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Research Article

Evaluating Anambra State's Readiness and Willingness for a Subnational Carbon Market for Climate Change Mitigation and Sustainable Development

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Abstract

Climate change necessitates innovative strategies, with carbon markets emerging as a key tool for mitigation. This study assesses the readiness and willingness of stakeholders in Anambra State to engage in a subnational carbon market. Using a structured questionnaire distributed across government, industry, and academia, the data were analyzed through descriptive statistics, Pearson correlation, and multiple regression analysis. The findings indicate a moderate level of readiness (M = 3.47) and willingness (M = 3.48) among stakeholders. Correlation analysis revealed a significant alignment between composite willingness indicators and direct willingness to participate (r = 0.406, p = 0.004) but a weak and nonsignificant relationship between composite readiness indicators and direct readiness (r = 0.164, p = 0.261). This finding shows that willingness is partly aligned, but stakeholders doubt actual readiness. Regression analysis revealed that technological capability (B = 0.554, p = 0.002) and monitoring, reporting, and verification (MRV) capacity (B = 0.381, p = 0.006) are the strongest predictors of willingness. In contrast, financial constraints (B = 0.201, p = 0.197), institutional frameworks (B = -0.035, p = 0.858), and coordination between the government and private sectors (B = 0.137, p = 0.554) did not significantly influence willingness. These results indicate that stakeholders prioritize operational and technical readiness over financial and institutional factors, emphasizing the need for robust MRV systems and transparent technological infrastructure to foster confidence in the carbon market. The study recommends targeted investments in MRV infrastructure, governance reforms to address stakeholder skepticism, and enhanced stakeholder education on carbon market mechanisms.

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Introduction

Climate change looms large throughout the 21st century, highlighting the urgent need for collective inter-disciplinary action to mitigate its widespread effects [1]. Since the Industrial Revolution, our reliance on fossil fuels has led to an exponential increase in greenhouse gas emissions, ushering in unprecedented environmental challenges [2]. The IPCC's Sixth Assessment Report presents a clear scientific consensus: rising global temperatures, sea-level rise, extreme weather events, and biodiversity loss threaten human societies and natural ecosystems worldwide [1].

This pressing crisis has spurred a global response. Nations have united under the United Nations Framework Convention on Climate Change (UNFCCC) to create international agreements aimed at reducing greenhouse gas emissions and adapting to climate impacts. Landmark agreements such as the Kyoto Protocol and the Paris Agreement have set ambitious emission reduction targets and mobilized financial resources for climate action [3]. However, despite these efforts, progress has

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been uneven. Emissions continue to rise, and the effects of climate change are becoming more apparent. This situation calls for continual exploration of innovative strategies to speed up the shift to a low-carbon, climate-resilient future.

Among the many strategies used to fight climate change, carbon markets have become a key market-based tool. This carbon market framework concept, alongside the theory of planned behavior, is the basis of this study. The theory of planned behavior [4] provides a useful lens for understanding how “readiness” and “willingness” shape stakeholders’ actions toward adopting a carbon market. According to theory, an individual’s behavior is guided by intention, which in turn depends on attitude, subjective norms, and perceived behavioral control. In the context of carbon markets, willingness reflects stakeholders’ attitudes and normative beliefs about participating in emissions trading, whether they view it as beneficial, fair, and feasible, whereas readiness represents the enabling conditions and perceived control that make participation possible, such as institutional frameworks, technical capacity, and financial resources. By aligning these behavioral dimensions with the structural elements of carbon market development, this study links human intention and systemic preparedness, providing a holistic understanding of what drives or constrains participation in a subnational carbon market.

Carbon markets are designed to incentivize emission reductions and promote investment in clean technologies [5]. The basic idea is to assign a price to carbon emissions, internalizing the external costs associated with greenhouse gases [6]. This price signal encourages emitters to cut their carbon footprint, either by investing in cleaner technologies or by purchasing carbon credits from those who have reduced their emissions below a set limit.

Carbon markets are appealing because they harness market forces to reduce emissions, stimulate innovation in clean technologies, and attract private sector financing for climate action. The European Union Emissions Trading System (EU ETS), the world's largest and most established carbon market, has shown how these mechanisms can achieve significant emissions reductions in the power and industrial sectors [7]. Additionally, carbon markets can generate revenue that can fund further climate mitigation and adaptation efforts, creating a positive cycle of emissions reduction and sustainable development.

Although the theory behind carbon markets is convincing, putting them into practice is complex and challenging. Designing and operating effective carbon markets requires careful attention to many factors: setting appropriate carbon prices; establishing robust monitoring, reporting, and verification (MRV) systems; and preventing carbon leakage and market manipulation [8]. If these complexities are not properly managed, unintended consequences such as the over-allocation of carbon credits, undermining environmental integrity, and worsening existing inequalities can result [9].

Nigeria, on the other hand, faces significant challenges in turning its ambitious climate goals, as outlined in its nationally determined contribution (NDC), into concrete actions [10–11]. While the NDC sets admirable targets for emission reduction and renewable energy deployment, the absence of a comprehensive policy framework and the country's reliance on fossil fuels are major hurdles. This gap between goals and implementation highlights the urgent need for innovative and effective climate strategies such as carbon markets that are tailored to Nigeria's unique situation.

