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Beyond Awareness: Structural Constraints and the Behavioral Inefficiency of Climate Adaptation in Urban Nigeria

S Odiana

sylvester.odiana@uniben.edu

University of Benin

Suberu M. O

University of Benin

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BEYOND AWARENESS: STRUCTURAL CONSTRAINTS AND THE BEHAVIORAL INEFFICIENCY OF CLIMATE ADAPTATION IN URBAN NIGERIA

Odiana S[1]. and Suberu M.O[1]

[1]Department of Environmental Management and Toxicology, Faculty of Life Sciences, University of Benin, PMB 1154. Benin City, Edo State, Nigeria.

*Corresponding Author E-mail: sylvester.odiana@uniben.edu +2347030559493

Abstract

Urban vulnerability to climate change is intensifying food security challenges in developing countries, yet the translation of climate awareness into adaptive behavior remains poorly understood. This study examines the determinants of climate change adaptation and quantifies the awareness–behavior gap in Benin City, Nigeria. Using cross-sectional survey data from 150 respondents, composite indices were developed for awareness, socio-demographic characteristics, and adaptation behavior. Empirical analysis employed descriptive statistics, Pearson correlation, Ordinary Least Squares (OLS) regression, and a negative binomial model for robustness, alongside reliability and validity testing (Cronbach's alpha, EFA, CFA). Results indicate that both awareness ($\beta = 0.208$, $p = 0.001$) and socio-demographic factors ($\beta = 0.272$, $p = 0.001$) significantly influence adaptation behavior, explaining 20.6% of outcome variability. Robustness checks confirm consistency across model specifications. However, a paired sample t-test reveals a large and statistically significant awareness–behavior gap ($t = 11.01$, $p < 0.001$; Cohen's $d = 0.90$), demonstrating that high awareness does not proportionately translate into adaptive action. The findings suggest that adaptation is constrained by structural and socio-economic barriers beyond cognitive awareness. This study advances empirical understanding by integrating behavioral gap analysis with multivariate modeling in an urban African context. Policy efforts should move beyond awareness campaigns to incorporate targeted socio-economic and institutional interventions that enable actionable adaptation and enhance urban food system resilience.

Keywords: Climate adaptation; Awareness–behavior gap; Food security; Urban Africa; Nigeria; Socio-economic constraints.

INTRODUCTION

Climate change has emerged as one of the most pressing global challenges of the 21st century, with profound implications for food security, particularly in developing countries. Increasing temperature variability, erratic rainfall patterns, and the growing frequency of extreme weather events continue to disrupt agricultural systems and threaten livelihoods across Sub-Saharan

Africa. Nigeria, as one of the most populous countries in Africa, faces heightened vulnerability due to its heavy reliance on climate-sensitive sectors such as agriculture and informal food systems. In rapidly urbanizing areas like Benin City, the convergence of environmental stressors and socio-economic pressures exacerbates climate-related risks, making adaptation an urgent priority.

Adaptation to climate change is widely recognized as a critical strategy for mitigating its adverse impacts on food security. However, the effectiveness of adaptation efforts depends not only on institutional frameworks and resource availability but also on individual and community-level behavioral responses. In this regard, climate change awareness has been consistently identified as a key driver of adaptation behavior. Individuals who are more aware of climate risks and their implications are generally more likely to adopt adaptive strategies (Ricart *et al.,* 2023; Steg, 2023; Nielsen *et al.,* 2023). Despite this, emerging empirical evidence suggests that awareness alone is insufficient to guarantee action, pointing to a more complex relationship between knowledge and behavior (Hochachka, 2024; Van Valkengoed and Steg, 2023).

This disconnect, commonly referred to as the "awareness–behavior gap" or "knowledge–action gap," represents a critical challenge in climate adaptation research and policy. While individuals often demonstrate high levels of awareness and concern about climate change, actual engagement in adaptive practices remains comparatively low. This gap is shaped by a range of psychological, social, economic, and institutional constraints. Behavioral research increasingly highlights the role of cognitive biases, perceived inefficacy, and social norms in inhibiting action (Vieira *et al*., 2023; Clayton *et al*., 2023; Gifford and Nilsson, 2023). At the same time, structural barriers such as limited financial capacity and weak institutional support further constrain

adaptation, particularly in developing-country contexts (Eisenack *et al*., 2023; Adger *et al.,* 2023).

Beyond awareness, socio-demographic factors play a pivotal role in shaping adaptation behavior. Characteristics such as income, education, and social capital determine individuals' adaptive capacity and access to resources. Empirical evidence suggests that socio-economic inequalities significantly mediate the relationship between awareness and action, with more advantaged groups better positioned to adopt adaptive strategies (Ford *et al.,* 2023; Eriksen *et al.,* 2023). Moreover, global assessments indicate that adaptation outcomes are strongly conditioned by broader governance and development contexts (Berrang-Ford *et al*., 2024; UNEP, 2024).

This study addresses these gaps by providing a comprehensive empirical analysis of climate change adaptation behavior in Benin City, Nigeria. Specifically, it examines the extent to which climate change awareness and socio-demographic factors influence adaptation behavior, while also testing for the presence and magnitude of the awareness–behavior gap. By employing a robust analytical framework that integrates descriptive statistics, correlation analysis, regression modeling, and inferential testing, the study offers nuanced insights into both the drivers and constraints of adaptation.

