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Climate Change Adaptation Strategies And Their Impact On Food Security In The Ikom Agricultural Zone.

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Abstract
This study explores climate change adaptation measures and food security in Ikom Agricultural Zone, Cross River State, Nigeria. Three research questions guided the study, with corresponding null hypotheses tested at a 0.05 alpha level. A survey research design was used, employing stratified and proportionate sampling to select 445 respondents. Data were collected through a validated structured questionnaire, "Climate Change Adaptation Strategies and Food Security." Hypotheses were tested using simple linear regression analysis. Findings indicate that improved agricultural technologies significantly enhance food security, while most soil and water conservation practices had little impact. However, agroforestry practices showed a positive statistical relationship with food security. These results highlight the link between climate adaptation strategies and food security, emphasizing the need for effective policy implementation in Cross River State. Policymakers should integrate adaptive measures to strengthen food security and promote sustainable agricultural development. Based on these findings, the study recommends increased adoption of agricultural technologies, reassessment of soil and water conservation efforts, and promotion of agroforestry practices among farmers. These strategies will enhance climate change adaptation, improve food security, and inform policy formulation in Cross River State and similar regions facing climate-related challenges.

Key words: Climate Change Adaptation, Food Security, Agricultural Practices, Agroforestry, Sustainable Development.

Introduction
Global climate change continues to be a vital issue largely affecting world agriculture, and therefore food security given that many world regions rely on agricultural production. Thus, sub-Saharan Africa, including Nigeria, is especially in the red because of rain fed farming and low coping capability (Chari & Ngcamu, 2022). Climate change specifically warns that higher temperatures and changes in the rainfall regimes are adversely affecting agricultural production and, therefore, food production and security for millions of people. Therefore, this paper focuses on how climate variation affects agriculture and therefore advocates for

simplicity in Cross River State Nigeria, towards enhancing a workable adaptation aim to curb food insecurity.

There are coping mechanisms which may be enhanced to reduce vulnerability to climate-induced impacts; Dualism for instance, better farming techniques, afforestation, the conservation of soils and water all make up techniques under adaptation which may help societies to embrace impacts of climate change. Nonetheless, these interventions work differently depending on environment, social unlocking and cultural triggers which exist in the given locality (Campbell, Vermeulen, Aggarwal, Corner-Dolloff, Girvetz, Loboguerrero... & Wollenberg, 2016). It is therefore important to understand these general effects of these strategies in Cross River State to provide numismatic approaches for sustainable food systems and care for bulk of population in this agrarian area.

The impact of climate change adaptation on food insecurity in the Ikom Agricultural zone of Cross River State is the subject of this research. Seeking to analyse the correlations between various forms of adaptation – enhanced agricultural practices, measures in water and soil management, and agroforestry – with the aim of identifying the links between improvement of climate change adaptation and increased food security, this study aims to offer recommendations for the policymakers.

They also hope to inform the current literature with ideas of sustainable development and climate change risk reduction in developing regions.

There are no doubt efficient farming techniques facilitate increased food production as a way of mitigating food insecurity. Hunger fighting tactics gain a specific aspect of food security through the practices of increasing foods accessibility, availability, quality, and signing for its stability. With the global population set to continue to rise and climate shocks increasing, only the appropriate adoption and promotion of these agricultural innovations will encourage sustainable food security.

If soil and water conservation is to be deployed, then use of terraces, water conservation structures and maintenance of soil moisture by preventing formation of surface runoff is effective. Thus, SWC activities head an important duty of supporting agriculture production to increase food security in food production stability against forces of nature. The practices assist keep up the quality of natural resource that is valuable for future agricultural productivity and food security.

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The SWC activities include contour ploughing, making of terraces and use of cover crops which have the effect of enhancing the performance of soils. These practices have an impact of controlling the process of soil erosion in addition to increasing the nutrients in the soil and water infiltration, guarders of crop productivity. Diop et al., (2022) noted that in order to enhance agricultural production, there is need to embrace proper measures of soil conservation reduction on land degradation that also result to minimizing the loss of soil organic matter. Improved soil fertility avails nutrients to crops to grow, improve yields, and food security.

