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DEVELOPING A STANDARDIZED ADAPTATION INDEX TO EFFECTIVELY ASSESS CLIMATE RESILIENT PRACTICES AMONG FISHERMEN IN KATSINA STATE, NIGERIA

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ABSTRACT

Climate change has become a pressing concern for Nigeria in its efforts to ensure food and nutritional security for a rapidly growing population. In light of the challenges faced, it is essential to quantify the optimal weather conditions necessary for achieving higher yields. The aim of implementing adaptation is to effectively address potential climate risks in the forthcoming decades as the climate continues to evolve. This research aid in guiding choices made by farmers and policymakers, with consequences for a spectrum of timelines ranging from immediate tactical approaches to extensive long-term strategies. The adaptation index was developed following six (6) steps. Indicators selected for the index comprises of; Methods of fishery, Altered fishing periods, Varieties of Fishing gears, Crafts Management, Depth, Fishing frequency, Post-harvest techniques, and Varieties of baits. KMO and Bartlett's test was conducted using principal component analysis (PCA) to thoroughly evaluate the validity of the chosen indicators and sub-indicators. The obtained (KMO) value was 0.541, and it was acceptable. The approximate Chi-Square value was 412.836, with a significance value (p) of 0.000, which is less than 0.001. This finding indicates that the correlation matrix is not an identity matrix, reflecting a strong relationship among the variables. The reliability coefficient was measured at 0.89, which exceeds the standard value of 0.70. The adaptation index measures the climate-resilient practices embraced by fishermen. By quantifying their level of adaptation to climate change, this index provides valuable insights into the effectiveness of existing fishing practices in mitigating climate-related risks.

Keywords: Adaptation index, Fishermen, Climate change, Climate resilient practices

INTRODUCTION

Nigeria is widely acknowledged as the leading producer of fish and other aquatic products, playing a crucial role in global fishery output (MoA & FW, 2023). However, fish production yields are projected to decline due to the anticipated effects of climate change, which may reduce yields by 10% to 30% by 2030 (IPCC, 2023) among other reasons.

Climate change has become a pressing concern for Nigeria in its efforts to ensure food and nutritional security for a rapidly growing population. Significant negative impacts are expected from medium-term climate change (2010-2039), potentially leading to yield reductions of 4.5% to 9%, influenced by the extent and distribution of warming. Since agriculture constitutes approximately 16% of Nigeria's GDP, this decline in production suggests a financial loss of up to 1.5% of GDP per year due to climate change (Venkateswarlu et al., 2013).

In terms of vulnerability to extreme weather events, Nigeria ranks as the seventh most vulnerable nation globally. The development of advanced modeling techniques to assess the impact of climate change on fishery regions exemplifies efforts to manage risks and mitigate vulnerability. If no adaptation measures are implemented, fisheries could experience projected post-harvest losses of 10% to 40% over the next five decades. Furthermore, rising temperatures may reduce the yields of key aquatic food sources by 4% to 9% (IPCC, 2012). Fish production is also anticipated to decline significantly by nearly one metric ton if temperatures fluctuate irregularly by 20°C.

Fish contributes approximately 7% to Nigeria's agricultural GDP and supports about 600 million man-days of employment in the country (FAO, 2018; Dan-Kishiya, et al., 2018; Ahmad et al., 2017). The consumption of fish as a protein source for a large segment of the population, alongside its economic contributions and job creation, underscores its significance in national food security and income generation in Nigeria (Ahmad et al., 2019).

In Katsina State, the most abundant fish species tend to be more prevalent during the rainy season (May to September). However, the quantum and distribution of rainfall critical for fish well-being, reproduction, and migration have become erratic in recent years due to climate variability (Nababa et al., 2022; Ishfaq et al., 2020 & Nababa et al 2019). Climate variability, particularly related to temperature, rainfall, and solar radiation, poses major challenges to agricultural production, including both fish and crop production, on a global scale (Sadauki et al., 2024; IPCC, 2020; Pathak et al., 2018).