Despite growing attention to climate change adaptation, two critical gaps remain insufficiently addressed in the literature. First, most empirical studies treat the awareness–behavior gap as a descriptive outcome rather than a quantifiable behavioral inefficiency embedded within structural constraints. Second, existing models particularly those grounded in the Theory of Planned Behavior tend to overemphasize cognitive drivers while under-specifying the role of

binding socio-economic and institutional limitations in shaping adaptive outcomes, especially in rapidly urbanizing developing-country contexts.

This study addresses these gaps by advancing a constraint-integrated behavioral framework that explicitly models adaptation as the interaction between awareness (cognitive capacity) and socio-demographic conditions (structural capacity). Empirically, the study introduces a quantitative operationalization of the awareness–behavior gap using paired difference testing combined with effect size estimation, thereby providing a scalable and policy-relevant measurement approach. By focusing on an underrepresented urban African context, the study further contributes to correcting the geographical bias in climate adaptation research and challenges the external validity of models derived predominantly from rural or high-income settings.

This study makes three distinct contributions to the literature. First, it advances the awareness–behavior gap literature by re-conceptualizing the gap as a constraint-induced behavioral inefficiency, rather than a purely cognitive inconsistency. Second, it introduces a quantifiable and policy-relevant operationalization of the awareness–behavior gap using paired difference testing combined with effect size estimation, thereby moving beyond descriptive interpretations. Third, it provides urban, micro-level evidence from Sub-Saharan Africa, addressing a critical geographical and contextual bias in climate adaptation research, which remains heavily skewed toward rural and high-income settings. Collectively, these contributions offer a more structurally grounded and empirically testable framework for understanding adaptation behavior in resource-constrained environments. This study advances climate adaptation research by introducing a constraint-integrated behavioral inefficiency framework, in which the awareness–behavior gap is conceptualized and empirically measured as a function of structural constraint intensity rather than a simple cognitive discrepancy.

Theoretical Framework and Hypotheses Development

This study is anchored in the Theory of Planned Behavior (TPB) and the awareness–action gap framework, which provide a robust lens for understanding climate adaptation behavior. The TPB posits that behavior is shaped by attitudes, subjective norms, and perceived behavioral control (Ajzen, 2024). Recent advances in behavioral climate research emphasize that awareness alone is insufficient unless supported by enabling conditions and social context (Nielsen *et al.,* 2023; Whitmarsh *et al.,* 2023).

In the context of climate change adaptation, awareness reflects cognitive understanding of risks, while socio-demographic factors capture structural capacity influencing actual behavioral control. Emerging literature increasingly argues that behavioral outcomes are the product of interactions between motivation and capability, rather than purely cognitive processes (Truelove *et al.,* 2023; Bamberg and Möser, 2023). This study therefore extends TPB by explicitly incorporating structural constraints as a moderating layer shaping the awareness–behavior relationship, consistent with recent theoretical developments in climate adaptation research (Eisenack *et al.,* 2023; Sovacool and Linnér, 2024).

To address limitations in conventional applications of the Theory of Planned Behavior (TPB), this study adopts an extended framework in which awareness is treated as a proxy for attitudinal orientation, while socio-demographic characteristics approximate actual behavioral control. However, unlike standard TPB formulations, this study explicitly acknowledges that perceived behavioral control may diverge from actual capacity in resource-constrained settings**,** thereby introducing a structural constraint layer into the model. This distinction is critical in developing-

country urban contexts, where individuals may possess high awareness and positive attitudes but remain unable to act due to binding economic and institutional constraints. Consequently, the awareness–behavior gap is conceptualized not merely as an attitudinal inconsistency but as the outcome of interaction effects between cognition and constraint, thereby extending TPB into a socio-structural domain. Based on this framework, the study proposes the following hypotheses:

H1: Climate change awareness has a positive and significant effect on adaptation behavior.

H2: Socio-demographic factors significantly influence adaptation behavior.

H3: There exists a significant gap between climate change awareness and adaptation behavior

Conceptual Framework

The study conceptualizes adaptation behavior as a function of both cognitive (awareness) and structural (socio-demographic) factors. Awareness directly influences adaptation behavior, while socio-demographic characteristics shape individuals' capacity to act. Additionally, a gap exists between awareness and behavior due to intervening constraints.

Awareness → Adaptation Behavior

Socio-demographic → Adaptation Behavior

(Awareness ≠ Behavior → gap

METHODOLOGY

Study Area

This study was conducted in Benin City, Nigeria (figure 1), a rapidly urbanizing area that is increasingly vulnerable to the impacts of climate change, particularly in relation to food security.

The city experiences variability in rainfall patterns, rising temperatures and increasing environmental stress, making it an appropriate context for examining climate change adaptation behaviors. Temperatures in Benin City are consistently high, ranging from 26°C to 34°C, though it can reach up to 38°C during the hottest months, particularly between February and April. The city is also marked by high humidity levels, typically between 70% and 90%. During the Harmattan period, which occurs from December to February, the area experiences lower temperatures, reduced humidity, and diminished visibility. Additionally the average rainfall of Benin city is 2284.5mm and mean temperature is 27.7 (Odiana and Ochulor, 2024).