Techniques for water harvesting, filtration techniques like drip irrigation, and constructions of check dams are some of the proven practices for water use efficiencies in agricultural production. They also help avails water to crops all the times and thereby help reduce fluctuations in food production. Golla (2021) opine that through the integrated water resources management, water use efficiency could be improved and hence boost crop production hence food security in most regions especially in arid and semi-arid areas.
Successful Water Conservation (SWC) practices also increase the ability of the agricultural systems to cope with the weather shocks and other disasters. There are the agroforestry practices such as a combination of crops, pasture, and trees that give multiple advantages including; buffer effects such agroforests improve microclimate, increase diversity and ultimately charged carbon stock (Udawatta, Rankoth & Jose, 2019). These benefits translate into more sustainable Food Production Systems that are least vulnerable to climate change impacts and therefore food insecurity.

Piggy backing on SWC methods like intercropping as well as the conservation of habitats improves the ecosystem services which are fundamental in agricultural production. Diverse systems warrant less chemicals through control of pests and diseases and support sustainable agricultural practices (Roberts & Mattoo, 2018). This ecological balance also enables a constant production of foods that are important to help in the sustenance of man because it will keep on correcting itself in case of any unnecessary shocks that are hard to be negotiated in the agriculture systems.

SWC measures are therefore important instruments of addressing food security in a way that favors improvement in the health status of the soils and utilization of water in production. These practices also enhance ecological diversities and bring economic development for farmers based on yield increase that results to improved incomes and better economic availability to food. Studies show that adoption of sustainable agricultures (SAs) increases farm performance and income and hence support food security and livelihood. High economic

stability enhances investment on proper farm inputs and technology and thus enhances food production. Scrutiny of SWC practices is basic to sustain world food security in the light of such cross-cutting issues as climate change and population explosion.

Availability, accessibility, utilization and stability of food improved by agroforestry practice also has a positive bearing on food security. Interception of rainfall, IPR, promotes soil development by increasing; aggregation and nutrient contents resulting in better crop yields from farming systems where trees are incorporated. Also, they offer fruits, nuts and any edible produce thus enhancing food supply output in the market. These systems make farmers have multiple sources of income through sale of tree products thereby reducing the impact and risks arising from crop failure and enhancing access to food from an economic view point. This includes in that all trees used in Agroforestry practice contain necessary vitamins and minerals that make the meal a balanced diet. Moreover, these systems enhance the capacity to withstand environmental challenges due to their ability to protect crops and stabilise agricultural production amidst, climate change.

The diversification of livelihoods also improves on the coping capacity by engaging into other different means of income sources minimizing on farming activities.

The aim of this research is to examine the ability of climate change mitigation measures in enhancing food security within the Ikom Agricultural zone. More specifically, it looks into the affect that the enhanced agricultural technologies, SWC practices, and adoption of agroforestry has on food security. This research is based on the Vulnerability and Adaptation Theory and the Sustainable Livelihoods Frameworks to determine how social, economic, and environment determine adaptive capabilities. This study employs surveyed data from 445 respondents, and results obtained suggest that the application of better agricultural practices and agroforestry improved the course of food security and that SWC practices did not produce the desired effects.

Thus, the study provides significant buttress for enhancing improved agricultural practices, reassessing the soil and water conservation program and practicing an agroforestry practice, among others to deal with the food security issues as desired. They are useful for policy making to bring about better all-round types of sustainable development programmes in similar settings across the world.

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Literature review

Improved agricultural practices and food security.