In light of the challenges faced, it is essential to quantify the optimal weather conditions necessary for achieving higher yields. This information can aid in the development of management strategies to enhance fish productivity in Nigeria. Sanchez et al. (2014) suggest that the optimal temperature for the vegetative growth of fish is approximately 28°C, while the ideal temperature for grain filling ranges from 21.7°C to 26.7°C. Ahmed et al. (2015) observed a decrease in 1000-grain weight and seed-setting rates when temperatures exceeded 27.0°C. Moreover, changes in rainfall patterns, temperature variability, and sunlight duration during the wet season significantly impact fish production and reproduction. Research identifies maximum temperatures and low rainfall conditions as key factors influencing fish yields in Nigeria, which also affects the national economy (IPCC, 2014). Climate change exacerbates these challenges, posing a threat to Nigerian agriculture, influencing food security, and hindering efforts to meet Sustainable Development Goals

(IPCC, 2023). It is important to manage these vulnerabilities to minimize losses for farmers. Fishermen should receive information on climate change mitigation measures through various extension channels, including radio, journals, newspapers, and magazines.

Adaptation to climate change involves changes in agricultural management practices in response to shifting climate conditions (Magawata et al., 2013 & Akinnagbe and Irohibe, 2015). It typically includes a combination of individual responses at the farm level, assuming access to alternative practices and technologies available in the region. Effective adaptation to climate change requires long-term investments in strategic research and new policy initiatives that incorporate climate change adaptation into development planning (Grigorieva et al., 2023). Awareness of climate-resilient agricultural practices is necessary for farmers to manage vulnerabilities and ensure food and water security (Berhanu and Oljira, 2019; Osigwe et al., 2019).

Against this backdrop, the proposed research aims to address the knowledge gap by developing adaptation practices tailored for fishermen in Katsina State, Nigeria (Nababa et al., 2020). These practices will consider a comprehensive set of parameters, including methods of fishery establishment, adjusted artisanal fishing dates, fishery varieties, and overall climate-resilient practices that impact fish production. The resulting practices are intended to contribute to academic scholarship and serve as practical tools for policymakers, researchers, and stakeholders addressing the challenges of climate change in Nigerian agriculture.

Theoretical Background of the study

Adaptation is a complex process that occurs across multiple dimensions and scales, defined as the adjustments made to behaviours or economic frameworks to decrease societal vulnerability in response to scarcity or environmental threats (Adger et al., 2003). It encompasses changes in natural or human systems in reaction to actual or anticipated climatic stimuli or impacts, aimed at reducing harm or seizing beneficial opportunities (IPCC, 2007). Additionally, it involves the actions taken by individuals, nations, and communities to adjust to the changes in climate that have already taken place. The goals of adaptation can include: minimizing exposure to risks of destruction; enhancing the ability to manage unavoidable damages; and capitalizing on emerging opportunities. The aim of implementing agricultural adaptation is to effectively address potential climate risks in the forthcoming decades as the climate continues to evolve. Current adaptation research can aid in guiding choices made by farmers, agribusinesses, and policymakers, with consequences for a spectrum of timelines ranging from immediate tactical approaches to extensive long-term strategies (Nababa et al., 2022).

Operationalization of adaptation of climate resilient practices by fishermen

The adaptation of climate-resilient practices by fishermen was defined as the changes or modifications made by fishermen in their fishing methods, including adjustments in crop production, techniques for conserving soil and water, strategies for managing floods, land utilization, labor management, financial planning, and family management, all aimed at minimizing the impacts of climate change.

MATERIALS AND METHODS

The adaptation index was developed by following the procedure given below:

Step 1: Identification of indicators

The adaptation of climate-resilient practices by fishermen was identified as a dependent variable. Based on a thorough consideration of the results from (Sadauki *et al.,* 2024) on climate change perception mitigating strategies in Katsina state, as well as a review of other literature related to adaptation of climate resilient practices by fishermen and indicators were identified.

Step 2: Collection of sub-indicators

Numerous sub-indicators were developed for each indicator related to the adaptation of climate-resilient practices by fishermen. This process was based on a review of the literature and discussions with relevant specialists. The sub-indicators were then carefully edited, revised, and restructured into questionnaires, which underwent a validation process.

A total of 240 questionnaires were distributed across three agricultural zones (KTARDA), as well as to academic departments in related fields at universities, polytechnics, and colleges of education within the state. The aim was to critically evaluate the relevance of each indicator and its sub-indicators using a three-point scale: Relevant (R), Slightly Relevant (SWR), and Not Relevant (NR), scored as 3, 2, and 1, respectively. Respondents were also encouraged to suggest additional indicators that they deemed relevant for assessing the adaptation of climate-resilient practices by fishermen.