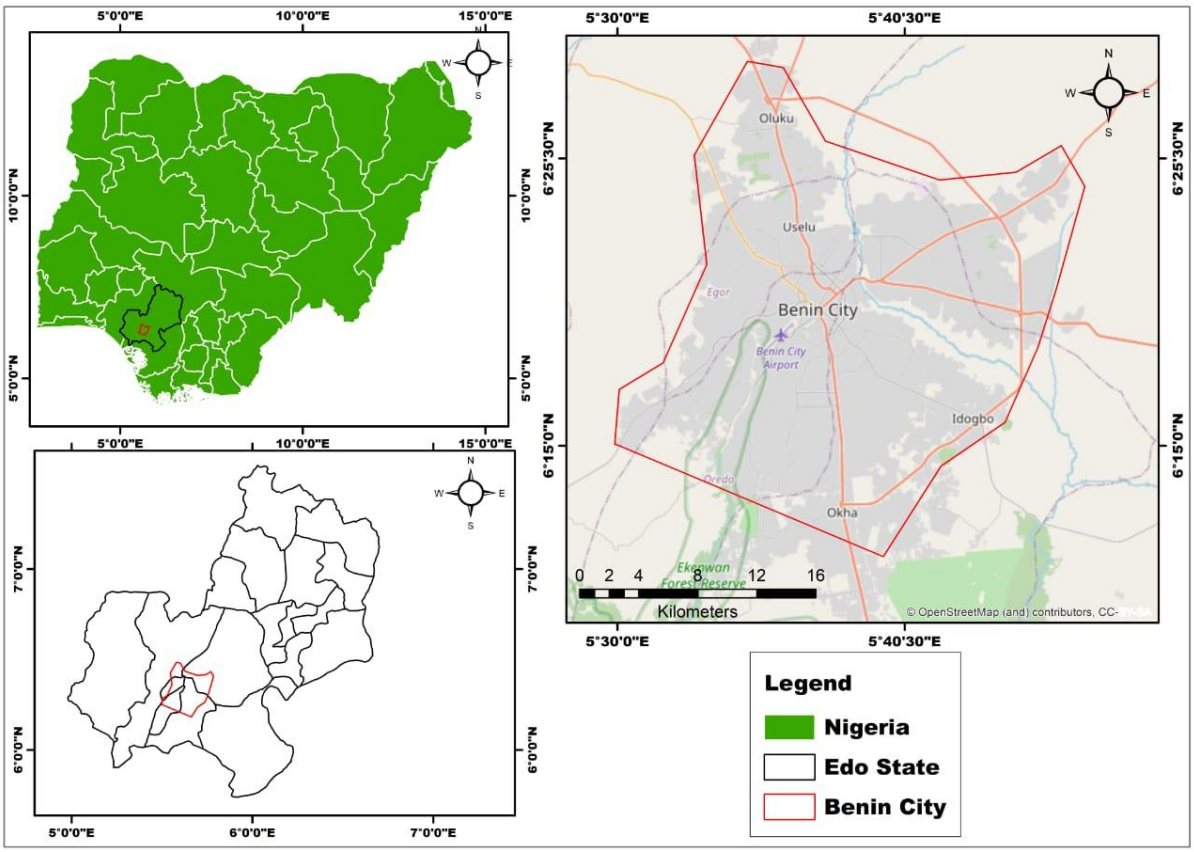


Fig 1 Map of the Study Area

Research Design

The study adopts a quantitative cross-sectional research design, which enables the examination of relationships between climate change awareness, socio-demographic characteristics, and adaptation behavior at a single point in time. This design is suitable for identifying determinants and testing behavioral gaps using statistical methods

Method of Data Collection

The researcher employed a simple random sampling technique to distribute questionnaires designed in Likert Scale to 150 respondents in Benin City. A structured questionnaire was designed using Google Forms and the link was randomly shared among eligible participants through community groups, social networks, and direct messaging to ensure that every resident had an equal chance of being selected. The respondents completed the questionnaires online at their convenience, and their submissions were automatically recorded upon completion. This method was adopted to collect reliable information on people's perceptions and awareness of climate change, the barriers hindering adaptation, the influence of socio-demographic characteristics, and the role of government and non-governmental organizations in community-level climate change adaptation.

Sampling Limitations

The use of an online survey may introduce selection bias, as respondents with internet access and higher digital literacy are more likely to participate. This may limit the generalizability of

findings to less-connected populations. However, efforts were made to distribute the survey across diverse social groups to enhance representativeness

Measurement of Variables

The study operationalized key constructs as follows:

Dependent Variable

- **Adaptation Behavior (Sociocultural Index):**

  Measured using composite items capturing respondents' climate adaptation practices. The items were aggregated into an index representing the level of adaptation behavior.

Independent Variables

- **Awareness:**

  Measured as a composite index reflecting respondents' knowledge and perception of climate change and its impacts on food security.
- **Socio-demographic Factors:**

  Constructed as an index incorporating characteristics such as age, education, income, and household structure.