The success of any climate policy tool, including carbon markets, is closely tied to the broader policy environment. Complementary measures such as renewable energy standards or carbon taxes can amplify the effectiveness of carbon markets by creating a supportive framework that drives emission reductions and promotes equitable outcomes. In the absence of such measures, carbon markets may fall short of their intended impact or, worse, produce unintended consequences that undermine environmental objectives.

Nigeria’s federal structure, which grants considerable decision-making power to its 36 states [12], requires a carefully balanced approach that aligns national climate objectives with local priorities. Decentralization opens the door for states to design and implement policies that address specific environmental challenges. Lagos State, for example, enacted the Lagos State Environmental Management and Protection Law of 2017, establishing the Lagos State Environmental Protection Agency (LASEPA), alongside the Lagos Climate Adaptation and Resilience Plan (LCARP) 2024. These localized initiatives allow Lagos to respond directly to its unique vulnerabilities while still being consistent with national and global commitments under frameworks such as the Paris Agreement. However, strong and ongoing coordination between state and federal bodies remains pivotal to ensure policy coherence and the seamless integration of subnational efforts into national climate strategies.

Subnational carbon markets have gained traction globally as a promising avenue for targeted climate action, although complexities remain [13]. Initiatives such as the Western Climate Initiative (WCI) involving California and Quebec and the Regional Greenhouse Gas Initiative (RGGI) in the northeastern United States demonstrate that regional markets can successfully reduce emissions while stimulating investment in clean energy. Notably, many countries incrementally test these mechanisms, either in specific regions or in certain sectors, to refine key processes such as MRV before

scaling up. China's phased approach, which piloted carbon markets at the city and provincial levels prior to a more comprehensive rollout, illustrates the benefit of starting small to iron out complexities and learn from early experiences.

Although Nigeria has yet to establish a national carbon market, lessons from these subnational examples elsewhere could inform similar efforts within the country. Moreover, the ultimate effectiveness of any carbon market depends not only on robust policy design but also on stakeholder willingness to participate and technical preparedness to execute core functions such as MRV and regulatory oversight. If stakeholders lack the drive or capacity to engage meaningfully, even the most well-intentioned market architecture can fail to achieve meaningful emissions reductions.

Evidence from other jurisdictions demonstrates that the success of subnational carbon markets is not determined by technical design alone but also by how these mechanisms interact with governance structures, local political economies, and institutional trust. In federal or decentralized systems, alignment between state and national policies has been shown to accelerate climate governance, whereas weak coordination can dilute outcomes [13]. Similarly, policy diffusion studies reveal that international instruments such as carbon markets are rarely transplanted wholesale; they are reinterpreted and reshaped to fit local contexts, as seen in China's phased pilots and California's integration with Quebec [14–15]. Behavioral and institutional economics further suggest that the willingness to participate depends not only on economic incentives but also on perceptions of fairness, transparency, and institutional credibility [16-17]. Taken together, these insights indicate that assessing readiness and willingness in a state such as Anambra requires attention to both operational capacity and the wider institutional environment in which stakeholders make decisions.

Against this backdrop, the aim of this research is to evaluate the readiness and willingness of Anambra State, Nigeria, to create and maintain a subnational carbon market as a tool for climate change mitigation and sustainable development.

This study specifically aims to assess Anambra State's readiness to participate in a carbon market by examining its technical and institutional capacity to support such a system. Particular attention is given to stakeholder perspectives on MRV frameworks. Additionally, the study evaluates the willingness of stakeholders to engage in a carbon market by analyzing their commitment to ensuring market integrity, promoting transparency, and actively participating in a potential cap-and-trade scheme.

Finally, while indicators of stakeholder readiness, such as infrastructure, policy frameworks, and institutional capacity, may or may not appear strong, they do not necessarily translate into a direct willingness to engage in a subnational carbon market. This suggests a disconnect between structural preparedness or lack of it and personal or organizational commitment to participate. Understanding and bridging this gap is essential for designing targeted interventions that foster both readiness and willingness, thereby increasing the likelihood of a functional and inclusive carbon market system in Anambra State.

Methods

1) Study area

This study examines Anambra State, a major economic hub in southeastern Nigeria, to assess stakeholders' readiness and willingness to adopt a subnational carbon market. The state is densely populated, industrially active, and faces serious environmental challenges such as erosion and deforestation, making it both a high-emission and climate-vulnerable region. The mix of economic activity and demonstrated policy interest in sustainability provide a relevant setting for evaluating the feasibility of carbon market mechanisms. The selection was purposive to capture perspectives from the government, industry, and academia, the sectors most directly affected by such a market. While the focus on a single state limits generalizability, the findings offer insights applicable to other subnational contexts in the Global South where similar institutional and governance dynamics exist.

2) Research design

This research adopts a descriptive design anchored on a stakeholder approach, combining quantitative analysis with unstructured interviews to capture context. The design focuses on key stakeholder groups, viz., the government, industry, and academia, and examines two central variables: readiness, which is assessed through infrastructure and technological capacity, and willingness, measured by their disposition to participate in a carbon market. This methodology is consistent with the works of Leventon et al. [18].

