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Smallholder Onion Farmers' Perceptions On CSA Technologies: Their Inclination Towards Collective Participation in Pro-Environmental Activities in Nigeria's Kano State

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تقييم إدراك صغار مزارعي البصل لتقنيات الزراعة الذكية مناخيًّا وميلهم للمشاركة الجماعية في الأنشطة الصديقة للبيئة في ولاية كانو النيجيرية

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Abstract

This study assessed smallholder onion farmers' perceptions of climate-smart agricultural (CSA) technologies and their interest in participating in collective pro-environmental activities in Kano State, Nigeria. A sample of 132 respondents was selected using a multi-stage sampling technique, and cross-sectional data for the 2023 cropping (rainy) season were collected through a well-structured questionnaire combined with an interview schedule. Moreover, inferential statistics were used to analyze the collected data. Empirically, it was shown that the majority of farmers were middle-aged, male, married, educated, had limited opportunity for crop diversification, cultivated onion on marginal scale, had poor economic capital, experienced morbidity in their households, and had limited access to credit facilities. Furthermore, for a better economic well-being of the farmers, the recommended social welfare threshold per capita per annum was ₦120,405 ($172.01). Owing to scarcity of resources, majority of the farmers were not actively willing to adopt CSA technologies. Besides, willingness to pay for CSA technologies among majority of the farmers was driven by the needs for soil nutrient reclamation, drought mitigation, and conservative adaptive measures. Further, the interest in collective participation in pro-environmental activities is hindered by perceived behavioural control and subjective norms. Succinctly, the study recommends the need for adequate credit provision and using a farmer-to-farmer extension approach so as enlighten farmers on the vitality of CSA technologies.

Keywords: CSA technologies, environment, farmers, sustainability, Nigeria

Introduction

It is widely acknowledged that climate change represents the most significant challenges to agriculture on a global scale (Sadiq et al., 2017a&b; Anuga et al., 2019; Sadiq et al., 2021a; Khoza et al., 2021). This has considerable implications for food security (Sadiq et al., 2017c; Gemtou et al., 2024), livelihoods (Sadiq et al., 2016; Sadiq et al., 2017d; Pagliacci et al., 2020), and environmental sustainability (Sadiq and Singh, 2017; Marr and Howley, 2019; Swart et al., 2023). In Nigeria, particularly in Kano State, smallholder farmers engaging in onion production are increasingly vulnerable to the adverse impacts of climate variability and change. These farmers heavily rely on rain-fed agriculture and face uncertainties related to rainfall patterns, temperature fluctuations, and extreme weather events, all of which affect crop yields and household incomes.

Amidst these challenges, the concept of climate-smart agriculture (CSA) has emerged as a promising approach to promote sustainable farming practices that enhance resilience to climate change, while reducing greenhouse gas emissions and improving productivity (Belay et al., 2022; Li et al., 2024; Bazrafkan et al., 2024). The benefits of CSA technologies encompass a range of practices and innovations tailored to specific agro-ecological conditions, aiming to optimize resources use efficiency and minimizing environmental impacts (Sargani et al., 2023; Makamane et al., 2023).

Despite the potential benefits of CSA technologies, their adoption among smallholder farmers in Kano State, particularly onion farmers, remains limited. This gap between potential and actual adoption rates underscores the importance of understanding farmers' perceptions of CSA technologies and their intentions towards participating in collective pro-environmental activities.

This study focuses on assessing the perceptions of smallholder onion farmers in Kano State regarding climate-smart agricultural technologies and their inclination towards collective participation in pro-environmental activities. By conducting a detailed case study and employing both qualitative and quantitative methods, the research aims to explore the factors influencing farmers' attitudes towards CSA technologies. It also seeks to investigate the motivations, barriers, and facilitators that shape farmers' intentions to engage in collective actions aimed at mitigating climate risks and promoting sustainable agricultural practices.

The specific context of onion farming in Kano State offers a unique lens to examine t these dynamics. Onions (Allium cepa) are a staple crop in the region, significantly contributing to local diets and economic livelihoods. Understanding how onion farmers perceive and respond to CSA technologies is crucial for developing context-specific strategies that can enhance adoption rates and promote sustainable agricultural development in the face of climate change.

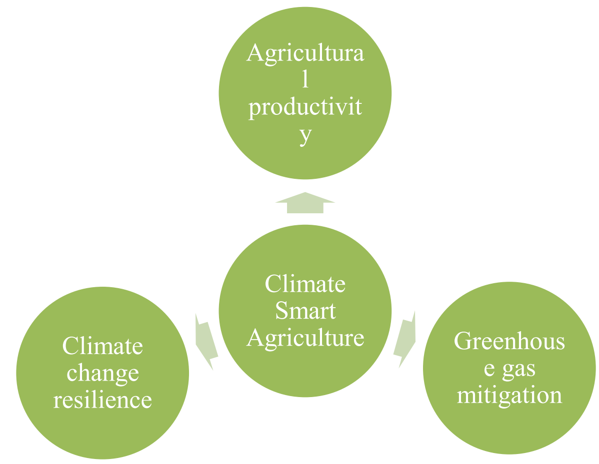
By bridging the gap between theory and practice, this study aims to generate practical and actionable insights for policymakers, agricultural extension services, and development practitioners. These insights can help support smallholder farmers in adopting climate-smart agricultural practices. Ultimately, these efforts are essential for building resilience, ensuring food security, and promoting environmental sustainability in the agricultural sector of Kano State, Nigeria.

In summary, this study contributes to the broader discourse on climate adaptation in agriculture by examining smallholder onion farmers' perceptions of CSA technologies and their intentions towards collective participation in pro-environmental activities in Kano State, Nigeria. The specific objectives include assessing the socio-economic characteristics of the farmers, determining the social welfare status of the farmers, assessing the extent of their willingness to apply and pay for the

CSA technologies, and identifying the factors influencing their intention to collectively participate in pro-environmental activities in the study area.

Figure 1

The goals (pillars) of climate smart agriculture



Source: Taimour et al., 2022; Davis et al., 2019.

Research methodology

Kano State, situated in northern region of Nigeria, is one of the country's most densely populated and economically significant states (Sadiq, 2023; Sadiq et al., 2022a&b) (Figure 2). It is known for its rich cultural heritage, historical significance, and vibrant agricultural sector. The State is bordered by Katsina State to the northwest, Jigawa State to the northeast, and Kaduna State to the southwest (Sadiq et al., 2022a, & b). Its geographic coordinates ranged from approximately 11.5°N to 13.5°N latitude and 7.5°E to 9.5°E longitude (Sadiq et al., 2022a, & b; Sadiq et al., 2021b, c, & d). Further, the State exhibits diverse agro-ecological zones, including the Sudan savanna, Sahel savanna, and Guinea savanna (Sadiq et al., 2021b, c, & d). These zones are characterized by varying levels of rainfall, soil types, and vegetation cover, which influence agricultural production systems and cropping patterns within the state (Sadiq et al., 2021b, c, & d).

Agriculture is the backbone of the economy in Kano State, providing employment for a large portion of the population and substantially contributing to the state's Gross Domestic Product (GDP) (Sadiq et al., 2022b). Kano is well known for its diverse agricultural activities, including crop cultivation, livestock rearing, and agro-processing industries (Sadiq et al., 2022b; Sadiq et al., 2021b, c, &d).