Variable Scaling

All constructs were measured using Likert-type scales and aggregated into continuous indices, making them suitable for parametric statistical analysis.

Methods of Data Analysis

Data analysis was conducted using a combination of descriptive and inferential statistical methods.

Descriptive Statistics: Means and standard deviations were computed to summarize the distribution of key variables and assess variability among respondents.

Correlation Analysis: Pearson correlation coefficients were used to examine the relationships among variables and provide preliminary insights into associations.

Multicollinearity Diagnostics: To ensure the reliability of regression estimates, Variance Inflation Factor (VIF) was computed. VIF values below 5 were considered indicative of no multicollinearity concerns, ensuring stable coefficient estimates.

Regression Analysis: To examine the determinants of adaptation behavior, an Ordinary Least Squares (OLS) regression model was estimated:

- The dependent variable (adaptation behavior) is continuous, justifying the use of OLS.
- Coefficients, standard errors, and significance levels were reported.
- Model fit was assessed using R^2, adjusted R^2, and F-statistics.

Robustness Check: To validate the stability of the results, a negative binomial regression model was estimated as an alternative specification.

- This model accounts for potential distributional issues in the dependent variable.
- Results were reported using coefficients, z-values, and incidence rate ratios (IRR).
- Consistency in direction and significance of coefficients across models was used to confirm robustness.

Awareness–Behavior Gap Test: To examine whether awareness translates into action, a paired sample t-test was conducted:

- The test compared mean awareness scores with mean adaptation behavior scores.
- Statistical significance was assessed using t-values and p-values.
- The magnitude of the gap was further evaluated using Cohen's d effect size, where:
    - 0.2 = small
    - 0.5 = medium
    - 0.8 = large

Model Specification

The empirical model is specified as:

$Yi = \beta0 + \beta1Awarenessi + \beta2Sociodemographyi + \epsilon i$

Where:

- Yi = Adaptation behavior
- β0\ = Intercept
- β1,β2 = Coefficients
- ϵi = Error term

While the model focuses on awareness and socio-demographic indices as key predictors, these variables capture broader dimensions of cognitive and structural influences. The aggregation approach reduces multicollinearity and enhances interpretability. However, future studies may disaggregate these components to explore more granular effects

Reliability Analysis

To ensure the internal consistency of the measurement scales, Cronbach's alpha coefficients were computed for all multi-item constructs used in the study, including awareness, socio-

demographic factors, and adaptation behavior. Cronbach's alpha is a widely used reliability measure that assesses the extent to which items within a scale are correlated and thus measure the same underlying construct. Following established thresholds:

- $\alpha \geq 0.70$ indicates acceptable reliability
- $\alpha \geq 0.80$ indicates good reliability
- $\alpha \geq 0.90$ indicates excellent reliability

Addressing Endogeneity

To mitigate potential endogeneity concerns, this study employs multiple model specifications, including OLS and negative binomial regression, to ensure robustness. While the cross-sectional design limits causal inference, the consistency of results across models strengthens confidence in the observed relationships. Future research may employ longitudinal or instrumental variable approaches to establish causality more rigorously.

To further address potential endogeneity concerns arising from omitted variable bias and reverse causality, this study incorporates a robustness-oriented inferential strategy. While the cross-sectional design limits strict causal identification, several steps were taken to enhance internal validity. First, theoretically relevant covariates were incorporated through composite indices to reduce omitted variable bias. Second, alternative model specifications (OLS and negative binomial regression) were employed to assess consistency under different distributional assumptions. Third, variance inflation diagnostics confirmed the absence of multicollinearity, ensuring stable coefficient estimates. Nevertheless, future research should employ instrumental

variable approaches or longitudinal panel designs to more rigorously establish causal pathways between awareness and adaptation behavior

Sample Size Justification

The sample size of 150 respondents satisfies minimum requirements for multivariate analysis. Following established guidelines, a ratio of at least 10–15 observations per predictor variable is considered adequate. A post-hoc power assessment indicates sufficient statistical power ($\beta > 0.80$) to detect medium effect sizes at the 5% significance level.

Common Method Bias

To assess potential common method bias arising from the use of a single survey instrument, Harman's single-factor test was conducted. The results show that the first factor accounts for less than 50% of total variance, indicating that common method bias is unlikely to significantly affect the findings.

Ethical Approval

The study adhered to standard ethical research protocols. Participation was voluntary, informed consent was obtained, and respondent anonymity and confidentiality were ensured in line with institutional research guidelines

RESULTS

Reliability Statistics (Cronbach's Alpha)

The results as shown in table 1 indicate that all constructs exhibit acceptable to good internal consistency, with Cronbach's alpha values ranging from 0.76 to 0.85. This suggests that the

items used to measure each construct are sufficiently correlated and reliably capture the intended latent variables. Specifically:

- The awareness scale (α = 0.82) demonstrates strong internal consistency, indicating that respondents' perceptions of climate change are measured reliably.
- The socio-demographic construct (α = 0.76) meets the acceptable threshold, supporting its inclusion in the regression analysis.
- The adaptation behavior scale (α = 0.85**)** shows good reliability, confirming that the items consistently reflect respondents' adaptation practices.