3) Population and sample size

The population was defined through stakeholder records obtained from the relevant administrative heads in government, industry, and academia. A comprehensive list of 159 industries was secured from the Anambra State Ministry of Trade and Commerce, of which 147 management staff members consented to participate following preliminary engagement. The additional respondents included 43 officials from the Ministry of Environment and 38 academic staff from the Departments of Environmental Management at Nnamdi Azikiwe University (UNIZIK) and Chukwuemeka Odumegwu Ojukwu University (COOU). This produced a total popu-

lation of 228 stakeholders, all of whom were targeted for inclusion, yielding a near-census approach.

The final sample of 228 (147 industries, 43 regulators, and 38 academics) represents more than 90% of the identified population across the three stakeholder groups, ensuring that the findings reflect the views of the principal actors relevant to carbon market adoption in the state (Table 1). This high coverage minimizes sampling error and strengthens the representativeness of the results, although the scope remains specific to Anambra State.

4) Data collection

Data were collected via a structured questionnaire. The questionnaire was divided into three main sections:

1. Demographic information: Gathering background details of the respondents.

2. Knowledge testing section: Assessing the knowledge of stakeholders regarding carbon markets and their potential role in reducing greenhouse gas emissions. This ensured that the respondents understood the subject matter before evaluating their Readiness and Willingness.

3. Readiness and willingness section: This section was designed around variables identified in the literature and operationalized through survey items presented in Table 2. Readiness was measured through five indicators: coordination and trust (perceptions of collaboration between the government and private sector), technical challenges (the ability to overcome infrastructural and technological gaps), the capacity to develop MRV (confidence in accurate monitoring and reporting of emission reductions), the institutional framework (the strength of laws and agencies to govern a market), and financial constraints (the extent to which funding gaps may hinder participation). Willingness was assessed via three indicators: Perceived Barriers (concerns about corruption), Transparency and Accountability (respondents' preparedness to act openly in a market setting), and Market Participation (belief that sufficient entities, including themselves, would participate if a carbon market was instituted).

5) Knowledge assessment

To ensure the reliability of the responses, an initial knowledge assessment was conducted before the main survey. This assessment consisted of five preliminary questions designed to evaluate the respondents' understanding of carbon markets. Only respondents who scored at least 40% were included in the final analysis, adhering to the methodological precedent set by Ruhimat and Ruhimat [19] and Erwinsyah [20]. This approach ensured that only participants with sufficient knowledge of the topic were considered, thereby minimizing the risk of unreliable data. This step was crucial given the lack of prior training on carbon markets provided to the respondents. The exclusion of those who are less knowledgeable might introduce some sampling bias, but overall, it would improve the reliability of the results.

It is important to note the reduction in the sample size due to the exclusion of respondents lacking sufficient knowledge of carbon markets. A total of 168 (82.3%) of the 204 returned questionnaires met the knowledge criteria (Table 3), representing 73.7% of the initial target population of 228 respondents. This reduction does not negatively impact the survey's outcome, as the focus is on knowledgeable stakeholders who can provide meaningful insights. Ensuring that only informed participants are included enhances the validity and value of the research, especially in a stakeholder-focused study such as this one.

6) Data analysis

The questionnaire was structured into demographic, knowledge testing, and readiness/willingness sections, with items developed from existing carbon market readiness studies and adapted to the Anambra context (see Table 3). Responses were captured on a five-point Likert scale ranging from Strongly Disagree =1 to Strongly Agree =5, and composite scores for readiness and willingness were calculated by averaging item responses within each construct. Correlation and regression analyses were then used to evaluate the relationships between these variables and direct willingness and readiness questions, providing a clear basis for interpretation. To enhance reliability, a knowledge screening test was conducted to exclude uninformed respondents, while the internal consistency of the main survey instrument was assessed via Cronbach's alpha. Content validity was supported through expert review by faculty in environmental management, who confirmed alignment between items and the study objectives.

Table 1 Study population

No.	Stakeholders	Target group	Population size	Sample size	Sample size (%)
1.	Regulators	Ministry of Environment, Anambra State	43	43	100%
2.	Industries	Management Staff in Industries in Anambra State	159	147	92.5%
3.	Academia/experts	Lecturers from UNIZIK and COOU	38	38	100%
	Total		228	228	100%