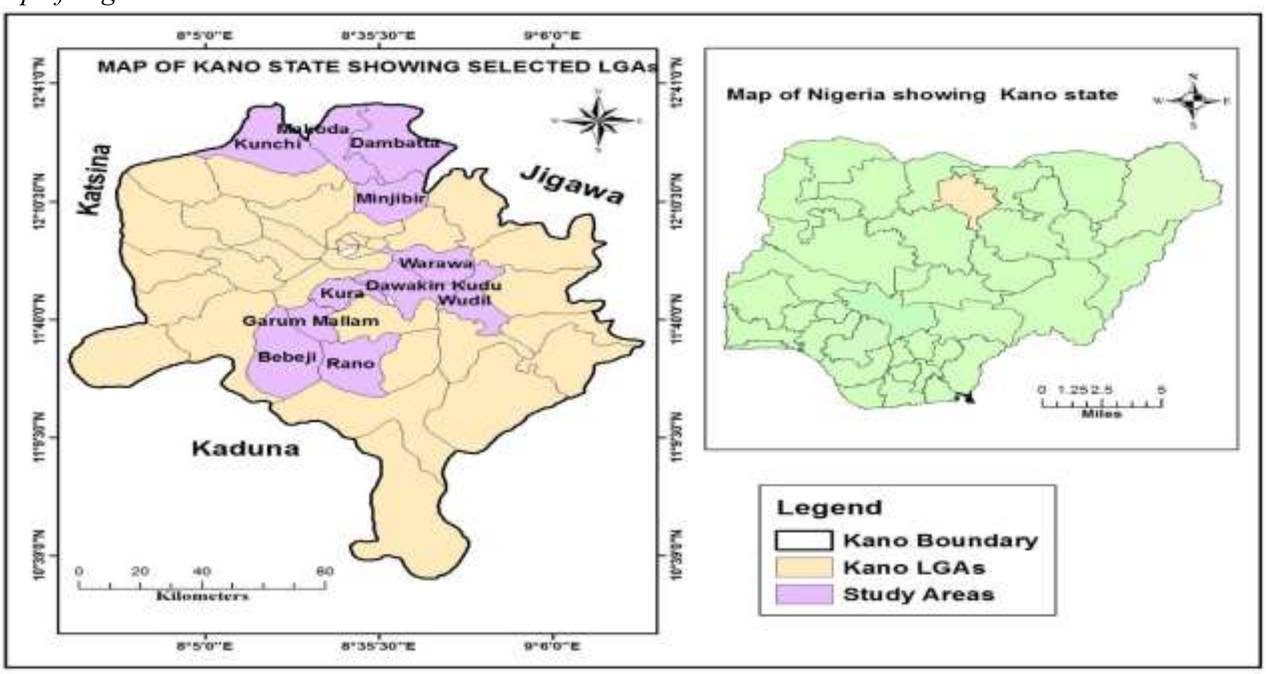
One of the prominent agricultural activities in Kano State is the cultivation of onions, which has made the region one of the leading onion-producing regions in Nigeria. Smallholder farmers in the region rely on favorable agro-climatic conditions, including sandy soils, warm temperatures, and adequate rainfall during the rainy season, which create conducive environments for onion cultivation (Sadiq et al., 2021b, c & d). Smallholder farmers play a significant role in onion production, employing traditional farming practices alongside modern techniques.

Kano is home to a diverse mix of ethnic groups, including the Hausa, Fulani, Kanuri, and others, each with its unique cultural heritage and farming traditions. Traditional institutions, social networks, and community-based organizations play crucial roles in shaping agricultural practices, resource management, and collective decision-making processes within rural communities. Despite its agricultural potential, Kano State faces various challenges, including land degradation, water scarcity, pest and disease outbreaks, limited access to inputs and credit facilities, and inadequate infrastructure. However, the State also presents opportunities for innovation, investment, and sustainable development initiatives aiming at enhancing agricultural productivity, resilience, and environmental sustainability.

Using a multi-stage sampling technique, a total of 132 onion farmers constituted the sample size. First, given the prevalence of onion cultivation in the State, all the stratified ADP (Agricultural Development Project) zones; namely, Zones I (Rano), II (Dambatta) and III (Gaya), were adopted. Second, a proportionate sampling technique, utilizing a 30% scale, was applied to select the representative Local Government Areas (LGAs). Noteworthy, given the high density of onion production in Zones I and II, all the LGAs totaling 27 constituted the sampling frame. Whereas, in Zone III, only 11 out of the 17 LGAs comprised the sampling frame as the remaining 6 LGAs are metropolises with little or no onion farming activities. Succinctly, using a 30% scale, four LGAs were randomly selected from Zones I and II, and three LGAs were selected from Zone III, resulting in a total of 11 LGAs. Subsequently, three villages were randomly chosen from each of the selected LGAs. Since there was no definite sampling frame for onion farmers, a freelance survey was conducted, and four farmers were randomly selected from each of the chosen villages, amounting to a total sample size of 132 farmers. Further, a well-structured questionnaire alongside an interview schedule was used to elicit cross-sectional data on onion production during the 2023 cropping (rainy) season, employing an easy-cost route approach. Objectives I, III and IV respectively, were achieved using the K-means cluster model, while objectives II and V were fulfilled using Atkinson's social welfare index and confirmatory factor analysis (CFA), respectively.

Figure 2

Map of Nigeria's Kano State



Source: Authors' own drawing, 2023.

Table 1
Sampling procedure and sample size

Zones	LGAs	Villages	Sample size
		Kiriya	4
	Bebeji	Babuda	4
		Dirbawa	4
		Dorawar Sallau	4
Zone I	Garun Malam	Kadawa	4
		Garin Babba	4
		Karfi	4
	Kura	Imawa	4
		Kura	4
		Jan Garu	4
	Rano	Rurum	4
		Sabuwar Kaura	4
		Diggol	4
	Dambatta	Gwanda	4
		Zakirai	4
		Kasuwar Kuka	4
Zone II	Kunchi	Zanchi	4
		Sabon Ruwa	4
		Dan Marke	4
	Makoda	Dunawa	4
		Koguna	4
		Baita	4
	Minjibir	Dan Madanho	4
		Wasai	4
		Gidan Gayawa	4
	Dawakin Kudu	Sarai	4
		Yan Baran	4
		Garin Dau	4
Zone III	Warawa	Katarkawa	4
		Dan Hawa Giwa	4
		Tsibiri	4
	Wudil	Lajawa	4
		Wudil	4
3	11	33	132

Source: KNADP and Reconnaissance survey, 2023.

Definition of Variables and Measurements

Table 2

CSA technologies

Technology(ies)	Mitigation measures
Water-smart	**Interventions that improve water use efficiency**
Land leveling (W1)	Leveling the field ensures uniform distribution of water in the field and reduces water loss (also improves nutrient use efficiency)
Land drainage (W2)	Removal of excess water (flood) through water control structure
Runoff control channels (W3)	Digging channels around the farm to prevent flooding
Using the raised-bed cultivation method (W4)	Makes furrow in the farm to control the runoff
Energy-smart	**Interventions that improve energy use efficiency**
Minimum tillage (E1)	Reduces amount of energy use in land preparation. In long-run, it also improves water infiltration and organic matter retention into the soil.
Using biogas (E2)	Converting livestock waste to biofuels to reduce greenhouse gases.
Direct cultivation (Without tillage) (E3)	Using machines to plant seeds in the proper depth, without tillage. This method of seed cultivation eliminates the need for plowing and reduces the amount of energy use in land preparation.
Carbon-smart	**Interventions that reduce GHG emissions**
Integrated pest management (C1)	Reduces use of chemicals.
Fodder management (C2)	Promote carbon sequestration and sustainable land use.
Concentrate feeding for livestock (C3)	Reduces nutrient losses and livestock requires lower amount of feed. Enteric fermentation processes within the cow are a major source of GHGs that could be managed by an appropriate feeding strategy.
Agroforestry (C4)	Promotes carbon sequestration and sustainable land use.
Weather-smart	**Interventions that provide services related to income security and weather advisories to farmers**
Crop planning based on the regional climate condition (WT1)	Considering climate condition in selection of crops to increase the resilience toward climate change.
Climate smart housing for livestock (WT2)	Protection of livestock from extreme climatic events (e.g. cold stresses/ flood).
Multiple cropping (WT3)	Growing two or more crops in the same piece of land during one growing season to compensate income loss due to vagaries of weather.
Crop insurance (WT4)	Crop-specific insurance to compensate income loss due to vagaries of weather.

Technology(ies)	Mitigation measures
Knowledge-smart	**Use of combination of science and local knowledge**
Consult with villagers to control runoff (K1)	Using local knowledge and experience to control the runoff.
Contingent crop planning (K2)	Climatic risk management plan to cope with major weather-related contingencies like drought, flood, heat/cold stresses.
Weather based crop agro-advisory (K3)	Climate information-based value added agro-advisories to the farmers.
*Seed and fodder banks (K4)	Conservation of seeds of crops and fodders to manage climatic risks.
Nutrient-smart	**Interventions that improve nutrient use efficiency**
Site-specific integrated nutrient management (N1)	Optimum supply of soil nutrients over time and space matching the requirements of crops with the right product, rate, time and place.
Intercropping with legumes (N2)	Cultivation of legumes with other main crops in alternate rows or mixed. This practice improves nitrogen supply and soil quality.
Leaf color chart (N3)	Quantify the required amount of nitrogen use based on greenness of crops. Mostly used for split dose application in rice but also applicable for maize and wheat crops to detect nitrogen deficiency.
Cover crops method (N4)	Reduces evaporation of soil water (also adds nutrients and organic matter into the soil).

Source: Adapted from Taimour et al., (2022).

Note: The asterisk indicates that the sub-technology was dropped due to multicollinearity; measurement was based on five-point Likert scale (Very likely to Unlikely)

Table 3

Theory of planned behavior attributes

Indicators	Statements
Intention (IP) (α = 0.89)	I intend to participate in environment and nature conservation.
	I intend to cooperate with the government, experts and stakeholders engaged in environment and nature conservation.
	I intend to pay for environment and nature conservation.
	I intend to learn the required skills for environment and nature conservation.
Perceived Behavioral Control (BP) (α = 0.76)	I believe that participation in environment and nature conservation activities is easy.
	I have the required time and skill for engagement in environment and nature conservation activities.
	I enjoy the required economic capability (affordability) for participation in environment and nature conservation.
	*Participation in environment and nature conservation is feasible.
Attitude (AP) (α = 0.80)	I think participation in environment and nature conservation is a desirable activity.