Developments on agricultural techniques are important to increase world food stability. At the same time, they increase agricultural yields without harming the physiosphere and, thus, provide food for ever-growing global population (German et al., 2017). Special emphasis to sustainable agricultural practices (SAP) are small holder farmers in sub-Saharan Africa where land tenure has a great bearing on the chances of SAP adoption then there is trouble ahead for the sub-Saharan Africa farmers. In the study conducted by Nkomoki, Bavorová, and Banout (2018) the Zambian Households with statutory land tenure were tended to employ crop diversification and other conservation techniques like agroforestry, planting basins hence increasing food security.

Tokhayeva et al. (2020) compared the state of food security in Kazakhstan before and after the country's independence and voiced the latter's achievements in improving Food Security Index through the introduction of progressive innovations in the sphere of agriculture. After decreasing the rates of malnutrition and increasing food production there are still problems, such as low food intake compared to the standards. To support food self-reliance, the authors propose to utilize agricultural innovation systems to fund research, improve infrastructures, and augment the flow of information between farmers and researchers.

Nicholson et al., (2021) underscored the importance of noble research solutions that provide multi-sectorial agricultural systems based on FAO's four dimensions of food security: availability, access, utilization, and stability. In their own review, they noted the absence of empirical data as well as the low inclusion of access and stability factors in models, implying the need for dynamically oriented methods of assessment of food security.

In their paper titled: Local Food, Sustainability, Health and Environmental Impacts Coelho et al. (2018) endorse consumption of locally farmers' markets locally adapted food produced through sustainable methods of production using environmentally friendly technologies. The authors pointed out that even though local food systems make sense with regard to "food miles," production dominates the image of sustainable food systems.

Collectively, these papers highlight the need to move towards better farming methods, new technologies, and a systems-approach to consider food security. That is, acknowledgement of factors like; land tenure, technological, and missing dimensions in food security will enable the formulation of policy measures to improve food security and sustainability for the wellbeing of people in the global society.

Soil and water conservation practices (SWCP) and food security

In this regard, measures that promote soil and water conservation, that is, SWCP are crucial in view of the mounting food and water challenges. They help to protect important resources and contribute to improvement of yields and agricultural produce for sustainable food security (Mishra et al., 2021). Like the foundation of any built structure, healthy soil serves as the base support for crop growth through offering nutrients to the plants but this has now changed with cases of deterioration such as erosion, nutrient poor and polluted soils being a major threat to world food security (Silver et al., 2021; Lal, 2015).

According to Mideksa, Muluken, and Eric (2023), severe erosion has been reported in major food producing zones of the world including Ethiopia, India and the Mediterranean Europe. Using propensity score matching, their study demonstrated that households in the SWCP received 854.78 increased kilocalories and higher FCS. However, these results provide empirical support to the claim that SWCP positively impacted the status of food security and, therefore, more studies employing different indicators are warranted.

Soil securitization was deemed important for sustainable development by Mugandani et al. (2021). CA which adopts no-till practices contributes to agriculture sustainability, improves on species diversity, tackles climate change and offers services in an ecosystem. CA practices were found successful in enhancing yield and saving water, and raising farm receipts through double cropping in rainfed ecosystems in North Eastern region of India.

No less important are the issues of water saving. Gobarah et al. (2015) have established that lack of water is caused by population growth and climate change in future expects a water shortage crisis in 2050. The need to implement new practices that would contribute to developing efficient irrigation systems, to switch from flood irrigation to drip irrigation are crucial. Halophytes are considered non-traditional crops, which are useful for biofuel and soil purposes helping to save freshwater for more vital uses.

These practices collectively not only engage with the urgent need for adequate food and water but also with climate-related risks. It would help increase the usage of sustainable approaches by incorporating new technologies and furthering the studies on SWCP to improve agriculture around the globe to meet the challenging needs of global human civilization.

Agroforestry practices and food security.