Table 2 Wiliness and readiness to engage in a carbon market

No.	Aspects	Regulators					Industries					Academia					Mean score
		SD	D	N	A	SA	SD	D	N	A	SA	SD	D	N	A	SA	
	Readiness																
1.	Level of coordination and trust between the government and private sectors is high.	0	11	19	5	7	18	36	36	0	0	4	16	16	0	0	2.55
2.	Anambra can overcome technological challenges/ gaps that will hinder the operational integrity of carbon markets.	12	18	12	0	0	37	25	16	12	0	10	20	4	0	2	2.02
3.	Anambra can develop capacity for accurate monitoring, reporting and verification (MRV) of emission reduction.	0	0	4	18	20	22	20	24	20	4	8	10	4	14	**0**	3.10
4.	Anambra can develop a strong institutional framework to govern a carbon market.	0	0	0	7	35	0	0	4	40	44	1	2	3	12	18	4.47
5.	Financial constraints will not be a significant challenge.	6	17	13	0	6	40	30	4	8	8	12	8	8	6	2	2.36
	Willingness																
6.	Corruption will not be a significant barrier.	31	11	0	0	0	54	20	16	0	0	14	10	2	8	2	1.73
7	I am prepared to be transparent and accountable in a carbon market.	0	0	12	18	6	17	3	20	28	12	6	0	8	20	2	3.42
8	Sufficient number of entities will participate in a carbon market if instituted.	0	1	9	17	15	30	28	20	12	**0**	8	10	6	6	6	2.95
	Single question direct response																
9	Anambra is willing to participate in a carbon market.	0	0	7	0	35	6	8	28	24	24	6	0	4	18	8	3.84
10	Anambra State is ready to enter a carbon market?	5	1	18	16	2	10	40	24	12	4	4	14	18	0	0	2.63

Remark: SD: Strongly disagree, D: Disagree, N: Neutral, A: Agree, SA: Strongly Agree

Table 3 Knowledge assessment

No.	Stakeholders	Target group	Sample size	Returned	Knowledgeable
1.	Regulators	Ministry of Environment, Anambra State	43	42	42
2.	Industries	Management staff in industries in Anambra State	147	126	90
3.	Academia/experts	Lecturers from UNIZIK and COOU	38	36	36
	Total		228	204	168

Pearson correlation analysis (Eq.1) was conducted to assess the relationships among the composite readiness score, the willingness score, and their respective direct responses, verifying whether the calculated composite scores aligned with self-reported responses.

$$r = \frac{n\sum XY - \sum x \sum y}{\sqrt{(n\sum x^2 - (\sum x)^2).(n\sum y^2 \quad -(\sum y)(^2)}} \quad \text{(Eq.1)}$$

Finally, multiple regression analysis was conducted to evaluate whether stakeholders' readiness indicators significantly predict their willingness to participate in a subnational carbon market. In this specification, willingness to participate (Y) is the dependent variable, whereas the readiness constructs, viz., coordination and trust (X_1), technological challenges (X_2), the capacity to develop MRV (X_3), the institutional framework (X_4), and financial constraints (X_5), serve as the independent variables. The model is therefore expressed as Eq.2.

$$Y = a + b_1X_1 + b_2X_2 + b_3X_3 + b_4X_4 + b_5X_5 + E \quad \text{(Eq.2)}$$

where a is the intercept, b represents the regression coefficient, and E is the residual error term.

7) Hypothesis testing

The following hypotheses were tested as part of this study:

H01: Stakeholders' composite willingness scores are consistent with their responses to willingness to participate.

H02: Stakeholders' composite readiness scores are consistent with their responses to readiness to engage.

H03: Stakeholders' indicators of readiness do not significantly predict their direct willingness to participate in a subnational carbon market.

8) Justification of methods

This approach allows for a nuanced understanding of stakeholders' perspectives on both readiness and willingness. By using a combination of composite scores and direct response comparisons, this research provides a comprehensive assessment of whether stakeholders' readiness aligns with their willingness and how these two variables interact with broader infrastructural and technological barriers.

9) Data interpretation

This section presents the findings from the data collected through structured questionnaires distributed to stakeholders in government, industry, and academia. The data are organized to illustrate the key variables of interest: stakeholders' readiness and willingness to adopt a subnational carbon market in Anambra State. Descriptive statistics, composite scores, correlation analyses and multiple regression analysis are utilized to highlight patterns, relationships, and gaps between readiness and willingness.

Results

1) Survey results on the wiliness and readiness to engage in a carbon market

Table 2 shows the mean scores for each question and their responses. The mean scores were generally low, reflecting limited readiness and willingness across sectors. For example, the level of coordination and trust between the government and private sectors, the ability to address technological challenges, and financial constraints all scored poorly. Similarly, willingness indicators, such as concerns about corruption and transparency, also received low mean scores, highlighting the significant challenges faced in adopting a carbon market in Anambra. Across stakeholder categories, regulators recorded higher institutional confidence, whereas industry respondents reported lower technological readiness. Academics exhibited higher awareness but moderate willingness.

2) Composite mean

The descriptive statistics provide insight into the stakeholders' overall perceptions of their readiness and willingness to participate in a subnational carbon market in Anambra State.

Table 4 presents descriptive statistics for composite willingness and composite readiness based on a sample of 168 respondents. Composite readiness comprises the mean of respondents' responses to items 1 to 5 in Table 2, whereas composite willingness comprises items 6 to 8. The composite willingness has a mean score of 3.4762, with a standard deviation of 0.77579, indicating moderate variability in the responses. The minimum value recorded is 1.33, whereas the maximum is 5.00. The skewness of -0.691 suggests a slight leftward skew, meaning that more responses are concentrated toward higher values, whereas the kurtosis of 0.508 indicates a relatively normal distribution. Composite readiness, on the other hand, has a mean score of 3.4653, with a lower standard deviation of 0.45164, signifying less variability compared with composite willingness. The responses range from a minimum of 2.40 to a maximum of 4.60. The skewness value of -0.210 suggests a nearly symmetrical distribution, with a slight leftward skew, whereas the kurtosis value of 0.081 implies a distribution close to normal. Overall, both variables exhibit moderate means, with composite readiness having a more compact range of responses and lower variability than composite willingness. The skewness and kurtosis values indicate that while both distributions are fairly normal, composite willingness is

slightly more negatively skewed than composite readiness. The sample size of 168 provides a robust basis for these statistical observations.