Indicators	Statements
	Participation in environment conservation and nature is wise.
	Participation and engagement in environment and nature conservation has economic, social and environment benefits.
	Individual's participation in environment and nature conservation in the current crisis is a necessity.
	*The effects of collective environmental actions on nature and environment should be evaluated in long-term.
	*Participation in pro-environmental collective activities should be prevalent in the society.
Subjective Norms (SNP) (α = 0.85)	My acquaintances believe that you should participate in environment and nature conservation activities.
	My commitment to participation in environment and nature conservation leads to confirming you by friends and acquaintance.
	*Because of my confirmation by acquaintances, I should participate in environment and nature conservation activities.
Social Identity (SIP) (α = 0.72)	I am happy to participate as a member of a group or non-governmental pro-environmental association in environment and nature conservation.
	Participation in environment and nature conservation is an important part of your self-concept.
	*I think that empathy is a good characterization of individual's participating in environment and nature conservation.

Source: Adapted from Faghani et al., (2023)

Note: The asterisk indicates that the sub-technology was dropped due to multicollinearity; measurement was based on five-point Likert scale (Strongly Agree to Strongly Disagree); α = Cronbach's Alpha reliability coefficient

Empirical Model

Social welfare model

Nuancing from the work of Sadiq and Sani (2024), the Atkinson social welfare indicator is presented below:

$$\xi(k;\varepsilon)=\begin{cases}\left|\frac{1}{\sum_{i=1}^{n}w_i^k}\sum_{i=1}^{n}w_i^k(y_i)^{1-\varepsilon}\right|^{\frac{1}{1-\varepsilon}} \rightarrow if\ \varepsilon\neq 1\ and\ \varepsilon\geq 0\\ Exp\left|\frac{1}{\sum_{i=1}^{n}w_i^k}\sum_{i=1}^{n}w_i^k ln(y_i)^{1-\varepsilon}\right| \rightarrow \varepsilon=1\end{cases} \quad \ldots\ldots (1)$$

Using the symbol $\xi(k;\rho)$ to denote the S-Gini social welfare indicator, we have:

$$\xi(k;\rho)=\sum_{i=1}^{n}\left[\frac{(V_i)^{\rho}-(V_{i+1})^{\rho}}{[V_1]^{\rho}}\right]y_i \quad \ldots\ldots (2)$$

$$V_i=\sum_{h=i}^{n}w_h^k \quad \ldots\ldots (3)$$

Using the notation $\xi(k;\varepsilon,\rho)$ to denote the Atkinson-Gini social well-being index, we have:

$$\xi(k;\varepsilon,\rho)=\begin{cases}\left[\sum_{i=1}^{n}\left[\frac{(V_i)^{\rho}-(V_{i+1})^{\rho}}{[V_1]^{\rho}}\right](y_i)^{1-\varepsilon}\right]^{\frac{1}{1-\varepsilon}} \rightarrow if\ \varepsilon\neq 1, \varepsilon\geq 0\ and\ \rho\geq 1\\ Exp\left[\sum_{i=1}^{n}\left[\frac{(V_i)^{\rho}-(V_{i+1})^{\rho}}{[V_1]^{\rho}}\right]lny_i\right] \rightarrow \varepsilon=1\ and\ \rho\geq 1\end{cases}$$

…… (4)

$$V_i=\sum_{h=i}^{n}w_h^k \quad \ldots\ldots (5)$$

Results and Discussion

Socio-Economic Characteristics

In describing the socio-economic characteristics of the farmers, three categories of farmers were identified as evident from the k-mean cluster analysis vis-à-vis clusters 1, 2 and 3 (Table 4 and Figure 3a). In the first cluster, the farmers have the following characteristics: late-middle-aged farmers with marginal operational holdings, small income earners, and no agricultural holdings. Moreover, they are illiterate, widowed/divorced, and have a small household size, often consisting of their biological children. Further, they are new entrants into onion production with minimal farming experience, no extension contact(s), and no health challenges are encountered among household members in the last production season. However, they have access to credit.

The second cluster is composed of farmers with large income base, who cultivate onions on a large scale, practice crop diversification, they are young, non-married males, have encountered sickness(s) among the household members in the last production season, and have adequate farming experience in onion production. Besides, these farmers have extension contact, but have no access to credit facilities. They are illiterate, thus a challenge to effective adoption of new farm practices that are not compatible with the conventional farm practices in the study area. Despite being youngsters and non-married males, the result showed that they support/shoulder a large household size, possibly because they serve as the breadwinners for the larger family. This is common among vulnerable households composed of women and elderly, or perhaps in the case when the primary head of the household is deceased. In the study area, cultural and religious norms restrict women from becoming the primary household head, if there is a living male adult in the household fold.

The last cluster consists of farmers who are in their early middle age, married males, literate, have extension contacts, have small households, and have negligible experience in onion farming– i.e, new entrants into this type of farming. Moreover, they have no access to credit, with limited resources. Further, they are marginal farmers or laborers who work on shared crops, due to the absence of an adult male child in their respective households. However, farmers in this category have access to extension contacts. Likewise, last season, the farming families also experienced heath challenges.

Noteworthy, the f-statistics showed household size and extension contact do not constitute significant causal factors in the socio-economic profile of the farmers in the study area. Nevertheless, the percentage of farmers in clusters 1, 2 and 3 was 10.61%, 28.03%, and 61.36%, respectively. Generally, based on the ANOVA results, the majority of the farmers are middle-aged; a cogent factor that will permit active participation in onion farming. The enterprise is male-dominated; i.e., gender bias due to religious and cultural barriers. They are married, i.e., a possibility that the farmers would see the enterprise as their prime source of livelihood. The majority are literate, i.e., a cogent reason for easier disseminations and adoptions of CSA technologies. Moreover, they are new entrants into the onion farming; cultivate onion on a marginal scale with limited tendency for crop diversification. Also, the majority has poor economic capital, limited access to credit facilities, and have experienced morbidity in their various households.

Table 4

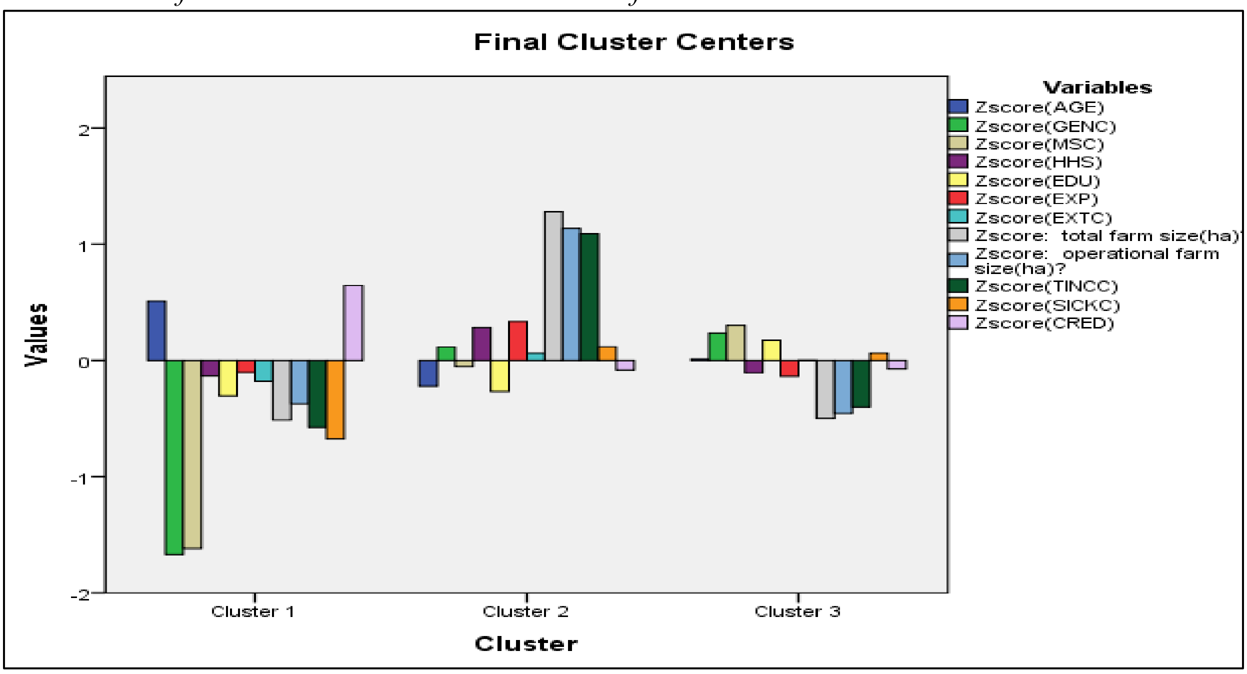
Socio-Economic Profile of the Farmers

Variables	Cluster 1	Cluster 2	Cluster 3	F-statistics
Age (year)	0.51012	-0.22022	0.01243	2.80*
Gender (male=1, otherwise=0)	-1.66946	0.1156	0.23575	32.64***
Marital status (married =1, otherwise=0)	-1.61862	-0.05172	0.30338	32.88***
Household size (number)	-0.13234	0.28192	-0.1059	2.08^{NS}
Education (year)	-0.30365	-0.26638	0.17416	3.29**
Farming experience (year)	-0.10368	0.33463	-0.13494	2.971*
Extension contact (yes=1, otherwise=0)	-0.17723	0.06304	0.00184	0.29^{NS}
Agricultural holding (hectare)	-0.51104	1.28044	-0.49657	116.39***
Operational holding (hectare)	-0.37377	1.138	-0.45522	66.82***
Income (Naira = ₦)	-0.5746	1.09229	-0.39964	57.43***
Sickness of household member (number)	-0.67405	0.11795	0.06262	3.75**
Credit Access (yes =1, otherwise=0)	0.64571	-0.0822	-0.07406	3.39**
Population	14(10.61)	37(28.03)	81(61.36)	
Distances between final cluster centers				
1	-	4.004	2.989	
2	4.004	-	2.948	
3	2.989	2.948	-	

Source: Field survey, 2023.
Note: Value in parenthesis is percent; ***,**,* & NS mean 1, 5, 10% and non-significant respectively.