Ultimately, 21 completed questionnaires were used for further analysis. From the gathered data, the Relevancy Rating Score was calculated for all indicators and sub-indicators using a specific formula.

$$\text{Relevancy Rating Score} = \frac{\text{R}\times 3 + \text{SWR}\times 2 + \text{NR}\times 1}{\text{No.of judges responded} \times \text{Maximum score}}. \quad (1)$$

In the evaluation conducted by the judges, only those items with a relevancy rating score of 0.80 or higher were deemed significant enough to advance to the next stage of analysis. As a result, the identified indicators and their corresponding sub-indicators were carefully selected for further examination. This process included making necessary adjustments based on the valuable feedback provided by experts in the field. The indicators that successfully met these established criteria are detailed in Table 1.

Step 3: Normalization of Indicators and sub-indicators

Relevant rating scores were selected for inclusion in the index. Consequently, the scores of all indicators and sub-indicators were normalized using the provided formula.

$$U_{ij} = \frac{Y_{ij} - Min_{yj}}{Max_{ij} - Min_{yj}} \quad (2)$$

Where,

U_{ij} = Unit score of the ith respondents on the jth component

Y_{ij} = Value of ith respondent on the jth component

Max_{ij} = Maximum score on the jth component

Min_{yj} = Minimum score on the jth component

Step 4: Validity Test

In the present investigation, KMO and Barlett's Test was adopted to compute the validity of the Adaptation Index and it was established by the expert's judgment. The variance proportion can be interpreted as per the following table

Table 1: The KMO Value Interpretation Criteria

KMO Value	Interpretation of sampling adequacy
1 to 0.9	Very Good
0.8 to 0.9	Good
0.7 to 0.8	Medium
0.6 to 0.7	Reasonable
0.5 to 0.6	Acceptable
< 0.5	Unacceptable

Normalized data was analyzed using KMO and Bartlett's Test to evaluate item validity for measuring sampling adequacy, employing SPSS software (version 20).

Step 5: Assessment and refinement of indicators and sub-indicators through Principal component analysis (PCA)
The index was calculated using Principal Component Analysis (PCA) for extraction and the varimax method for rotating factors, employing SPSS software (version 20). This approach was used to assess and refine factor loadings exceeding 0.5 for the sub-indicators, allowing us to compute index values for the indicators based on these factor loadings. The initial Eigenvalues above were identified, and based on the number of Eigenvalues greater than 1, an equal number of rotated components were extracted for each sub-indicator, as illustrated in the rotated component matrix.

Step 6: Reliability of the Adaptation Index
The analysis was conducted using SPSS software version 20. To assess the internal consistency of the items involved, the Cronbach's Alpha coefficient was calculated. A coefficient value of 0.70 or higher is generally accepted as an indicator of good internal consistency among the items. Only those items meeting this criterion were considered suitable for further inclusion in the index.

RESULTS AND DISCUSSION

Selection of indicators for inclusion in the index: The responses were quantified and presented in Table 2

Table 2: Relevant Rating Score of Indicators

Indicator	RRS
Methods of fishery	0.90
Altered fishing periods	0.87
Varieties of Fishing gears	0.94
Crafts Management	0.88
Depth	0.84
Fishing frequency	0.85
Post-harvest techniques	0.82
Varieties of baits	0.87

The relevancy rating scores ranged from 0.82 to 0.94, calculated by dividing the actual score obtained by the maximum possible score from 30 experts. Only those indicators with a relevancy rating score exceeding 0.80 were included in the adaptation index. A total of eight indicators met this criterion: methods of fishing, altered fishing periods, varieties of fishing gear, craft management, depth, fishing frequency, post-harvest techniques, and types of bait.

For the selection of sub-indicators, only items with a relevancy rating score greater than 0.80 were considered for inclusion in the index. The relevancy scores were derived by dividing the actual score by the maximum possible score. Out of the initially considered 28 items, 21 were ultimately selected for inclusion in the index. The quantified responses for these index items are detailed in Table 3.

Table 3: Relevancy Rating Score of Sub-indicators

Indicator	Sub-indicator	Relevant Rating score
Methods of fishery	Passive fishing	0.93
	Active Fishing	0.90
Altered fishing period	Full-day setting (24 hours)	0.94
	Half day setting (≤12 hours)	0.82
Varieties of Fishing gears	Net	0.97
	Hooks	0.93
Crafts Management	Intensive management	0.85
	Extensive management	0.91
Depth	Narrow (≤3m)	0.84
	Far depth (≥3m)	0.85
Fishing frequency	Daily	0.88
	Weekends	0.84
	Occasional	0.86
Post-harvest techniques	Smoking	0.81
	Frying	0.83
	Drying	0.80
Varieties of baits	Fish parts	0.92

Insects	0.84
Chicken visceral	0.82
Food left-over	0.94
Artificial bait	0.80

Validation and Assessment of indicators and sub-indicators through Principal Component Analysis

KMO and Bartlett's test was conducted using principal component analysis (PCA) to thoroughly evaluate the validity of the chosen indicators and sub-indicators. This statistical test is essential for determining whether the responses provided are adequately representative of the sample population being analyzed. The outcomes of this analysis are detailed below.

