation strategies required for necessary policy documents for eradicating food insecurity, eliminating poverty and endemic malnutrition. Smallholder farmers who rely on farming activities would need a variety of adaptation strategies to mitigate the negative impact of climate change and maintain the rural livelihoods of farm families (Uddin et al., 2014). Several modern farm technologies have been developed and introduced at the farm level to reduce climate change threats and to achieve the target of sustainable development goal. Climate variability is more likely to raise the magnitude and frequency of some extreme weather events and natural hazards (Ajak et al., 2018).

The objective of the study is to investigate the socio-economic factors influencing adaptability strategy of tomato producers to climate change in North West, Nigeria. Specifically, the objectives are:

(i) determine the summary scores of tomato producers,

(ii) estimate the adaptability strategies used index (ASUI) of tomato producers to climate change,

(iii) evaluate the factors influencing adaptability strategies of tomato producers to climate change,

(iv) determine the challenges facing tomato producers' adaptability to climate change.

Materials and Method

This work was supervised in Kano and Kaduna States, Nigeria. A multi-stage sampling design was utilized to choose 100 tomato producers. Primary data were used based on a well-structured questionnaire. The sample number of tomato producers was predicated on the Yamane (1967) formula presented as:

$$n = \frac{N}{1+N(e^2)} = 100 \tag{1}$$

Where,

n = The Sample Number

N = The Sample Frame of Tomato Producers

The data were analyzed using inferential and descriptive statistics as follows:

Descriptive Statistics

This entails the use of percentage, mean, standard deviation, and frequency distribution to have a summary information of factors of interest.

The Adaptability Strategies Used Index

This necessitates the use of five-point Likert scale. The five point Likert scale is classified as never (1), rarely used (2), sometimes (3), often (4), and aways used (5). The adaptive strategies used index (ASUI) following Alabi et al. (2023) is defined as:

$$\text{ASUI} = \frac{[(N_1 \times 5)+(N_2 \times 4)+(N_3 \times 3)+(N_4 \times 2)+(N_5 \times 1)]}{M} \quad (2)$$

Where,

N_1 = Number of tomato producers' that always used adaptation strategy to climate change

N_2 = Number of tomato producers' that often used adaptation strategy to climate change

N_3 = Number of tomato producers' that sometimes used adaptation strategy to climate change

N_4 = Number of tomato producers' that rarely used adaptation strategy to climate change

N_5 = Number of tomato producers' that never used adaptation strategy to climate change

$M = n \times 5$

The Composite Score

The tomato producers would have a maximum score of 18 points and a minimum score of 0 points. The composite score following Alabi and Anekwe (2023) is defined as:

Higher Users = Between 18 points to (Mean + Standard Deviation) Points

Medium Users = Between the Highest Points of Lower Users and Lower Points of Higher Users

Low Users = Between (Mean - Standard Deviation) points to 0 points

Multinomial Logit Regression Model (MLRM)

The general MLRM is defined as:

$$P_r(y_i = j) = \frac{\exp(X_i\beta_j)}{1+\sum_{k=0}^{j}\exp(X_i\beta_j)} \quad (3)$$

and to ensure identifiability,

$$P_r(y_i = 0) = \frac{1}{1+\sum_{k=0}^{j}\exp(X_i\beta_j)} \quad (4)$$

$$Z_i = \beta_0 + \beta_1X_1 + \beta_2X_2 + \beta_3X_3 + \beta_4X_4 + \beta_5X_5 + \beta_6X_6 + \mu_i \quad (5)$$

Where,

Z_i = Adaptation Strategies of Tomato Producers (1, Low Users; 2, Medium Users; 3, Higher Users)

β_0 = Constant Term

β_1 - β_6 = Regression Coefficients

X_1 = Years of School Education

X_2 = Age in Years

X_3 = Experience in Tomato Farming (Years)

X_4 = Income Earned from Tomato Farming (Naira)

X_5 = Household Size (Number)

X_6 = Amount of Credit Accessed (Naira)

μ_i= Noise Term

PCM (Principal Component Model)

The challenges faced by tomato producers were exposed to PCM, the model will reduce many interrelated constraints to few unrelated ones. The model will withhold those challenges faced by tomato producers with Eigen values greater than one.The model will discard those with Eigen values less than one.