Figure 3a

Distribution of the Farmers' Socio-Economic Profile

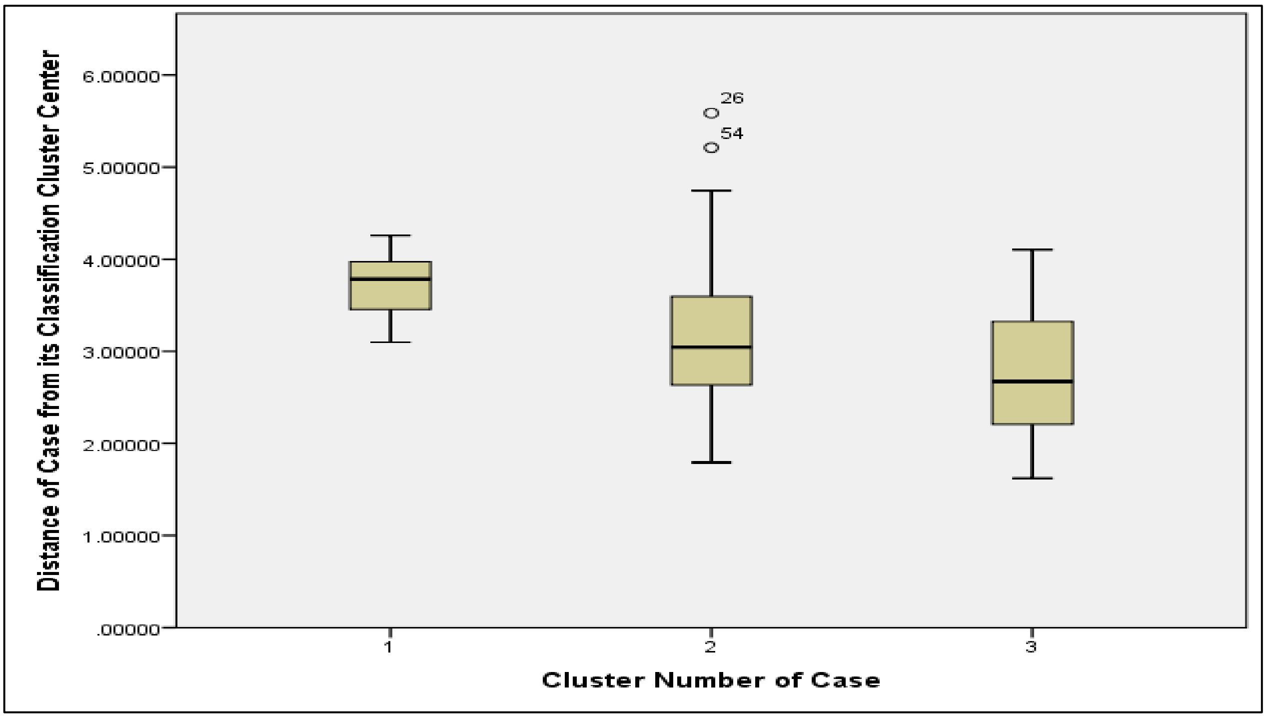


Source: SPSS output

Furthermore, the box plot assessment showed cluster 1 had a minimal internal difference in the distribution of the respondents and had small concentration of the respondents in the highest position (Figure 3b). Whereas, the box plots of clusters 2 and 3 had large internal differences in the distribution of the respondents and had concentration of social qualities of clusters 2 and 3 in the low position. Though, co-operative membership as a variable was dropped due to multicollinearity, the present study advises the farmers in clusters 1 and 3 to explore social capital pooling to address the associated human risks vis-à-vis land acquisition, poor economic capital, poor level of literacy, and access to advisory services (peculiar to cluster 1), and poor access to credit (peculiar to cluster 3). Noteworthy, social capital pooling has the wherewithal to improvise affordable and quality healthcare, particularly for farmers in cluster 3.

Figure 3b

Box Plot Assessment of Farmers' Socio-Economic Profile



Source: SPSS output

Social Welfare Status of the Farmers

Table 5 and Figure 4 provide an insightful hint into the welfare status of small-scale onion farmers within the study area. The Atkinson index, a measure of inequalities, is calculated to be 0.040649. This index suggests a low level of inequalities in the distribution of total income among all households. The subsequent social welfare value of ₦1,012,502 indicates the recommended threshold for normal social welfare per household annually in the studied area. Furthermore, the average welfare level, estimated at ₦1,055,404, serves as a benchmark for the recommended comfort zone for each household per annum. This information not only gauges the disparities in income distribution, but also provides a tangible reference point for assessing the overall economic well-being of the farmers.

Examining the income per capita (Table 5 and Figure 4), an Atkinson index of 0.064955 is derived. This index serves as a metric for the level of inequality in the distribution of total income per capita, revealing a low degree of inequality in this aspect. The associated social welfare value of

₦120405 suggests that this amount is the recommended level for normal social welfare per farmer annually in the study area. Additionally, the average welfare level of ₦128769.20 indicates the recommended comfort zone for each individual in the studied region. This insight offers a nuanced understanding of the economic disparities, not only at the household level but also at the individual level, contributing to a more comprehensive evaluation of the welfare status within the farming community.

Table 5

Social Welfare Status of Onion Famers

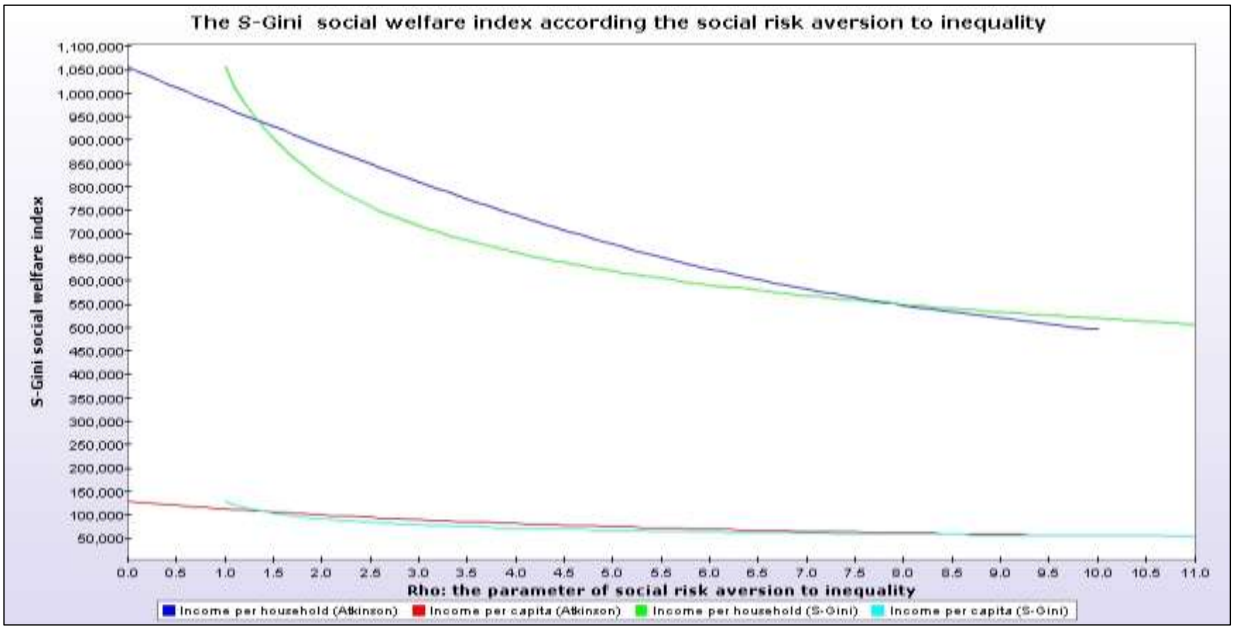
Variable	**Atkinson (Welfare)**			**S-Gini (Welfare)**		
	Coefficient	**SE**	**t-statistic**	**Coefficient**	**SE**	**t-statistic**
	Income per household					
Estimate	0.040649	0.004827	8.42***	0.226735	0.01469	15.43***
SW	1012502	40006.97	25.30***	816106.5	31532.18	25.88***
Average	1055404	42703.65	24.71***	1055404	42703.64	24.71***
	Income per capita					
Estimate	0.064955	0.007667	8.47***	0.285407	0.017697	16.12***
SW	120405	5526.66	21.78***	92017.6	4511.73	20.39***
Average	128769.20	6014.66	21.40***	128769.2	6014.66	21.40***
	Atkinson-Gini (Welfare)					
	Coefficient	SE	t-statistic			
	Income per household					
Estimate	0.249614	0.016715	14.93***			
SW	791960.1	31169.36	25.40***			
Average	1055404	42703.64	24.71***			
	Income per capita					
Estimate	0.312835	0.020099	15.56***			
SW	88485.7	4457.74	19.84***			
Average	128769.2	6014.66	21.40***			

Source: Field survey, 2023.