3) Hypothesis testing

Three hypotheses were tested for this study.

1. Stakeholders' composite willingness scores are consistent with their responses to “willingness to participate”.

In the analysis of Anambra State's stakeholders regarding their willingness to participate in a subnational carbon market, the Pearson correlation coefficient between composite willingness and the direct question of whether stakeholders are willing to participate is 0.406 (Table 5). This indicates a moderate positive relationship between the overall willingness score, which combines multiple indicators, and the straightforward question of whether stakeholders are willing to engage in the carbon market.

The p value of 0.004 shows that this correlation is statistically significant at the 0.01 level, reinforcing that the relationship between these variables is not due to chance. Stakeholders' general willingness, as measured by a range of factors, aligns reasonably well with their direct, self-reported readiness to participate in the market.

This suggests that although the willingness indicators offer a more nuanced, composite understanding, they still correspond meaningfully with how stakeholders directly express their willingness to engage in the carbon market. This alignment is important for understanding that stakeholders’ broader perceptions of the carbon market reflect their actual willingness to take part, although it leaves room for factors outside of the composite score that may influence their final decision to participate.

2. Stakeholders' composite readiness scores are consistent with their responses to “readiness to engage”.

The correlation between stakeholders' direct responses to "readiness to engage" and their composite readiness scores is 0.164 (Table 6), indicating a weak positive relationship. This suggests that while there is some alignment between broader readiness indicators, such as technological and infrastructural capacity, and stakeholders' expressed readiness to engage, the connection is not strong.

The p value of 0.261 indicates that this correlation is not statistically significant at the 0.05 level, meaning that the relationship observed in this sample may be due to chance rather than a meaningful association. This result suggests that while composite readiness captures key structural aspects of preparedness, stakeholders' direct readiness scores contradict this, indicating a disconnect between objective indicators of readiness and stakeholders' confidence in the system. Even though certain infrastructural and technological aspects appear to be in place, stakeholders remain hesitant to engage, suggesting a deeper lack of trust in the system.

The weak correlation implies that beyond structural readiness, broader systemic issues, such as government trust, corruption, policy instability, and past experiences with ineffective initiatives, may play a significant role in shaping stakeholders' perceptions. This highlights the reality that readiness is not just about having the right mechanisms in place but also about ensuring that stakeholders believe in the integrity and functionality of those mechanisms. Addressing these concerns requires a more holistic approach that goes beyond technical preparedness to focus on governance, transparency, and stakeholder confidence in the system’s ability to deliver fair and predictable outcomes.

Table 4 Descriptive statistics for composite mean for willingness and readiness

Composite mean	N	Minimum	Maximum	Mean	Std. deviation	Skewness		Kurtosis	
	Statistic	Statistic	Statistic	Statistic	Statistic	Statistic	SE	Statistic	SE
Willingness	168	1.33	5.00	3.4762	0.77579	-0.691	0.340	0.508	0.668
Readiness	168	2.40	4.60	3.4653	0.45164	-0.210	0.340	0.081	0.668
Valid N (listwise)	168								

Remark: SE: Standard error

Table 5 Correlation between composite willingness and direct willingness

		Composite willingness	Willing to participate
Composite willingness	Pearson correlation	1	0.406**
	Sig. (2-tailed)		0.004
	N	168	168
willing to participate	Pearson correlation	0.406**	1
	Sig. (2-tailed)	0.004	
	N	168	168

Remark: ** Correlation is significant at the 0.01 level (2-tailed).

Table 6 Correlations between composite readiness scores and direct readiness score

		Readiness	Composite readiness
Readiness	Pearson correlation	1	0.164
	Sig. (2-tailed)		0.261
	N	168	168
Composite readiness	Pearson correlation	0.164	1
	Sig. (2-tailed)	0.261	
	N	168	168

3. Stakeholders' indicators of readiness do not significantly predict their direct willingness to participate in a subnational carbon market.

Regression analysis was conducted to evaluate whether stakeholders' indicators of readiness significantly predict their willingness to participate in a subnational carbon market. The model demonstrated a moderate correlation between the predictors (financial constraints, level of coordination and trust between the government and private sector, institutional framework, technological challenges, and capacity to develop MRV) and the dependent variable (willingness to participate), with an R value of 0.562. The model (Table 7) explained 31.6% of the variance in willingness (R^2 = 0.316), although the adjusted R^2 of 0.237 indicates a slight reduction in explanatory power when accounting for the number of predictors. The Durbin–Watson statistic of 1.998 suggests no significant autocorrelation in the residuals. The remaining 68.4% of unexplained variance points to other influential factors not captured in the model, such as political culture, enforcement consistency, social norms, and past policy experiences. These contextual elements likely shape stakeholder behavior beyond measurable readiness indicators, highlighting the need for further investigation into institutional trust and sociopolitical dynamics that affect market participation.