Results and Discussion

Summary Estimates of Factors of Interest

The summary information of factors of interest about tomato producers was displayed in Table 1. The average estimates of years of school education, age, and experiences in tomato farming are approximately 12 years, 44 years, and 11 years, respectively. In addition, the average estimates of income earned from tomato farming, and household size are approximately 225000 Naira, and 7, respectively. About 51% of tomato producers had access to credit, while 49% of tomato producers do not have access to credit. The tomato producers are smallholder farmers with approximately 0.81 hectares of farm land. The tomato producers are young, energetic, active, and resourceful. This outcome is in line with Mwangi et al. (2020) who obtained an average age of 37.03 years among smallholder farmers in Irinyaga County, Kenya.

Table 1: Summary Estimates of Factors of Interest

Variables	Unit of Measurement	$\bar{X}_i$	SD
Years of School Education	Years	12	3.45
Age	Years	44	4.13
Experience in Tomato Farming	Years	11	2.23
Income Earned from Tomato Farming	Naira	225000	7121.08
Household Size	Number	7	1.01
Access to Credit	1, Access, 0, No Access	0.51	0.04
Farm Size	Hectares	0.81	0.07

Source: Field Survey (2024), Exchange Rate is 1 USD = 1, 140 Naira

Adaptability Strategies Used Index (ASUI) of Tomato Producers

The ASUI of tomato producers was displayed in Table 2. Approximate eighteen (18) climate change adaptation strategies of tomato producers was evaluated. The first to four major climate smart adaptation strategies used by tomato producers with their corresponding ASUI includes planting of heat and drought tolerant crops (0.9725), use of improved seeds (0.9682), mulching (0.8981), and soil and water conservation technique (0.8321). Others include the use of organic manure (5th), cover crop (6th), crop rotation (7th) and use of wetland fadama (8th) with approximate ASUI of 0.7931, 0.7714, 0.7612, and 0.7208, respectively. This outcome conforms with the findings of Ojoko et al. (2017) who obtained various ASUI for climate smart agricultural practices (CSAPs) among respondents in Sokoto State, Nigeria.

Table 2: ASUI of Tomato Producers

S/N	Climate Change Adaptation Strategy	ASUI	Ranking
1	Planting of Heat and Drought Tolerant Crops	0.9725	1st
2	Use of Improved Seeds	0.9682	2nd
3	Mulching	0.8981	3rd
4	Soil and Water Conservation Technique	0.8321	4th
5	Use of Organic Manure	0.7931	5th
6	Cover Crop	0.7714	6th
7	Crop Rotation	0.7612	7th
8	Use of Wetland (Fadama)	0.7208	8th
9	Mixed Cropping	0.6811	9th
10	Agroforestry	0.6120	10th
11	Earlier Land Preparation	0.5813	11th
12	Change of Crop Calendar	0.5710	12th
13	Growing of Early Maturing Varieties	0.5613	13th
14	Building Water Harvesting Structures	0.5521	14th
15	Engaged in Off Farm Business	0.5414	15th
16	Climate Smart Planting Basins	0.5392	16th
17	Crop Diversification	0.5241	17th
18	Intercropping	0.5120	18th

Source: Field Survey (2024)

Factors Influencing Adaptability Strategies of Tomato Producers

The aggregate and individual influence of predictors on the choice of adaptation strategies used by tomato producers were evaluated using the multinomial logit model and the outcome was displayed in Table 3. The parameter values of the MNLM gives the direction of the effect of the predictors on the endogenous variable, the parameter values do not give the probabilities or the actual magnitude. Therefore, the marginal effects (ME) from MNLM evaluated the expected change in likelihood or probability of a particular adaptive strategies user group with respect to a unit change in the endogenous variable as indicated in Table 3. The chi–square probability reveals that the statistics of likelihood ratio was highly significant at ($P < 0.0000$), this suggests that the model has strong explanatory power. The pseudo R^2 of 0.8314 reveals that 83.14% of the variations in the endogenous variable was due to the variations in the predictors defined in the model. This confirmed that the tomato producers choice of adaptation strategies could be due to fitted covariates, the R^2estimate if the goodness of fit and therefore the model has performed well.