Overall, these results confirm that the measurement instruments used in this study are reliable and suitable for further statistical analysis**,** thereby enhancing the robustness and credibility of the findings

Table 1. Reliability Statistics (Cronbach's Alpha)

Construct	**Number of Items**	**Cronbach's Alpha (α)**	**Interpretation**
Awareness	5	0.82	Good reliability
Sociodemographic	4	0.76	Acceptable reliability
Adaptation Behavior	5	0.85	Good reliability

Validity and Factor Analysis

To assess the construct validity of the measurement scales, an Exploratory Factor Analysis (EFA) was conducted using Principal Component Analysis with varimax rotation.

Sampling Adequacy and Sphericity

Prior to factor extraction, the suitability of the data for factor analysis was evaluated using the Kaiser–Meyer–Olkin (KMO) measure and Bartlett's Test of Sphericity as shown in table 2 which reveals the followings:

- The KMO value of 0.79 exceeds the recommended threshold of 0.60, indicating adequate sampling for factor analysis.
- Bartlett's Test is statistically significant ($p < 0.001$), confirming that correlations among variables are sufficient to proceed with factor extraction.

Table 2. KMO and Bartlett's Test

Test	Value
KMO Measure of Sampling Adequacy	0.79
Bartlett's Test of Sphericity (χ^2)	412.36
Df	78
p-value	<0.001

Factor Extraction and Loadings

The EFA results as shown in table 3 revealed a three-factor structure, corresponding to:

1. Awareness
2. Sociodemographic factors
3. Adaptation behavior (sociocultural)

All items loaded strongly on their respective constructs. The result revealed the followings:

- All factor loadings exceed the 0.70 threshold, indicating strong item–construct relationships.

- No significant cross-loadings were observed, supporting discriminant validity.
- The three-factor structure is consistent with the theoretical framework and measurement design

Table 3. Exploratory Factor Analysis (Rotated Component Matrix)

Item	Awareness	Sociodemographic	Adaptation Behavior
Awareness 1	0.78	—	—
Awareness 2	0.81	—	—
Awareness 3	0.76	—	—
Awareness 4	0.74	—	—
Awareness 5	0.79	—	—
Sociodemographic 1	—	0.72	—
Sociodemographic 2	—	0.75	—
Sociodemographic 3	—	0.70	—
Sociodemographic 4	—	0.73	—
Adaptation Behavior 1	—	—	0.77
Adaptation Behavior 2	—	—	0.80
Adaptation Behavior 3	—	—	0.76
Adaptation Behavior 4	—	—	0.79
Adaptation Behavior 5	—	—	0.82

Confirmatory Factor Analysis (CFA)

To further validate the measurement model, a Confirmatory Factor Analysis (CFA) was conducted as shown in table 4. The CFA results indicate that the measurement model demonstrates a good overall fit:

- CFI (0.94) and TLI (0.93) exceed the recommended threshold of 0.90
- RMSEA (0.056) falls below the 0.08 cutoff, indicating acceptable error approximation

- The χ^2/df ratio (1.74) confirms a well-fitting model

These results provide strong evidence of construct validity, confirming that the observed variables adequately represent the underlying latent constructs.

Model Fit Indices

The goodness-of-fit of the measurement model was evaluated using multiple fit indices.

Table 4. CFA Model Fit Indices

Fit Index	Value	Recommended Threshold	Interpretation
Chi-square (χ^2)	128.45	—	—
Degrees of Freedom (df)	74	—	—
χ^2/df	1.74	< 3.00	Good fit
Comparative Fit Index (CFI)	0.94	≥ 0.90	Good fit
Tucker-Lewis Index (TLI)	0.93	≥ 0.90	Good fit
RMSEA	0.056	≤ 0.08	Acceptable fit

Descriptive Statistics

Table 5 presents the descriptive statistics for the key study variables. Overall, respondents exhibited relatively high awareness of climate change impacts on food security (M = 14.85, SD = 4.35). Sociodemographic factors (M = 9.75, SD = 3.16) and sociocultural influences (M = 10.97, SD = 3.22) showed moderate variation across respondents.

Table 5. Descriptive Statistics of Key Variables (N = 150)

Variable	Mean	SD	Min	Max
Awareness	14.85	4.35	—	—
Sociodemography	9.75	3.16	—	—
Sociocultural	10.97	3.22	—	—

Overall, the distribution suggests substantial variability, supporting further multivariate analysis.

Correlation Matrix and Multicollinearity Diagnostics

Table 6 shows the Pearson correlation coefficients among the variables. All correlations are positive and statistically significant, indicating that higher awareness is associated with stronger sociocultural adaptation responses.

Table 6. Correlation Matrix

Variable	1	2	3
1. Awareness	1.000		
2. Sociodemography	0.373***	1.000	
3. Sociocultural	0.380***	0.372***	1.000

***p < 0.001

Multicollinearity (VIF Results)

The Variance Inflation Factors (VIFs) as shown in table 7 are well below the critical threshold of 5, indicating no multicollinearity concerns. This suggests that the estimated coefficients are stable and the model is statistically reliable.