Note: *** means significant at 1% probability level; SW = Social welfare

Figure 4

Atkinson and S-Gini Social Welfare Index According to the Social Risk Aversion to Inequality



Source: SPSS output

Extent of Farmers' Agreement to Apply CSA Technologies

In assessing the extent of farmers willingness to apply the climate-smart agricultural technologies, the k-mean cluster analysis classified the farmers into three clusters *viz*., clusters 1, 2 and 3 as shown in Table 6 and Figure 5a. Cluster 1 comprised 32.58% of farmers who strongly agreed to apply energy smart technology; cluster 2 comprised 40.91% of farmers who strongly agreed to apply knowledge and nutrient smart technologies, while cluster 3 comprised 26.51% of farmers who strongly agreed to apply water, carbon, weather and knowledge-smart technologies. Upon examining the box-plots (Figure 5b), it was observed that clusters 1 and 2 exhibited high dispersion, indicating unbalanced distribution, whereas cluster 3 exhibited small dispersion, indicating balanced distributions among farmers in the overall extent of applying climate-smart agricultural technologies. In addition, it was noted that half of the farmers in cluster 1 and the majority in cluster 2 were above the mean level, whereas in cluster 3, only a few farmers were above the mean level, as evident from the cross margin of their respective box-plots (Figure 5b).

In summary, it can be inferred that cluster 1 is characterized by farmers with lower or no educational levels, laggards/conservative with poor resources, operating marginal farm holdings, and showing a preference for low-cost technologies with short-term benefits. Cluster 2 is characterized by literate farmers with a lower income, operating small farm holdings and aiming for medium-term farm benefits. On the other hand, cluster 3 is characterized by innovative farmers, i.e., innovators; highly literate, possessing medium to large income, operating medium-to-large farm holdings, and aiming for long-term farm benefits.

In conclusion, the study suggests that the willingness of farmers to adopt climate-smart agricultural technologies in the study area is relatively low, as indicated by the majority within clusters 1 and 2. This may largely be attributed to resource paucity. Thus, the study recommends that farmers should explore social capital given its inherent enormous advantages *viz*., monetary economic advantages.

Table 6

Extent of Farmers' Agreement to Apply CSA Technologies

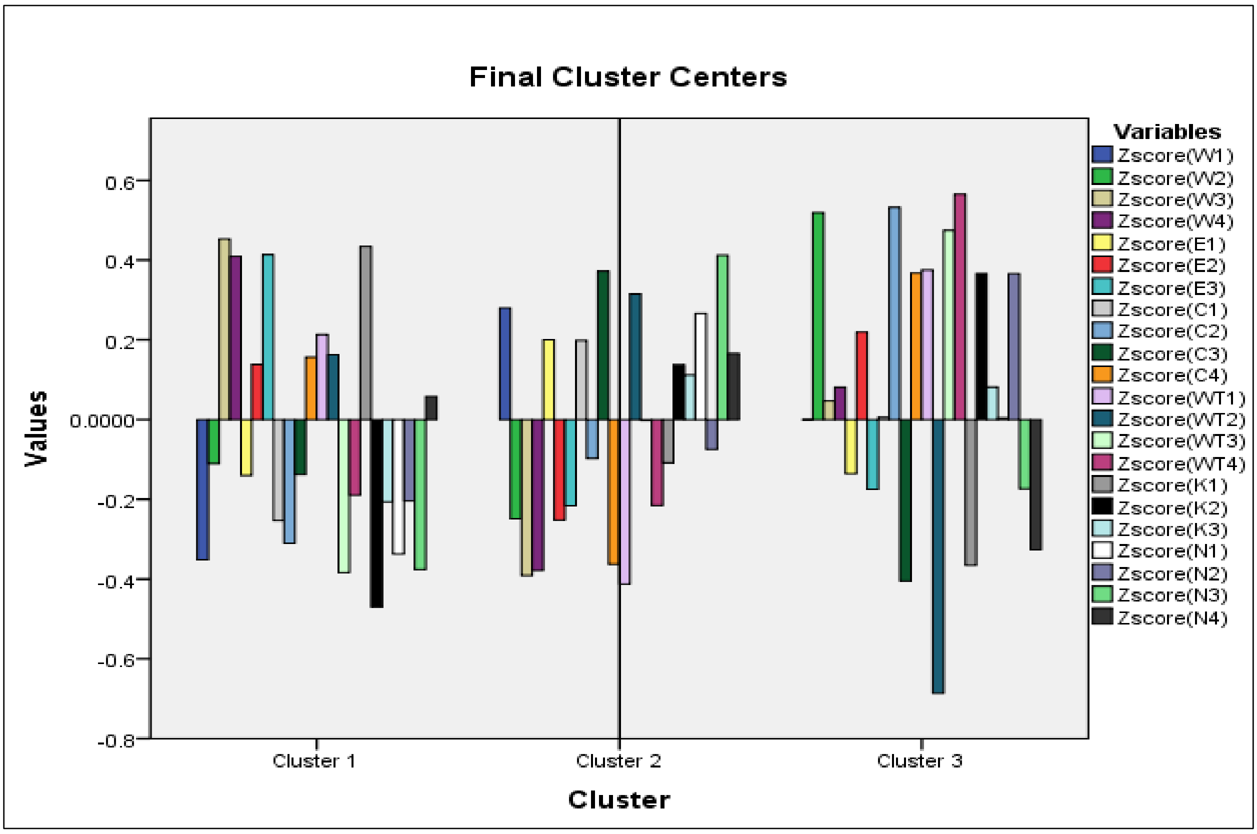
Variables	Cluster 1	Cluster 2	Cluster 3	F-statistics
W1	-0.35146	0.28011	-0.00038	5.07***
W2	-0.11007	-0.24883	0.51915	7.28***
W3	0.45288	-0.3911	0.04701	9.72***
W4	0.40937	-0.37861	0.0812	8.45***
E1	-0.14026	0.19987	-0.13605	1.84^{NS}
E2	0.13842	-0.2524	0.21935	3.06**
E3	0.41352	-0.21598	-0.17481	5.87***
C1	-0.25356	0.19845	0.00534	2.50*
C2	-0.31058	-0.09761	0.53217	8.07***
C3	-0.13799	0.37216	-0.40465	7.73***
C4	0.15658	-0.36281	0.36739	7.03***
WT1	0.21304	-0.41293	0.37535	9.03***
WT2	0.16306	0.31508	-0.68646	13.73***
WT3	-0.38384	-0.00212	0.47485	7.85***
WT4	-0.18981	-0.21504	0.56497	8.47***
K1	0.43386	-0.10843	-0.36574	7.35***
K2	-0.47056	0.13723	0.36638	8.48***
K3	-0.20673	0.11172	0.08162	1.38^{NS}
N1	-0.33743	0.2661	0.00401	4.60**
N2	-0.20386	-0.07492	0.36606	3.52**
N3	-0.376	0.41189	-0.17355	9.16***
N4	0.05809	0.1656	-0.32687	2.75*
Population	43 (32.58)	54(40.91)	35(26.52)	
Distances between final cluster centers				
1	-	2.353	2.479	
2	2.353	-	2.531	
3	2.479	2.531	-	

Source: Field survey, 2023.

Note: Value in parenthesis is percent; ***,**,* & NS mean 1, 5, 10% and non-significant respectively.