Principal component analysis (PCA) serves as a powerful variable reduction technique, aiming to maximize the variance explained by a smaller set of variables known as factors. By finding orthogonal linear combinations of the original variables, PCA effectively captures the most significant common information present within the dataset. This methodology allows researchers to condense a large number of variables into a smaller number of principal components, simplifying the analysis without losing critical information.

In the context of this study, factor analysis was employed to uncover the underlying variables, or factors, that illuminate the patterns of correlation among the observed variables. Specifically, PCA was applied to a selection of eight key indicators and twenty-five relevant sub-indicators, all focused on the adaptation of climate-resilient practices by fishermen. These indicators and sub-indicators were organized into a correlation matrix, facilitating a detailed examination of their interrelationships. To enhance the interpretability of the results, a Varimax orthogonal rotation with Kaiser Normalization was performed. The subsequent findings have been analyzed and are presented in detail below.

Table 4: KMO and Bartlett's Test Value for adaptation of climate resilient practices by fishermen

KMO and Bartlett's Test		
Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.541
	Approx. Chi-Square	412.836
Bartlett's Test of Sphericity	Df	253
	Sig.	.000

Table 4 provides the results of the KMO and Bartlett's test. The obtained Kaiser-Meyer-Olkin (KMO) value was 0.541, which, when compared to the values in Table 1, is considered acceptable. This suggests that the sum of the partial correlations was not significantly different from the sum of the correlations, accounting for 54.1% of the analysis variables. As a result, there was no diffusion in the correlation pattern, reinforcing the suitability of conducting factor analysis in this context. Hence, reliable and distinct factors could be extracted from this data through factor analysis.

Furthermore, Table 4 also details the results of Bartlett's Test of Sphericity. The approximate Chi-Square value was 412.836, with a significance value (p) of 0.000, which is less than 0.001. This finding indicates that the correlation matrix is not an identity matrix, reflecting a strong relationship among the variables. Therefore, factor analysis is deemed appropriate for this dataset.

Table 5: Eigenvalues for adaptation of climate resilient practices by fishermen

Total Variance Explained					
Component	Initial Eigenvalues			Extraction Sums of Squared Loadings	
	Total	% of Variance	Cumulative %	Total	% of Variance
1	3.698	16.514	16.514	3.798	16.514
2	3.457	14.538	31.110	3.357	14.596
3	2.022	9.226	40.337	2.122	9.226
4	1.942	8.010	48.347	1.842	8.010
5	1.680	6.868	55.215	1.580	6.868
6	1.406	5.679	60.894	1.306	5.679
7	1.266	5.070	65.965	1.166	5.070
8	1.164	4.625	70.589	1.064	4.625
9	0.835	4.064	74.654	-	-
10	0.853	3.706	78.360	-	-
11	0.711	3.043	81.403	-	-
12	0.776	2.940	84.342	-	-
13	0.739	2.735	87.077	-	-
14	0.675	2.557	89.635	-	-
15	0.510	2.108	91.743	-	-
16	0.367	1.768	93.512	-	-
17	0.269	1.475	94.987	-	-
18	0.258	1.338	96.325	-	-
19	0.254	1.105	97.430	-	-
20	0.203	0.882	98.313	-	-
21	0.099	1.749	99.062	-	-

Table 5 provides a detailed overview of the Eigenvalue specifications alongside the percentage of variance explained by each component analyzed. In this study, we specifically selected components that exhibited an Eigenvalue greater than one, identifying significant factors that influence the adaptation of climate-resilient practices among fishermen. Through this analysis, we successfully extracted eight distinct factors from the eight components, which collectively account for an impressive total variance of 70.58 percent. This finding highlights the substantial impact of these eight factors in shaping how fishermen adapt to climate resilience practices, underscoring their importance in the overall understanding of this adaptation process.