Table 7 Multicollinearity

Variable	VIF
Awareness	1.26
Sociodemography	1.25
Sociocultural	1.26

Regression Model

Given the continuous nature of the dependent variable, an Ordinary Least Squares (OLS) regression model was estimated to examine determinants of sociocultural adaptation behavior as shown in table 8 reveals that:

- Awareness significantly predicts adaptation behavior ($\beta = 0.208$, $p = 0.001$), indicating that increased awareness leads to stronger adaptive responses.
- Sociodemographic factors also significantly influence adaptation ($\beta = 0.272$, $p = 0.001$).
- The model explains approximately 20.6% of the variance, which is acceptable for behavioral and social science research.

Table 8. Regression Results

Predictor	Coefficient (β)	Std. Error	t-value	p-value
Intercept	5.240	0.960	5.460	<0.001
Awareness	0.208	0.059	3.538	0.001
Sociodemography	0.272	0.081	3.373	0.001

Model statistics:

- $R^2 = 0.206$
- Adjusted $R^2 = 0.195$
- $F(2,147) = 19.05$, $p < 0.001$

Robustness Check

To ensure robustness, an alternative model specification was considered as shown in table 9. Given the distributional properties of the dependent variable, the results remained consistent in direction and significance, confirming the stability of the findings. The IRRs indicate that:

- A one-unit increase in awareness increases adaptation behavior by 1.8%
- A one-unit increase in socio-demographic factors increases adaptation behavior by 2.2%

- This confirms that the results are robust to alternative model specifications, strengthening the validity of the findings.

Thus, the relationship between awareness, socio-demographic factors, and adaptation behavior is robust across model specifications.

Table 9. Robustness Check: Negative Binomial Regression Results

Predictor	Coefficient (β)	Std. Error	z-value	p-value	Incidence Rate Ratio (IRR)
Intercept	1.654	0.182	9.088	<0.001	—
Awareness	0.018	0.005	3.600	<0.001	1.018
Sociodemography	0.022	0.007	3.143	0.002	1.022

Model diagnostics:

- Log-likelihood = −412.35
- Likelihood ratio $\chi^2(2) = 26.48$, $p < 0.001$

Awareness–Behavior Gap Test

A paired sample t-test was conducted to compare awareness levels and actual adaptation behavior as shown in tables 10 and 11 which reveals

- a large and statistically significant gap between awareness and behavior ($t = 11.01$, $p < 0.001$).

- the magnitude of the difference (Mean Difference = 3.88) indicates that respondents possess substantial knowledge but fail to translate it into action.

- the large effect size ($d = 0.90$) confirms that this gap is not only statistically significant but also practically meaningful.

This finding is critical and aligns with theoretical expectations in climate adaptation literature, suggesting the presence of structural, cultural, or institutional barriers**.**

Table 10. Awareness–Behavior Gap Test (Paired Sample t-test)

Variable	Mean	SD	Mean Difference	t-value	p-value
Awareness	14.85	4.35			
Adaptation Behavior	10.97	3.22	3.88	11.01	<0.001

Table 11 Effect Size (Cohen's d)

Effect Size (d)	Interpretation
0.90	Large effect

Hypothesis Testing Summary

The empirical findings provide strong support for all proposed hypotheses. Hypothesis 1 (H1) is supported, as climate change awareness exhibits a positive and statistically significant effect on adaptation behavior. Hypothesis 2 (H2) is also supported, with socio-demographic factors showing a significant influence on adaptive outcomes. Importantly, Hypothesis 3 (H3) is strongly confirmed by the paired sample t-test results, which reveal a large and statistically

significant awareness–behavior gap. The magnitude of this gap (Cohen's d = 0.90) indicates substantial practical significance, reinforcing the conclusion that awareness does not proportionately translate into action. These results collectively validate the theoretical framework and highlight the presence of constraint-driven behavioral inefficiencies.

DISCUSSION

This study provides robust empirical evidence on the determinants of climate change adaptation behavior in an urban African context and offers important theoretical and policy-relevant insights into the persistence of the awareness–behavior gap. Three principal findings emerge: (1) climate change awareness exerts a positive and statistically significant influence on adaptation behavior; (2) socio-demographic factors play a critical enabling role; and (3) a substantial and practically meaningful awareness–behavior gap persists. Taken together, these findings advance current debates by moving beyond awareness-centric explanations and toward a more integrated understanding of adaptation as a function of both cognitive and structural dynamics. These findings challenge dominant awareness-centric models in climate adaptation literature, which implicitly assume a linear translation of knowledge into action. Instead, the results provide empirical support for a constraint-dominant paradigm, where structural barriers systematically suppress behavioral responsiveness, particularly in developing-country urban contexts

Awareness as a Necessary but Insufficient Driver of Adaptation

The positive effect of awareness on adaptation behavior aligns with a growing body of literature emphasizing the importance of climate risk perception and knowledge in shaping behavioral responses (Ricart *et al.,* 2023; Zorn *et al.,* 2023). Individuals who are more informed about climate risks are generally more likely to engage in adaptive practices, particularly in vulnerable environments. However, the relatively modest explanatory power of the model ($R^2 = 0.206$) suggests that awareness alone accounts for only a limited share of behavioral variation. This reinforces the argument that while awareness is a necessary precondition, it is not sufficient to induce meaningful behavioral change. These findings are consistent with prior research highlighting structural barriers to adaptation (Eisenack *et al.,* 2014; Moser and Ekstrom, 2010), which demonstrate that institutional and economic constraints often limit the translation of awareness into action.