Figure 5a

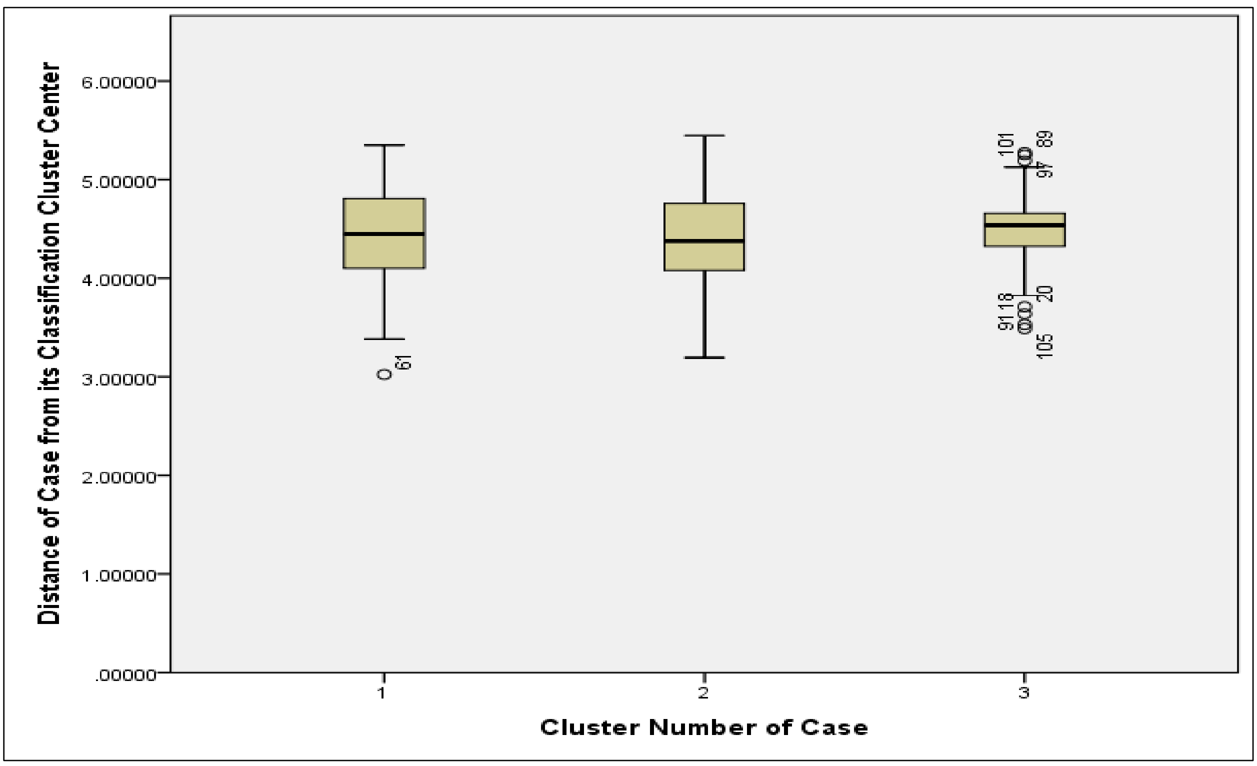
Distributions of Farmers' Agreement to Apply CSA Technologies



Source: SPSS output

Figure 5b

Box Plot Assessment of Farmers' Agreement to Apply CSA Technologies



Source: SPSS output

Farmers' Perceptions on Willingness to Pay for Climate-Smart Agricultural Technologies

To assess the farmers' perceived preference to pay for climate-smart agricultural technologies, the empirical evidence of k-mean cluster analysis identified three groups with inherent key indicators as evident from their respective f-statistics (Table 7 and Figure 6a). The first group of farmers showed a strong preference to pay for nutrient smart agricultural technology, focusing on soil fertility for better plant growth. The second group preferred to pay for water and carbon-smart agricultural technologies, aiming to address drought adaptation and water scarcity due to climate change. The last group has strong preference to pay for energy and carbon-smart technologies as a conservative adaptive strategy for tackling climate change. Besides, it was observed that the poor resource status may drive the use of the local adaptive farm practices to mitigate the effect of climate change on their farms. Additionally, the complexity of weather- and carbon-smart technologies might contribute to the low preference for these technologies among majority of the farmers in the study area. Noteworthy, the study found that proportion of the farmers in clusters 1, 2 and 3 were 39.40%, 25%, and 35.60%, respectively.

Table 7

Farmers' Perception on Willingness to Pay for CSA Technologies

Variables	Cluster 1	Cluster 2	Cluster 3	F-statistics
W1	-0.3401	0.29355	0.17017	5.45***
W2	-0.21258	0.46717	-0.09282	5.30***
W3	-0.2732	0.6956	-0.18613	12.64***
W4	-0.42109	0.03542	0.44103	10.54***
E1	0.20546	-0.35029	0.01863	3.237**
E2	-0.02431	0.4583	-0.29489	5.94**
E3	-0.29598	0.43491	0.02211	5.81**
C1	-0.16737	0.62924	-0.25663	10.02***
C2	0.18227	0.48941	-0.54528	14.17***
C3	0.4895	0.01106	-0.54934	16.47***
C4	-0.06105	0.25905	-0.11434	1.524^{NS}
WT1	-0.15826	0.43836	-0.13269	4.45**
WT2	0.05423	-0.10801	0.01585	0.27^{NS}
WT3	0.46899	0.07264	-0.56989	16.64***
WT4	-0.1431	-0.44241	0.46894	10.18***
K1	-0.08095	-0.34569	0.33228	5.03***
K2	-0.27474	0.47432	-0.02906	6.14***
K3	-0.19399	0.00477	0.21128	2.06^{NS}
N1	0.40771	-0.28969	-0.24769	7.90***
N2	0.19931	-0.25795	-0.03939	2.21^{NS}
N3	-0.36414	0.43978	0.09409	7.53***

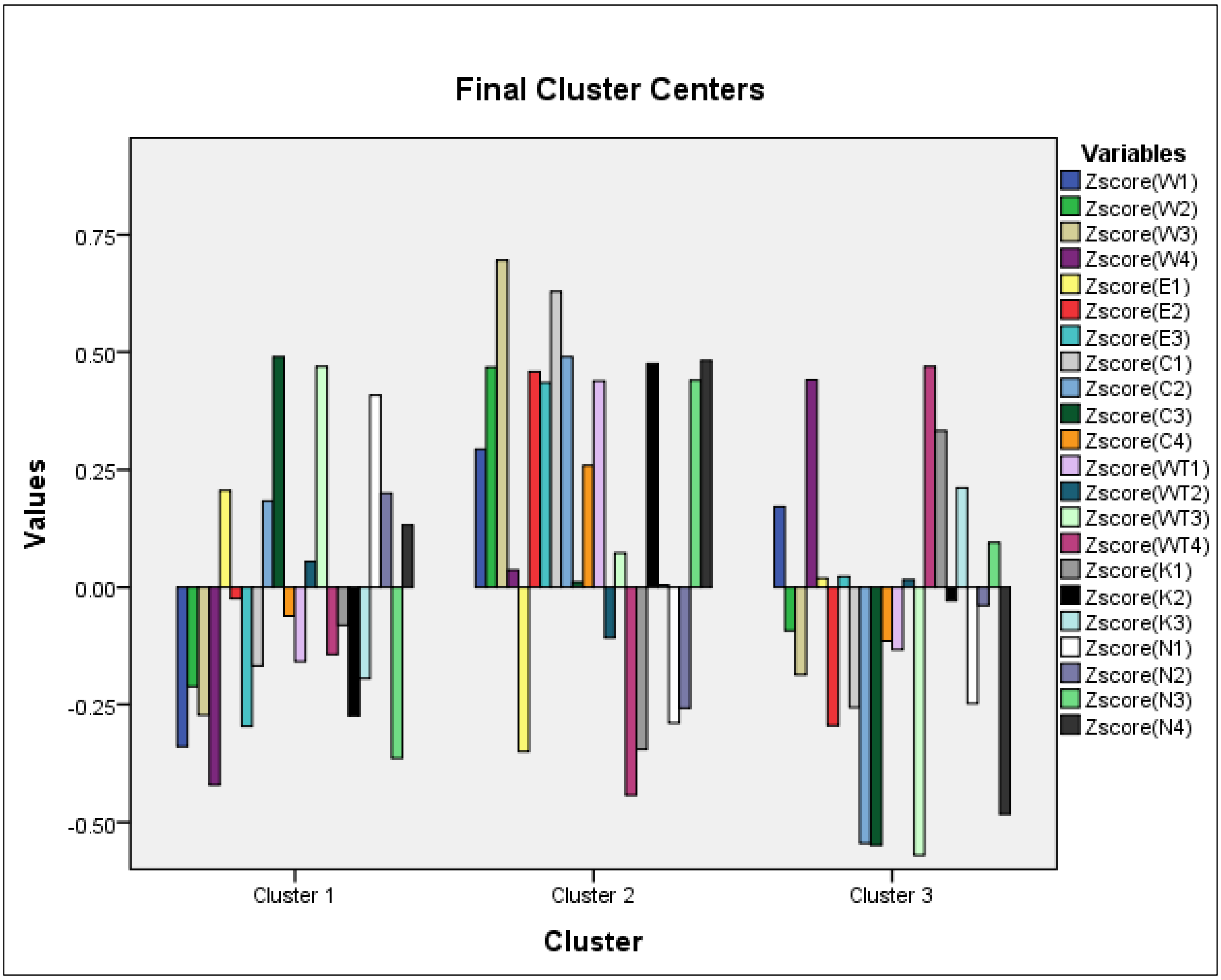
Variables	Cluster 1	Cluster 2	Cluster 3	F-statistics
N4	0.13163	0.48144	-0.48367	11.31***
Population	52(39.39)	33(25)	47(35.61)	
Distances between final cluster centers				
1	-	2.629	2.404	
2	2.629	-	2.81	
3	2.404	2.81	-	

Source: Field survey, 2023

Note: Value in parenthesis is percent; ***,**,* & NS mean 1, 5, 10% and non-significant respectively.