Table 6: Standardized Factor Loadings of an Adaptation Index of Fishermen

Indicator	Sub-indicator	Relevant Rating score
Methods of fishery	Passive fishing	0.83
	Active Fishing	0.70
Altered fishing period	Full-day setting (24 hours)	0.74
	Half-day setting (≤12 hours)	0.72
Varieties of Fishing gears	Net	0.77
	Hooks	0.53
Crafts Management	Intensive management	0.85
	Extensive management	0.91
Depth	Narrow (<3m)	0.84
	Far depth (>3m)	0.85
Fishing frequency	Daily	0.68
	Weekends	0.84
	Occasional	0.56
Post-harvest techniques	Smoking	0.61
	Frying	0.83
	Drying	0.80
Varieties of baits	Fish parts	0.82
	Insects	0.74
	Chicken visceral	0.52
	Food left-over	0.74
	Artificial bait	0.60

In Table 6, factor loadings greater than 0.5 were utilized to evaluate the sub-indicators of adaptation measures derived from Principal Component Analysis (PCA). Higher loadings signify a more robust representation of the original variables by the latent factors or components. Conversely, low or non-significant loadings may indicate that the variable does not substantially contribute to the factor or component under examination.

Testing for reliability of adaptation of climate resilient practices by fishermen

The internal consistency reliability method, using Cronbach's alpha, was employed to assess the reliability of the adaptation of climate-resilient practices with SPSS software version 20. The reliability coefficient was measured at 0.89, which exceeds the standard value of 0.70. This indicates a high level of reliability and good internal consistency for the vulnerability index presented in Table 8.

Table 7: Reliability Statistics of an Adaptation Index

Cronbach's Alpha	N of Items
0.89	21

Computation of index values to the adaptation of climate resilient practices by fishermen

To calculate the index values for each identified indicator, we will utilize the sum of the factor loadings obtained through Principal Component Analysis (PCA) for all associated sub-indicators. This approach will provide a comprehensive evaluation of the adaptation of climate-resilient practices by fishermen. The results of this analysis will be detailed in Table 8, highlighting the specific practices adopted and their corresponding contributions to the overall index values. This detailed assessment will enable us to understand better how different sub-indicators influence the resilience of fishing communities in the face of climate change.

Table 8: Index values of an adaptation of climate resilient practices by fishermen

Indicator	Index value	Rank
Methods of fishery	2.200	II
Altered fishing period	2.049	IV
Varieties of Fishing gears	1.342	VII
Crafts Management	1.562	VI
Depth	1.214	VIII
Fishing frequency	1.987	V
Post-harvest techniques	2.100	III
Varieties of baits	3.461	I

Table 8 presents the index values for various indicators related to the adoption of climate-resilient practices among fishermen. The data reveals that the use of different varieties of bait has the highest index value at 3.461, followed by fishing methods with an index of 2.20. Other notable practices include post-harvest techniques (2.10), altered fishing periods (2.049), fishing frequency (1.987), crafts management (1.562), varieties of fishing gears (1.342), and water depth (1.214).

Measurement Procedures for Indicators

The developed adaptation index is composite, incorporating both quantitative and qualitative measures. For each indicator, suitable sub-indicators and variables were identified, and specific measurement levels were established.

Schedule Development

A schedule was created for all indicators to capture the variability in the adaptation of climate-resilient practices by fishermen. A pilot study was conducted with 60 respondents outside the sample group to test the reliability and validity of the index.

Calculation of an Adaptation Index

To assess the climate-resilient practices implemented by fishermen, a comprehensive adaptation index was calculated. This index was derived using a specific formula designed to quantify the extent of these adaptive strategies in response to changing environmental conditions.

Developed Adaptation Index

$$= \frac{Obtained\ adaptaion\ score}{Maximum\ obtainable\ score} \times 100 \quad (3)$$

CONCLUSION

The adaptation index measures the climate-resilient practices embraced by fishermen. By quantifying their level of adaptation to climate change, this index provides valuable insights into the effectiveness of existing fishing practices in mitigating climate-related risks. Its comprehensive evaluation enables researchers and policymakers to identify vulnerable areas among fishermen and prioritize interventions accordingly. Furthermore, the index allows for the monitoring of progress over time and aids in the development of targeted strategies to enhance resilience in the face of shifting environmental conditions. Ultimately, the adaptation index represents a vital step toward establishing sustainable fishing systems capable of withstanding the challenges posed by climate change, thereby ensuring the long-term viability of fishery cultivation.

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