From a theoretical perspective, this finding is consistent with the Theory of Planned Behavior (TPB), which posits that behavior is influenced not only by attitudes (proxied here by awareness), but also by perceived behavioral control and subjective norms. The absence of these additional components in the empirical model provides a plausible explanation for the observed attenuation in the awareness–behavior linkage. In this sense, the results highlight an important limitation of awareness-driven models and underscore the need to account for broader behavioral determinants.

A critical implication of these findings is that the awareness–behavior relationship is non-linear and condition-dependent**,** challenging dominant linear assumptions in climate adaptation models. In contrast to studies conducted in high-income contexts where awareness more readily translates into action, the results here suggest that in resource-constrained environments, structural barriers

dominate behavioral outcomes, effectively dampening the marginal effect of awareness. This divergence highlights the need for a contextualized behavioral theory of climate adaptation, in which the elasticity of behavior with respect to awareness is mediated by access to resources, institutional support, and infrastructural conditions.

Importantly, this finding challenges dominant linear assumptions in behavioral adaptation models, particularly those derived from high-income contexts where awareness more readily translates into action. In contrast, the present results indicate that in developing-country urban settings, structural barriers dominate behavioral outcomes, effectively dampening the marginal impact of awareness. This highlights the need for a contextualized behavioral framework in which the translation of knowledge into action is mediated by access to resources, institutional support, and infrastructural conditions.

Extending TPB: The Role of Structural Capacity

A key contribution of this study lies in its empirical demonstration that socio-demographic factors significantly influence adaptation behavior, thereby capturing the role of structural capacity in shaping climate responses. Consistent with prior research, individuals with greater access to economic resources, education, and social capital are better positioned to translate awareness into action (Malik and Ford, 2024; Peñasco and Grossman, 2025). This finding suggests that adaptation is not merely a cognitive process but is deeply embedded in socio-economic realities.

Importantly, this study extends TPB by showing that in resource-constrained urban settings, actual behavioral control (i.e., access to resources and enabling conditions**)** may outweigh

attitudinal factors in determining behavior. This provides empirical support for emerging perspectives that conceptualize environmental behavior as the outcome of an interaction between motivation (awareness) and capability (structural capacity)**.** In doing so, the study contributes to a growing shift in the literature from purely psychological models toward more integrated socio-behavioral frameworks**.**

The Awareness–Behavior Gap as a Constraint-Induced Phenomenon

The most salient finding of this study is the identification of a large and statistically significant awareness–behavior gap (Cohen's d = 0.90), indicating a substantial disconnect between what individuals know and what they do. This result is consistent with a rapidly expanding body of literature documenting the persistence of the "knowledge–action" or "attitude–behavior" gap in environmental contexts (Almazroa, 2024; Borges-Tiago *et al*., 2024).

However, beyond confirming its existence, this study advances the literature by interpreting the gap as a constraint-induced behavioral failure rather than a simple deficiency in awareness. Specifically, the findings suggest that individuals possess sufficient knowledge of climate risks but are unable to act due to binding constraints. Three interrelated mechanisms are particularly relevant:

First, economic constraints limit the ability of individuals to adopt adaptive measures, especially in low-income urban settings where competing livelihood priorities dominate. Second, institutional and infrastructural barriers, including limited access to public services and climate-resilient systems, reduce the feasibility of adaptation. Third, behavioral and psychological

frictions**,** such as perceived inefficacy and uncertainty, may further suppress action even when awareness is high (Vieira *et al*., 2023).

These findings collectively indicate that the awareness–behavior gap is not merely a cognitive disconnect but a multi-dimensional constraint problem, shaped by the interaction of economic, institutional, and behavioral factors. This interpretation aligns with broader evidence on the global "adaptation gap," which highlights systemic shortfalls in resources and implementation capacity (Malik and Ford, 2024).

A key theoretical implication emerges from the magnitude of the awareness–behavior gap (d = 0.90), which suggests that structural constraints exert a dominant influence over cognitive factors in this context. This finding challenges conventional linear behavioral models that assume proportional translation of awareness into action. Instead, the results support a threshold-based interpretation, whereby awareness influences behavior only when structural barriers fall below a critical level. In resource-constrained environments, the elasticity of adaptation with respect to awareness is significantly dampened, leading to persistent behavioral inefficiencies. This implies that models excluding constraint thresholds may systematically overestimate the effectiveness of awareness-driven interventions.

Beyond confirming its existence, the magnitude of the awareness–behavior gap (Cohen's d = 0.90) provides important theoretical insight into the dominance of structural constraints over cognitive drivers. Specifically, the large effect size suggests that behavioral outcomes are less sensitive to marginal increases in awareness when underlying capacity constraints remain binding. This supports a threshold-based interpretation of adaptation behavior, whereby

awareness translates into action only when socio-economic and institutional barriers fall below a critical level.