Figure 6a

Distributions of Farmers' Willingness to Apply CSA Technologies

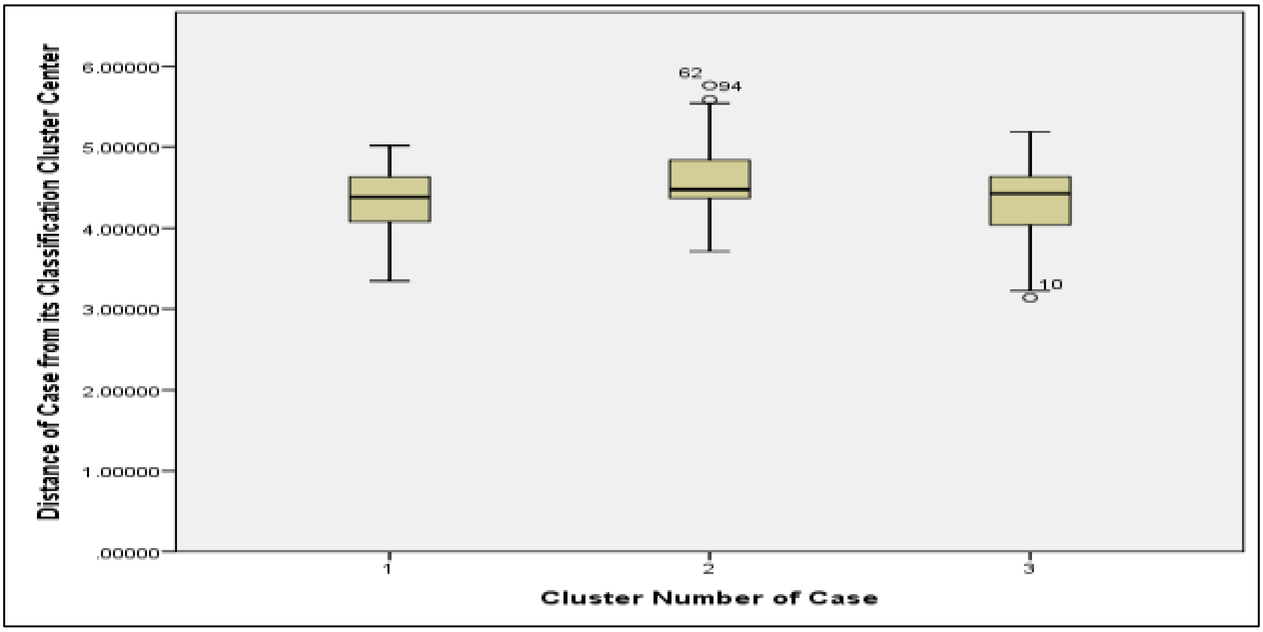


Source: SPSS output

Furthermore, the box plot assessments of all the clusters showed minimal internal differences in the distribution of the respondents and the concentration of social qualities. Specifically, clusters 1 and 2 exhibited high positions, while cluster 3 showed a low position, as evidenced by the quartile lines in the box plot (Figure 6b).

Figure 6b

Box Plot Assessment of Farmers' Willingness to Apply CSA Technologies



Source: SPSS output

Factors Influencing Farmers' Intention to Participate Collectively in Pro-environment Activities

An examination of the state of the relationship between different factors and their correlation with IP (Table 8a), it was observed that all the latent indicators had a significant correlation effect with IP. The correlation of AP and SNP with IP was positive, whereas, that of BP and SIP was negative. Among these latent indicators, the correlation effect of AP was the highest, followed by that of SNP. In other words, having a positive belief in the presence of climate change will lead to a greater willingness to engage in collective environmental activities. Likewise, promoting subjective norms will lead to willingness among farmers to participate in collective environmental activities. In a closely related study, except for the duo of BP and SNP, which might be attributed to high level of development, similar findings were confirmed by Faghani et al. (2023) on the intention of members of environmental NGOs to participate in collective pro-environmental activities in Tehran province of Iran. Similarly, Ajibade and Boateng (2021) established similar findings. However, concerning the two latent indicators with inverse relationships, this result contradicts the findings of Faghani et al. (2023); Jans (2021); and, Bruner et al. (2020).

Table 8a

Correlation matrix of planned behavior

Variables	**IP**	**BP**	**AP**	**SNP**	**SIP**
IP	1				
BP	-0.738	1			
AP	2.146	0.558	1		
SNP	0.693	0.445	0.942	1	
SIP	-6.141	-1.141	-2.016	-2.587	1

Source: Field survey, 2023

The results of the confirmatory factor analysis (CFA) showed that the structural equation model (SEM) adequately fits the specified equation, as evident from the various diagnostic statistics falling within their respective accepted recommended threshold values (Figure 7). Besides, the empirical results showed that all the variables *viz*. BP, AP, SNP and SIP have significant effects on the farmers' intention towards participation in collective pro-environment activities (IP) within the study area. This was evidenced by their respective coefficients that were within the acceptable margin of 10% probability level (Table 8b and Figure 7). Notably, BP and SNP had negative effects on IP, while both AP and SIP had positive effect on IP. The negative significance of BP invariably implied that farmers with poor internal intrinsic and extrinsic motivations vis-à-vis skills, abilities, information, emotions, and environmental/occupational factors, are less likely to have intentions towards participation in collective pro-environment activities. Likewise, the negative significance of SNP invariably implied that farmers who are laggards or have conservative attitudes owing to culture or family orientation are less likely to have intentions towards participation in collective pro-environmental activities. Consequently, farmer with poor behavioral control and those characterized as laggards/conservatives are less likely to participate in collective pro-environmental activities, with participation rates around 3.28% and 4.40%, respectively. As for AP and SIP, these findings conform to the findings of Faghani et al. (2023), however, the findings concerning BP and SNP contradict the findings established by Faghani et al. (2023).

On the other hand, the positive significance of AP shows that farmers who positively believe that climate change is the prime challenge affecting their livelihoods are likely to have intentions to participate in collective pro-environmental activities, representing 11.34%. Besides, the positive significant of SIP variably means that farmers with a good social network/integration, *viz*., participation in social organizations, cosmopolitanism, globalization, etc., are likely to have intentions to participation in collective pro-environmental activities. The likelihood of farmers with a good social network to participate in collective pro-environmental activities, compared to their inversely related counterparts, is 1.60%. Furthermore, given that the model had no indirect effect, the estimated coefficients of the latent predictors returned as the total effect. In discerning the effects of these four latent predictor indicators, it is evident that the AP has the strongest effect, followed by SIP with a noticeable distance. This suggests that the AP is the de facto variable for predicting intentions towards participation in collective pro-environmental activities in the study area.

Table 8b

Influence of Planned Behavior on Intention to Participate (IP)