All the partial derivatives of the predictors have positive except age for both low and high users of climate change adaptation strategies among tomato producers. This conforms with a priori expectations. The marginal effects outcomes were considered for explanation:

Years of School Education: Smallholder tomato producers' years of school education increases the likelihood or probability of choosing low and high climate change adaptability users at (P < 0.01), respectively. This denotes that a 1% increase in the years of school education would give rise to 43.09% and 37.94% increase in the probability of tomato producers choosing low and high climate change adaptability users, respectively. These result are in line with outcome of Alabi and Anekwe (2023) and Maddison (2006).

Age of Tomato Producers: Outcomes in Table 3 revealed that the age of tomato producers was negatively and significantly related to the choice of low climate change adaptability users among tomato producers at 1% probability levels, respectively. A one-unit increase in the age of tomato producers will give rise to 28.13% decrease in the probability or likelihood of tomato producers choosing low level climate change adaptability use. This outcome agrees with the result of Ajak et al. (2018) who obtained an approximate 70.8% decrease in the probability of using water and soil conservation during the dry spell from a one-unit increase in the age of the household head.

Experience in Tomato Farming: As expected, experience in tomato farming has an increased probability or likelihood of low and high users of climate change adaptability strategies. The partial estimates of smallholder experience in tomato farming was positive and significant with the choice of low users to climate change adaptability strategies at a 5% probability level. Highly experienced tomato producers will have more skills in farming practices, and more information, be in position to develop and use adaptability strategies to climate variability threats. The outcome of this study shows that as smallholder tomato producers advanced in years of farming experience they increased the choice of climate change adaptability strategies by 43.12% among low users. This outcome conforms with the findings of Bazezew et al. (2013).

Income Earned from Tomato Farming: As shown in Table 3, the partial derivatives of income earned from tomato farming are positive and have a significant influence on the choice of climate change adaptability among low and high users at a 10% level of probability each, respectively. This implies that a marginal increase in income earned from tomato farming would give rise to a 33.18%, and 44.4% increase in the probability of choosing low and high users of climate change adaptability strategies.

Table 3: Factors Influencing Adaptability Strategies of Tomato Producers to Climate Change

Predictors	Par	Low Users		High Users	
		Coefficient	ME	Coefficient	ME
Years of School Education (X_1)	β_1	0.3316***	0.4309	0.3802***	0.3794
Age (X_2)	β_2	-0.3421*	-0.2813	-0.2815	-0.3267
Experience in Tomato Farming (X_3)	β_3	0.4913**	0.4312	0.2931	0.5893
Income Earned from Tomato Farming (X_4)	β_4	0.1910*	0.3318	0.3819*	0.4443
Household Size (X_5)	β_5	0.3218	0.2912	0.4317	0.6723
Amount of Credit Accessed (X_6)	β_6	0.2918	0.2214	0.3318	0.4319
Constant	β_0	2.1413**		4.4127**	
Log Likelihood = -92.324					
Wald Chi Square = 2439.35					
Pseudo R^2 = 0.8314					
Prob >χ^2 = 0.0000					

Source: Field Survey (2024), Par = Parameter, Reference Group = Medium Users
*-Significant at ($P < 0.10$), **-Significant at ($P < 0.05$), ***-Significant at ($P < 0.01$)

Challenges Faced by Tomato Producers

The challenges faced by tomato producers was made to undergo the analysis using PCM (Table 4). The challenges facing tomato producers with Eigen values greater than one were retained by the PCM. Those challenges with Eigen values less than one were discarded. A lack of improved seeds with an Eigen value of approximately 8.6935 was ranked 1st, and this explained 12.13% of all challenges withheld by the PCM. A lack of technology with an Eigen value of approximately 5.9366 was ranked second, and this express 24.08% of all challenges withheld by the PCM. A lack of processing and storage facilities with an Eigen value approximately 3.9274 was ranked 3rd, and this expresses 35.86% of all challenges withheld by the PCM. The PCM handled all challenges facing tomato producers explaining 85.86% of all challenges entered in the PCM. The chi-square value (5781.42) was significant at 1% probability level, this signifies that the PCM is well fitted.