The overall model (Table 8) was statistically significant ($F(5, 163) = 3.980$, $p = 0.005$), indicating that the predictors collectively influence stakeholders' willingness to participate. However, the analysis of individual coefficients revealed that only two variables, the ability to overcome technological challenges (B = 0.554, p = 0.002) and the capacity to develop MRV (B = 0.381, p = 0.006), significantly predicted willingness. These findings suggest that while the ability to overcome technological challenges and perceived capacity are positively associated with stakeholders' willingness, other factors, such as financial constraints (B = 0.201, p = 0.197), the institutional framework (B = -0.035, p = 0.858), and the level of coordination and trust (B = 0.137, p = 0.554), were not significant predictors (Table 9). Thus, the hypothesis that readiness indicators do not significantly predict willingness is only partially supported, as some factors were found to have a meaningful effect on stakeholders' willingness to participate in the carbon market (Figure 1).

Table 7 Summary of regression analysis model

Model	R	R^2	Adjusted R^2	SE of the estimate	Durbin-Watson
1	0.562[a]	0.316	0.237	1.030	1.998

a. Predictors: (Constant), financial constraints, level of coordination and trust, institutional framework, tech challenges that will hinder, capacity to develop a carbon market

b. Dependent variable: Willing to participate

Remark: SE: Standard error

Table 8 Summary of the overall model (ANOVA[a])

Model		Sum of squares	df	Mean square	F	Sig.
1	Regression	21.100	5	4.220	3.980	.005[b]
	Residual	45.594	163	1.060		
	Total	66.694	168			

a. Dependent variable: Willing to participate

b. Predictors: (Constant), Financial Constraints, Level of Coordination and trust, Institutional Framework, Tech challenges that will hinder, Capacity to develop a carbon Market

Discussion

The findings of this study provide a comprehensive assessment of stakeholders' readiness and willingness to engage in a subnational carbon market in Anambra State. The results indicate that while stakeholders acknowledge the necessity of such a market, considerable structural and systemic barriers persist. The composite scores for readiness (M = 3.47) and willingness (M = 3.48) suggest that stakeholders perceive themselves as moderately prepared and interested in participation, yet the alignment between these perceptions and direct engagement indicators remains weak. This misalignment highlights critical gaps that must be addressed before a functional carbon market can be successfully implemented.

The correlation analysis between composite willingness and direct willingness to participate ($r = 0.406$, $p < 0.01$) underscores an important observation. The moderate correlation suggests that stakeholders' willingness to engage in a carbon market is partially captured by composite willingness indicators, meaning that broader factors, such as perceived market viability, regulatory confidence, and economic incentives, play a significant role in shaping engagement. While the composite

measure provides a structured assessment of willingness, the fact that stakeholders' direct responses do not strongly correlate with these indicators suggests the presence of external factors influencing their decision-making. This aligns with previous research indicating that stakeholders in developing economies weigh policy stability and governance credibility heavily when considering participation in market-based climate initiatives [21].

The weak correlation between composite readiness and direct readiness to engage (r = 0.164, p = 0.261) further complicates the picture. While readiness indicators, including institutional frameworks, financial capacity, and technological preparedness, suggest that Anambra State has some foundational capacity to support a carbon market, stakeholders' self-reported readiness contradicts this. This disconnect implies that even when technical and infrastructural components appear in place, or at least in this case, they appear to have the ability to develop, stakeholders remain unconvinced about the market's practical viability. This skepticism likely stems from deep-seated issues such as political instability, government inefficiency, and historical distrust in regulatory enforcement. Such challenges are well documented in developing regions where environmental markets struggle due to weak institutional backing and inconsistent policy execution [22].

Table 9 Coefficients of overall model

Model		Unstandardized coefficients		Standardized coefficients	t	Sig.	95.0% Confidence interval for B		Collinearity statistics	
		B	SE	Beta			Lower bound	Upper bound	Tolerance	VIF
1	(Constant)	-0.510	1.289		-0.395	0.694	-3.110	2.090		
	Level of coordination and trust btw govt & private sector	0.137	0.229	0.094	0.596	0.554	-0.326	0.599	0.634	1.577
	Tech challenges	0.554	0.171	0.460	3.243	0.002	0.210	0.899	0.789	1.268
	Capacity to develop MRV	0.381	0.131	0.420	2.905	0.006	0.116	0.645	0.762	1.312
	Institutional framework	-0.035	0.196	-0.025	-0.180	0.858	-0.430	0.359	0.792	1.262
	Financial constraints	0.201	0.154	0.194	1.311	0.197	-0.108	0.511	0.728	1.373