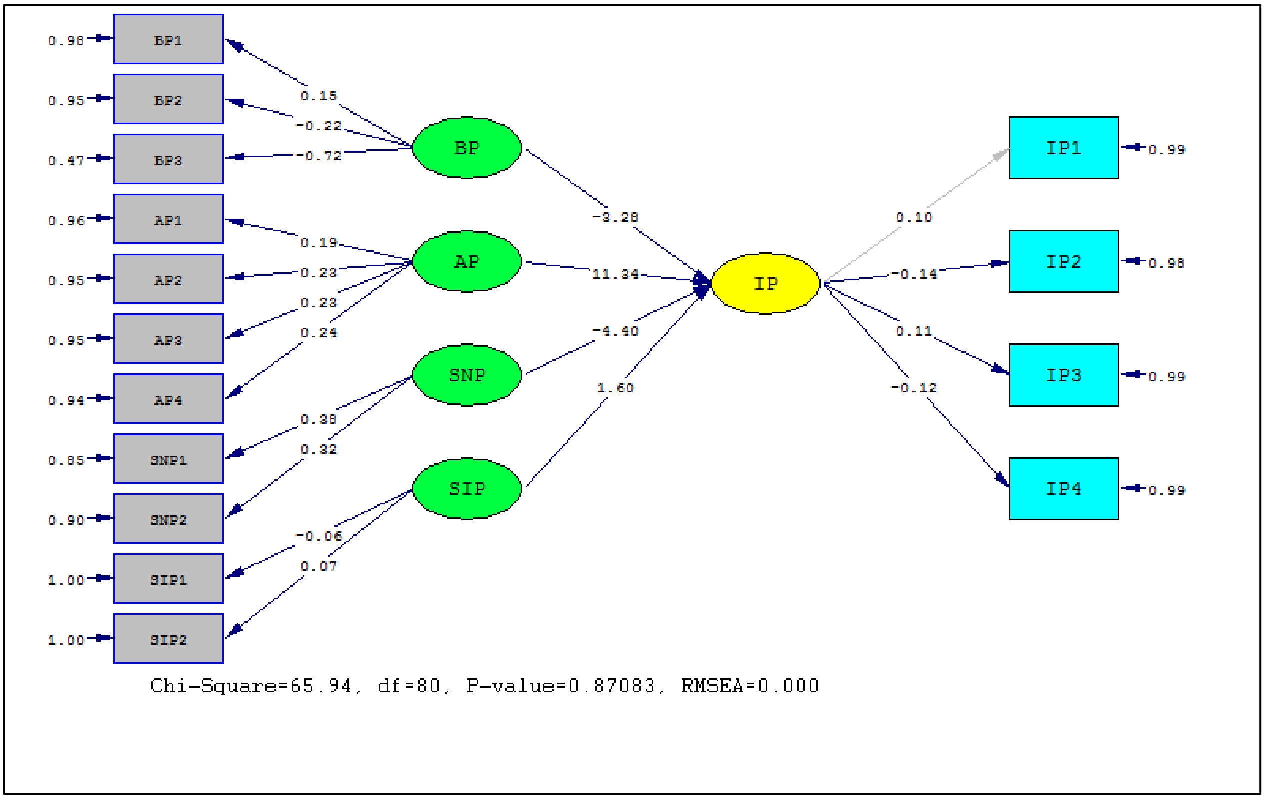
Indicators	Coefficient s	t-statistics
BP	-3.284(0.545)	6.022***
AP	11.336(1.364)	8.313***
SNP	- 4.395 (0.497)	8.845***
SIP	1.596 (0.0947)	16.865***
Error variance	12.905 (0.337)	38.272***
R^2	0.1391	

Source: Field survey, 2023

Note: Value in parenthesis is standard error; ***,**,* & NS mean 1, 5, 10% and non-significant, respectively.

Figure 7a

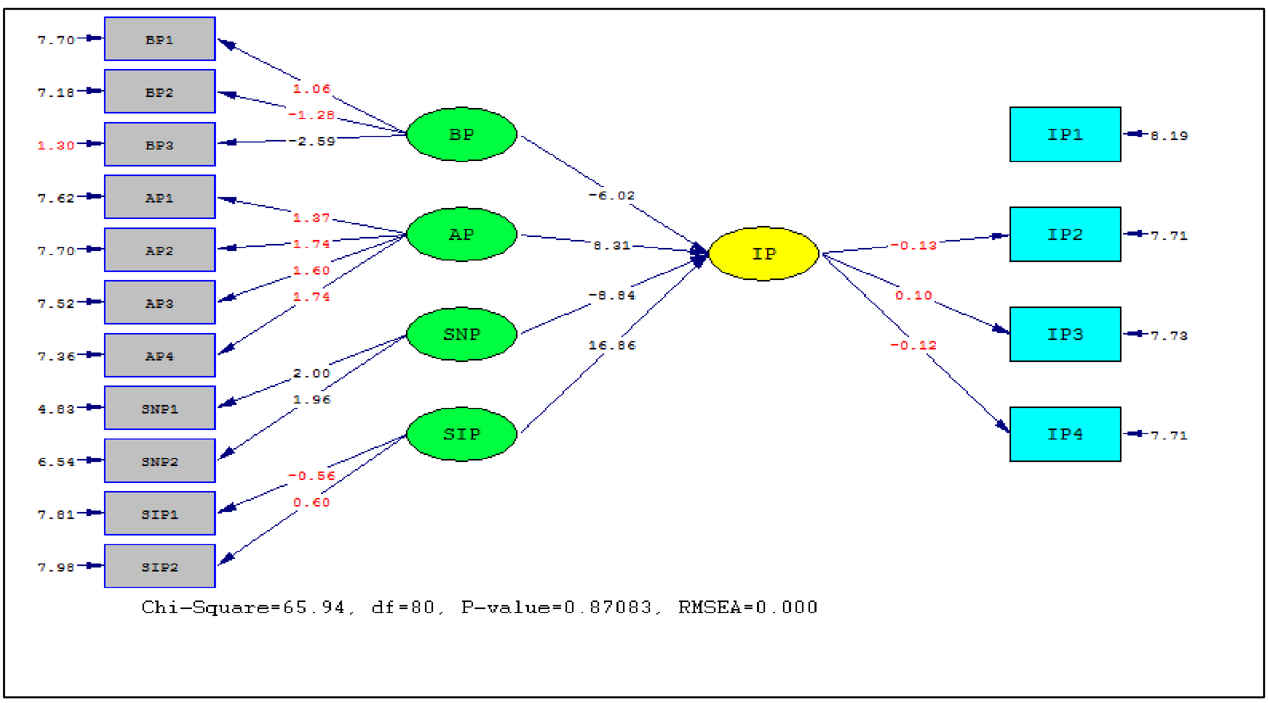
CFA of Planned Behavior Indicators Influence on IP (Estimated Coefficient)



Source: SPSS output

Figure 7b

CFA of Planned Behavior Indicators Influence on IP (T-Statistics)



Source: SPSS output

Conclusion and Recommendation

The research findings revealed that most of the farmers were resource-poor, cultivated onions on a marginal scale, with limited access to credit facilities. It is recommended to consider a social welfare value of ₦120,405 ($172.01) per person per annum for the overall economic well-being of the farming community. Additionally, the farmers expressed interest in investing in climate-smart technologies, such as soil nutrient reclamation, drought adaptive measures, and conservative adaptive strategies. However, their willingness to participate in collective pro-environmental activities is hindered by perceived behavioral control and subjective norms. Therefore, to promote the adoption of CSA technologies, the study calls for a farmer-to-farmer extension approach to boost the farmers' confidence, particularly for those with conservative farming practices in the study area. Furthermore, the farmers are encouraged to explore social capital pooling so as to gain access to credit facilities and other monetary economic benefits.

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تقييم إدراك صغار مزارعي البصل لتقنيات الزراعة الذكية مناخيًّا وميلهم للمشاركة الجماعية في الأنشطة الصديقة للبيئة في ولاية كانو النيجيرية

المستخلص

قامت هذه الدراسة بتقييم تصورات مزارعي البصل أصحاب الحيازات الصغيرة حول التقنيات الزراعية الذكية مناخيًّا (CSA)، وميلهم نحو المشاركة الجماعية في الأنشطة المناصرة للبيئة في ولاية كانو بنيجيريا. علاوة على ذلك، تم اختيار عينة مكونة من 132 مستجيبًا من خلال تقنية أخذ العينات متعددة المراحل، وتم جمع البيانات المقطعية للموسم الزراعي (المطري) لعام 2023 باستخدام استبيان جيد التنظيم مقترنًا بجدول زمني للمقابلة. علاوة على ذلك، تم استخدام الإحصائيات الاستدلالية لتحليل البيانات التي تم جمعها. ومن الناحية التجريبية، ثبت أن غالبية المزارعين كانوا في منتصف العمر، وذكور، ومتزوجين، ومتعلمين، لديهم فرصة محدودة لتنويع المحاصيل، يزرعون البصل على نطاق ضيق، لديهم رأس مال اقتصادي محدود، وتعاني أسرهم من الإصابة بالأمراض، كما أن وصولهم ضعيف إلى التسهيلات الائتمانية. علاوة على ذلك، ومن أجل رفاهة اقتصادية أفضل للمزارعين، تم اقتراح حد أدنى للرفاهة الاجتماعية بواقع 120405 نيرات (172.01 دولارًا أمريكيًّا) للشخص سنويًّا؛ لتحسين رفاهة المزارعين. وأعاقت قيود الموارد اعتماد تقنيات الزراعة الذكية مناخيًّا بشكل فعَّال، بينما كان الدافع الرئيس لرغبة المزارعين في الدفع هو استعادة مغذيات التربة، والتخفيف من الجفاف، واتخاذ تدابير تكيفية. كما أعاقت سيطرة السلوكيات والأعراف الشخصية العمل الجماعي بشأن القضايا البيئية. وتوصي الدراسة بزيادة توفر الائتمان، وتوسيع نطاق نهج الإرشاد من مزارع إلى مزارع؛ لتعزيز اعتماد تقنيات الزراعة الذكية مناخيًّا.

***الكلمات الدالة*:** تقنيات الزراعة الذكية مناخيًّا، صغار المزارعين، السلوك البيئي، العمل الجماعي، نيجيريا