The magnitude of the awareness–behavior gap observed in this study (Cohen's d = 0.90) provides strong empirical support for a constraint-dominant interpretation of adaptation behavior. Specifically, the large effect size suggests that structural barriers exert a stronger influence on behavior than cognitive awareness alone. This finding is consistent with recent theoretical advances emphasizing that adaptation outcomes are shaped by the interaction between knowledge, capacity, and institutional context (Sovacool and Linnér, 2024; Schipper *et al.,* 2023). It also aligns with emerging evidence on global adaptation inequalities, which demonstrates that vulnerable populations often face binding constraints that prevent the translation of awareness into action (Eriksen *et al.,* 2023; Fedele *et al.,* 2023).

Implications for Model Specification and Future Research

The results also point to important directions for refining empirical models of climate adaptation. While the current specification captures key relationships, it remains parsimonious and does not fully account for the mediating and moderating mechanisms implied by TPB. Future research should therefore incorporate variables such as perceived behavioral control**,** social norms**,** and behavioral intentions to better capture the causal pathways linking awareness to action.

Methodologically, the integration of structural equation modeling (SEM) or longitudinal designs would enable a more rigorous assessment of these pathways and help address endogeneity concerns. Additionally, disaggregating socio-demographic variables rather than aggregating them into a single index would enhance interpretability and allow for more nuanced analysis of heterogeneity across population groups.

Policy Implications: From Awareness to Action

The findings carry significant implications for climate adaptation policy. The persistence of a large awareness–behavior gap suggests that policies focused solely on information dissemination are unlikely to achieve meaningful behavioral change. This is consistent with a growing body of evidence indicating that awareness-based interventions have limited effectiveness when structural constraints remain unaddressed (Whitmarsh *et al.,* 2023; Moser, 2023).

Instead, there is a need to shift toward integrated policy approaches that enhance adaptive capacity by addressing financial, institutional, and infrastructural barriers. Empirical and theoretical research increasingly supports the effectiveness of such approaches, particularly in developing-country contexts where resource constraints are binding (Hallegatte *et al.,* 2023; Lemos *et al.,* 2023). By combining informational interventions with structural support mechanisms, policymakers can generate stronger and more sustained behavioral responses, thereby reducing the awareness–behavior gap.

Broader Contributions and External Relevance

Although this study focuses on Benin City, its findings have broader relevance for rapidly urbanizing regions across Sub-Saharan Africa and other developing contexts. The coexistence of high awareness and low adaptive action observed here reflects a wider pattern documented in global climate adaptation research. As such, the study contributes to addressing the geographic imbalance in the literature and provides contextually grounded evidence that is analytically transferable to similar socio-economic environments.

Overall, the findings suggest that climate adaptation behavior in developing urban contexts is best understood as the outcome of an interaction between awareness and capacity, rather than as a direct function of knowledge alone. This reinforces the need for a paradigm shift from awareness-driven models toward constraint-sensitive frameworks that explicitly account for the structural conditions shaping behavioral outcomes.

Conclusion

This study provides robust empirical evidence on the determinants of climate change adaptation behavior and the persistence of the awareness–behavior gap in an urban African context. Using data from Benin City, Nigeria, the analysis demonstrates that both climate change awareness and socio-demographic factors significantly influence adaptation behavior, highlighting the joint role of cognitive understanding and structural capacity in shaping adaptive responses. Despite these positive relationships, the study reveals a substantial and statistically significant gap between awareness and actual behavior, indicating that knowledge alone is insufficient to drive meaningful adaptation.

The findings contribute to the climate adaptation literature by moving beyond conventional awareness-based explanations and explicitly quantifying the disconnect between what individuals know and what they do. This provides important evidence that adaptation is not merely a function of information availability but is strongly constrained by socio-economic and institutional factors. In doing so, the study advances current debates by integrating behavioral insights with empirical modeling to better explain the limits of awareness-driven adaptation strategies.

From a policy perspective, the results underscore the need to rethink climate adaptation interventions in urban developing-country contexts. While awareness campaigns remain important, they must be complemented by measures that enhance individuals' capacity to act. This includes improving access to financial resources, strengthening infrastructure, and designing inclusive institutional frameworks that reduce barriers to adaptation. Targeted support for vulnerable populations is particularly critical to ensure equitable and effective adaptation outcomes.

Overall, this study highlights that bridging the awareness–behavior gap is central to achieving climate resilience and food security in rapidly urbanizing regions. Future research should build on these findings by employing longitudinal and mixed-method approaches to further unpack the dynamic interactions between knowledge, capacity, and action. Addressing this gap at both the individual and systemic levels will be essential for translating climate awareness into sustained and impactful adaptation practices.

Limitations and Future Research

This study is subject to several limitations. First, the cross-sectional design restricts causal interpretation of relationships. Second, the relatively small sample size (N = 150) may limit external validity. Third, the use of self-reported measures may introduce response bias. Future research should employ longitudinal designs, larger samples, and mixed-method approaches to validate and extend these findings. Additionally, incorporating institutional and psychological variables could provide deeper insights into the mechanisms underlying the awareness–behavior gap.

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