The use of trees and shrubs together with crops, and animals in cultivating a piece of land in a systematic way that produces food and shelter to farmer and his/her livestock respectively

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is known as Agroforestry according to Sobola et al., (2015). This approach has a positive impact on the increase of biological diversity, the improvement of the soil and making a disease immune to climate conditions. Mbow et al. (2014) noted that agroforestry increases food production and availability through the supply of improved germplasm, upon which agriculture extension systems build to help farmers produce food for food security as noted by Coulibaly et al. (2017) who viewed agroforestry as a climate change adaption and mitigation tool given the role fertilizer trees, such as Gliricidia sepium and Faidherbia These practices bring benefit to stakeholder smallholder farmers with small and sub-optimal land sizes, although more research is required to provide differentiated policy approaches based on varying farming contexts.

Gender disparities in agriculture are also fixed via agroforestry. Women were identified by Kiptot et al. (2014) as key players in the management of agroforestry systems but are limited by cultural barriers and resource endowment. Based on the findings, policy and institutional interferences should support women's activity and outcomes to boost HFSIA.

Biodiversity assumes a central status in agroforestry. Croplands in Kenya was the subject of investigation for tree diversity by Duffy et al (2021) with a notational of 73 species. They stressed development of capacities to support balance between the objective of promoting conservation of biological diversity and the enhancement of living standards. Likewise, for similar reasons, Waldron et al. (2017) pointed out that agroforestry practices are consistent with the global concept of SDGs as a way of enhancing crops' durability and relying on the smallholder producers as well as ensuring that both environmental and societal imperatives are incorporated into the crop growing processes.

Therefore, in a way, by focusing environmental contributions of agroforestry, where it was outlined as playing a role in climate change mitigation, carbon stock enhancement, and eco-intensification, Pantera et al. (2021). Nevertheless, its application still remains somewhat restrained, and thus needs increased policy and investment attention to enhance practice shares.

It has very diverse possibilities to respond to global problems; it can improve food security, increase the availability of bio-diversity and reduce the effects of climate change. Much research should be conducted, and appropriate polices should be added in order to get the best of the potential to solve current and emerging issues such as those in agriculture and environment.

Research hypotheses

The following research hypotheses were formulated to guide the study:

1. There is no significant effect of improved agricultural practices on food security.
2. There is no significant effect of soil and water conservation practices on food security
3. Adopting agroforestry practices have no significant effect on food security.

Methodology

This study adopted a survey research design to investigate climate change adaptation strategies and food security in Cross River State, Nigeria. Surveys efficiently gather data from diverse respondents, enabling trend analysis within populations (Couper, 2017). The study was conducted in Ikom Agricultural zone, located between latitudes 5.32° and 4.27°N and longitudes 2.20° and 7.50°E. This zone, with a projected population of 966,300, features a humid tropical climate (1,300–3,000 mm annual rainfall, 30°C average temperatures) and diverse vegetation ranging from rainforest to derived savannah. The population is predominantly agrarian, relying on subsistence farming of crops like yams, cassava, rice, and maize.

The target population comprised 8,902 farmers registered with the Cross-River State Agricultural Development Programme (CRADP, 2023). Stratified and proportionate sampling techniques were employed, selecting 5% of farmers from ten wards in each local government area (LGA). Random sampling from farmer registers yielded 445 participants, who received questionnaires at their registered addresses.

Data were collected using the Climate Change Adaptation Strategies and Food Security Questionnaire (CCASFSQ), a 40-item instrument covering demographics (Section A), climate change adaptation strategies (Section B), and food security issues (Section C). Two experts from the University of Calabar validated the instrument for face and content validity. Cronbach's alpha reliability coefficients ranged from 0.70 to 0.89, confirming consistency.
Data analysis utilized simple linear regression to assess relationships between adaptation strategies and food security outcomes, providing valuable insights for improving food security in the region.

Presentation of results

H_{o1}

There is no significant effect of improved agricultural practices on food security. The two variables in this hypothesis were effect of improved agricultural practices and food security

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in Ikom Agricultural zone of Cross River State. Both variables were measured continuously. To test this hypothesis, Simple Linear Regression analysis was used. A simple regression analysis was conducted to examine the relationship between the effects of improved agricultural practices and food security in the Ikom Agricultural zone of Cross River State. The results indicated that the model was statistically significant, $F(1, 443) = 7.744$, $p = .006$, and accounted for approximately 1.7% of the variance in food security ($R^2 = .017$, Adjusted $R^2 = .015$).