a. Dependent Variable: Willing to participate

Remark: SE: Standard error

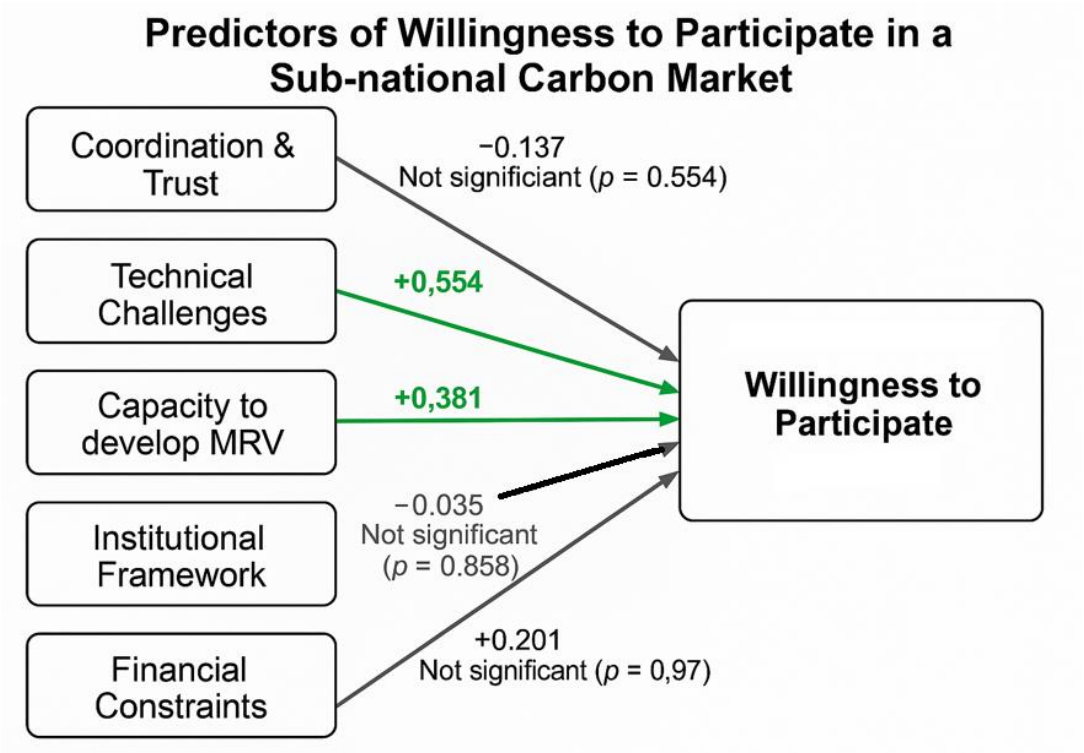

Figure 1 Willingness predictors in a subnational carbon market.

The regression analysis further illustrates the complexities of stakeholder willingness. While the overall model was significant ($F(5,163) = 3.980$, $p = 0.005$), indicating that the predictors collectively influence willingness, the explanatory power of the model remains moderate ($R^2 = 0.316$, adjusted $R^2 = 0.237$). This suggests that while readiness indicators contribute to explaining willingness, they do not account for the full scope of stakeholders' decision-making. Notably, among the tested predictors, only technological challenges ($B = 0.554$, $p = 0.002$) and the capacity to MRV systems ($B = 0.381$, $p = 0.006$) were significant predictors of willingness. These findings reinforce the notion that operational readiness, rather than broader institutional or financial factors, is the key driver of willingness to participate. Stakeholders appear to prioritize technical capacity and market transparency over abstract governance structures when determining their level of engagement.

Interestingly, financial constraints ($B = 0.201$, $p = 0.197$), institutional frameworks ($B = -0.035$, $p = 0.858$), and coordination and trust ($B = 0.137$, $p = 0.554$) did not emerge as significant predictors. This suggests that while stakeholders recognize these as systemic issues, they do not see them as immediate barriers to engagement. The implications of this finding are crucial: rather than focusing solely on institutional reform or financial incentives, policymakers should prioritize tangible, operational improvements such as ensuring technological infrastructure and credible MRV systems to build stakeholder confidence in the carbon market.

In Nigeria, financial and institutional barriers are often interwoven with governance challenges. Previous studies have highlighted that while financial capacity is essential for long-term market sustainability, initial engagement in environmental markets is frequently hampered more by political uncertainty and regulatory inconsistency than by outright financial limitations [23–25]. Stakeholders may therefore view financial challenges as secondary concerns contingent on broader systemic improvements. This aligns with observations made in similar economies, where uncertainty regarding policy implementation and corruption often outweighs purely financial considerations in influencing market engagement [26].

The lack of significance for the institutional framework as a predictor further reinforces the need to address stakeholder confidence. While a strong institutional framework is undoubtedly necessary for long-term market sustainability, its current lack of predictive power suggests that stakeholders do not perceive existing governance structures as either major facilitators or obstacles to engagement. This could indicate a more fundamental issue: stakeholders may simply lack faith in the ability of institutions to enforce and sustain a carbon market. Research on emerging environmental markets has shown that trust in institutions is a prerequisite for sustained engagement [27–28]. If stakeholders perceive governance structures as weak, they may hesitate to participate regardless of the theoretical existence of institutional frameworks.

These findings align with broader literature on market-based environmental interventions, which emphasize the primacy of operational readiness over structural governance in the early stages of market adoption [14, 29]. In regions where financial and institutional stability are variable, the presence of well-defined technical systems such as MRV mechanisms provides stakeholders with a more tangible sense of reliability. This explains why the capacity for MRV and technological preparedness emerged as significant predictors of willingness. When these systems are perceived as robust, stakeholders may feel more assured that the market will function transparently, reducing concerns related to corruption and mismanagement. Conversely, if the technical infrastructure is weak, even well-structured institutional policies may fail to instill confidence.