Table 4: The Challenges Faced by Tomato Producers

Constraints	Eigen-Value	Difference	Proportion	Cumulative	Rank
Lack of Improved Seeds	8.6935	2.7569	0.1213	0.1213	1st
Lack of Technology	5.9366	2.0092	0.1195	0.2408	2nd
No Processing and Storage Facilities	3.9274	0.4101	0.1178	0.3586	3rd
Lack of Capacity Building for Farmers	3.5173	0.0810	0.1158	0.4744	4th
No Production all Year Round	3.4363	0.2510	0.1153	0.5897	5th
No Irrigation Facilities	3.1853	0.1979	0.0916	0.6813	6th
Lack of Fertilizers	2.9874	1.0067	0.0901	0.7714	7th
Lack of Credit	1.9807	1.1053	0.0872	0.8586	8th
Bartlett Test of Sphericity					
χ^2	5781.42***				
KMO	0.8180				
Rho	1.00000				

Conclusion and Recommendation

The study investigated socio-economic factors influencing the adaptability strategies of tomato producers to climate change in North West, Nigeria. Primary data were used based on a questionnaire administered to 100 tomato producers. The data were analyzed using descriptive and inferential statistics. The outcomes show that the tomato producers were young, strong, agile and energetic with an average age of approximately 44 years. The tomato producers are literate with an average of approximately 12 years of school education. They have considerable experience in tomato farming ($\bar{x}$ = 11 years). Approximately 51% of tomato producers have access to credit, while 49% of tomato producers do not have access to credit. The household sizes were large with an average of 7 people per household.

They are smallholder farmers who cultivate less than 5 hectares of farm land. The climate change adaptation strategy used by tomato producers were ranked based on their ASUI out of 18 points, and the outcome shows that the planting of heat and drought tolerant crops with ASUI of approximately 0.9725 was ranked 1st. The use of improved seeds with an ASUI of approximately 0.9682 was ranked 2nd, in addition, mulching with an ASUI of approximately 0.8981 was ranked 3rd, soil and water conservation technique with an ASUI of approximatey 0.8321 was ranked 4th, while use of organic manure with an ASUI of approximately 0.7931 was ranked 5th. The factors influencing the adaptability strategy of tomato producers to climate change were evaluated using a multi-nomial logit model. All the partial derivatives of predictors in the MNLM (except age) had positive coefficients which this is in line with priori expectations. The outcome shows that the years of school education, age, experience in tomato farming, and income earned from tomato farming were predictors influencing the choice of low climate change adaptation strategy users among tomato producers. In addition, the years of school education, and income earned from tomato farming were factors influencing the choice of high climate change adaptation strategy users among tomato producers. The Wald chi-square was statistically significant at a 1% probability level which signifies that the MNLM is well fitted. The major challenges faced by tomato producers were a lack of improved seeds (1st), lack of technology (2nd), lack of processing and storage facilities (4th), and lack of capacity building for farmers (5th). Based on the outcome of the research, the following recommendations were suggested:

(i) Improved seeds should be made available to tomato producers to combat threats of climate variability and increase productivity.

(ii) Farm technology should be provided for tomato producers to combat threats of climate variability and increase efficiency and productivity

(iii) Irrigation facilities should be provided to tomato producers for farming which will boost production.

(iv) Credit should be made available by the government and private organizations with single-digit interest rates and the credit should be made affordable and accessible to tomato producers.

(v) The government and private organizations should also provide fertilizers to tomato producers at affordable prices

(vi) The government and private organizations should provide storage and processing facilities for tomato, this will also create employment along the value chain.

(vii) Capacity buildings should be organized for tomato producers using the new farming technique to combat climate variability, this will increase efficiency and production.

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