The unstandardized regression coefficient (B) for the effects of improved agricultural practices was .297, with a standard error of .107. This coefficient was statistically significant ($t = 2.783$, $p = .006$), indicating that for each unit increase in the effects of improved agricultural practices, food security increased by .297 units. The standardized coefficient (Beta) was .131, suggesting a small positive effect of improved agricultural practices on food security.

The results of this analysis support the hypothesis that improved agricultural practices have a significant positive effect on food security in the Ikom Agricultural zone of Cross River State. Despite the low percentage of explained variance, the relationship between the variables is statistically significant, indicating that improved agricultural practices can positively impact food security in the region. The results are presented in table 1.

Table 1: Summary of simple regression analysis for the relationship between effect of improved agricultural practices on food security in Ikom Agricultural zone of Cross River State

R	R Square	Adjusted R Square	Std. Error of the Estimate		
.131a	.017	.015	3.06960		
Model	Sum of squares	Df	Mean square	F-ratio	Sig.
Regression	72.963	1	72.963	7.744	.006[b]
Residual	4174.138	443	9.422		
Total	4247.101	444			
Variable	B	Std. Error	Beta	t	Sig.
(Constant)	19.932	1.843		10.815	.000
Effects of improved agricultural practices	.297	.107	.131	2.783	.006

a. Dependent Variable: Food Security

b. Predictors: (Constant), Effects of improved agricultural practices

H_{O2}

There is no significant effect of soil and water conservation practices on food security. The two variables in this hypothesis were effect of soil and water conservation practices and food security in Ikom Agricultural zone of Cross River State. Both variables were measured continuously. To test this hypothesis, Simple Linear Regression analysis was used.

A simple regression analysis was conducted to examine the relationship between the effect of soil and water conservation practices and food security in the Ikom Agricultural zone of Cross River State. The results indicated that the effect of soil and water conservation practices did not significantly predict food security, R^2=.000, F (1,443) = .132 F (1, 443) = .132, p=.716.

The regression equation was not significant, indicating that the effect of soil and water conservation practices explained 0.0% of the variance in food security. The unstandardized regression coefficient (B) for the effect of soil and water conservation practices was .068 (SE = .188), t (443) =.364, p=.716. As shown on table 2.

Overall, the results suggest that soil and water conservation practices do not have a significant impact on food security in this context. The standard error of the estimate was 3.096, and the intercept (constant) was 23.892, which was significant, t (443) =7.532 t (443) p<.005. In conclusion, the effect of soil and water conservation practices was not a significant predictor of food security in the Ikom Agricultural zone of Cross River State.

Table 2: Summary of simple regression analysis for the relationship between effect of soil and water conservation practices on food security in Ikom Agricultural zone of Cross River State

R	R Square	Adjusted R Square	Std. Error of the Estimate		
.017[a]	.000	-.002	3.09585		
Model	Sum of squares	Df	Mean square	F-ratio	Sig.
Regression	1.268	1	1.268	.132	.716[b]
Residual	4245.833	443	9.584		
Total	4247.101	444			
Variable	B	Std. Error	Beta	t	Sig.
(Constant)	23.892	3.172		7.532	.000
effect of soil and water conservation practices	.068	.188	.017	.364	.716

a. Dependent Variable: Food Security

b. Predictors: (Constant), effect of soil and water conservation practices

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H_{O3}

Adopting agroforestry practices have no significant effect on food security. The two variables in this hypothesis were Adopting agroforestry practices and food security in Ikom Agricultural zone of Cross River State. Both variables were measured continuously. To test this hypothesis.

A simple regression analysis was conducted to examine the relationship between the effects of adopting agroforestry practices and food security in the Ikom Agricultural zone of Cross River State. The result of the analysis is presented in Table 3.

The regression model was statistically significant, F (1,443) =254.13, p<.005. The model explained 36.5% of the variance in food security, as indicated by the R^2 value of .365.

The unstandardized coefficient (B) for the effects of adopting agroforestry practices was -1.461, indicating that for each unit increase in the effects of adopting agroforestry practices, food security decreases by 1.461 units. This relationship was statistically significant (p<.005). The standardized coefficient (β) was -.604, suggesting a moderate negative relationship between the effects of adopting agroforestry practices and food security.

Table 3: Summary of simple regression analysis for the relationship between effects of adopting agroforestry practices on food security in Ikom Agricultural zone of Cross River State

R	R Square	Adjusted R Square	Std. Error of the Estimate		
.604[a]	.365	.363	2.46825		
Model	Sum of squares	Df	Mean square	F-ratio	Sig.
Regression	1548.221	1	1548.221	254.128	.000[b]
Residual	2698.880	443	6.092		
Total	4247.101	444			
Variable	B	Std. Error	Beta	t	Sig.
(Constant)	48.709	1.489		32.712	.000
Effects of adopting agroforestry practices	-1.461	.092	-.604	-15.941	.000

a. Dependent Variable: Food Security

b. Predictors: (Constant), Effects of adopting agroforestry practices

Discussion of Findings

Analyzing the first hypothesis, it was revealed that improved use of agricultural technologies greatly and positively affects food security in Ikom Agricultural zone of Cross River State. Improved agricultural practices also pointed to a positive linear relationship to food security, and thus rejected the null hypothesis. This finding supports the study by Nkomoki et al (2018) that stated that the implementation of SAP leads to increase the yield and food security in smallholder farms in sub-Saharan African region. They pointed at the impact of one element only, namely land tenure, on the practices such as crop diversification and agroforestry that increase food security of the SAP. Also, in their different studies Coelho et al., (2018), pointed out on the implication of sustainable farming in production of food crops, locally and nationally as well as potential contribution to overall health of consumers and the environment.

The second hypothesis of this study was that the level of food insecurity in the study area is not significantly affected by the level of implementation of soil and water conservation practices. Since the test also showed that soil and water conservation practices have a rather small correlation with food security in the study region, the null hypothesis was accepted. This result is contrary to Mugandani et al. (2021) who emphasized the need to preserve soil in order to overcome the problem of land degradation and hunger. Evaluating the same field Gobarah and his colleagues, urged that water conservation remained highly significant due to escalation of demands and scarcity triggered by climate change.

Last, the test done on the third hypothesis established that there is a significant relationship between agroforestry practices and food security. This aligns with Coulibaly et al. (2017), who noted agroforestry's potential in enhancing soil fertility and crop production, and Kiptot et al. (2014), who highlighted its impact on food security, particularly through practices like fertilizer trees and gender-inclusive strategies. These findings underscore agroforestry's relevance in addressing food security challenges.

Implication of the findings

The study emphasizes the importance of investing in modern farming techniques to enhance food security and build resilience. While soil and water conservation practices alone may not ensure food security, a comprehensive approach integrating agricultural and socio-economic development is crucial. Additionally, the significant link between agroforestry and food security highlights its potential to improve soil health, biodiversity, and resilience, making it an essential strategy for sustainable agriculture and rural development.

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Conclusion

To support the identified claims and findings, the study focuses on the need to fund increased innovation in farming practices in order to boost food security. Although it is clear that SC will not guarantee food security on its own propagated farming systems, a more integrated approach to development involving agriculture and socio-economic development is fundamental. Furthermore, the profound positive correlation between agroforestry and the food security index indicates its effectiveness in improving on soil health, diversity and resource in order to be embraced as a tool of improving on agricultural sustainability and rural development.

Recommendations

The study recommends promoting improved agricultural practices through training and subsidies, reassessing the focus on soil and water conservation to prioritize impactful interventions, and encouraging agroforestry adoption by offering technical support and resources to farmers for enhanced resilience and food security.

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