Ultimately, these findings suggest that, for Anambra State to successfully implement a subnational carbon market, efforts must extend beyond traditional capacity-building initiatives. While institutional frameworks and financial incentives are important, they are not the immediate determinants of willingness to participate. Instead, stakeholder engagement appears to be driven primarily by tangible assurances of market integrity, particularly through reliable MRV systems and technological capacity. Addressing these areas first may serve as the most effective strategy for bridging the gap between perceived readiness and actual willingness to engage in carbon trading. Strengthening the technical infrastructure, improving transparency mechanisms, and ensuring consistent policy enforcement will be critical steps in fostering stakeholder confidence and enabling successful carbon market implementation in Anambra State.

Broader implications for policy and implementation

These findings provide essential guidance for policymakers aiming to implement a subnational carbon market in Anambra State. The moderate levels of readiness and willingness, as indicated by composite scores, suggest foundational optimism among stakeholders. However, the disconnect between structural readiness indicators and direct willingness underscores a critical challenge: stakeholders remain skeptical about the market's functionality despite recognizing some level of preparedness. This skepticism is rooted in concerns about governance, transparency, and institutional reliability, which must be addressed alongside technical improvements [30–32].

This challenge is not unique to Anambra State. Experiences from other subnational markets reinforce

this point, showing that effectiveness depends not only on technical soundness but also on the interplay between governance arrangements, local adaptation of global instruments, and institutional trust. Studies on policy diffusion highlight that instruments such as emissions trading are rarely transplanted wholesale but are reshaped by domestic political economies, as seen in China's provincial pilots and California's integration with Quebec [14–15]. Similarly, research in institutional and behavioral economics suggests that market participation is strongly conditioned by perceptions of credibility, fairness, and enforcement capacity rather than by design features alone [16–17]. Situating Anambra's case within these dynamics suggests that building operational capacity must go hand-in-hand with addressing the institutional and behavioral determinants of trust and participation.

The statistical significance of technological capacity and MRV infrastructure as predictors of willingness highlights the need for targeted investments in these areas. While financial constraints, coordination, and institutional frameworks were not significant predictors, stakeholders demonstrated a strong preference for tangible, operational readiness. Policymakers should therefore prioritize the development of transparent and efficient MRV systems, as well as capacity-building initiatives that enhance technological competence. Drawing from successful models in other developing economies, Anambra State can strengthen stakeholder engagement by ensuring that its carbon market mechanisms are both reliable and transparent [20, 33–34].

This study reflects a cautiously optimistic outlook among Anambra State stakeholders toward participating in a carbon market, tempered by systemic barriers to readiness. The weak correlation between readiness indicators and direct engagement suggests that broader trust issues, such as concerns over corruption, regulatory inconsistency, and enforcement capacity, must be addressed to secure full stakeholder commitment. While technical infrastructure plays a pivotal role, stakeholder confidence in governance structures remains a crucial determinant of long-term participation. Policymakers must recognize that operational effectiveness alone will not drive engagement; rather, it must be complemented by governance reforms that foster trust and reliability.

By focusing on both technical and institutional readiness, Anambra State can enhance its climate policy framework and align its carbon market ambitions with international best practices. Implementing strong governance mechanisms, ensuring transparency in carbon credit transactions, and fostering collaboration between government and private sector actors will be key to bridging the readiness-willingness gap. These findings offer a roadmap for Anambra and similar regions to structure their climate action initiatives in ways that not only support local development but also contribute to broader global climate objectives.

Conclusions

The findings of this study provide a nuanced understanding of the readiness and willingness of stakeholders in Anambra State to participate in a subnational carbon market. While composite readiness ($M = 3.47$) and willingness ($M = 3.48$) scores indicate a moderate level of optimism, a critical disconnect exists between structural readiness indicators and direct stakeholder engagement. Despite recognizing some level of preparedness, stakeholders remain hesitant, largely due to concerns about governance, transparency, and the operational integrity of the market.

The weak correlation between composite readiness and direct readiness to engage ($r = 0.164$, $p = 0.261$) underscores this skepticism, revealing that perceived readiness does not necessarily translate to confidence in participation. This misalignment suggests that beyond technical improvements, broader systemic issues such as trust in government institutions, corruption, and regulatory stability must be addressed to foster genuine engagement. Moreover, while financial constraints and institutional frameworks were acknowledged as challenges, they did not significantly predict willingness, reinforcing that stakeholders prioritize operational viability over abstract policy structures.

The regression analysis highlights that technological capability ($B = 0.554$, $p = 0.002$) and MRV capacity ($B = 0.381$, $p = 0.006$) are the most significant determinants of willingness. This finding aligns with the literature, which emphasizes that stakeholders are more likely to engage in carbon markets when transparent and reliable technical systems are in place. While financial and institutional challenges persist, the immediate priority should be strengthening MRV infrastructure, ensuring data accuracy, and enhancing the technological readiness of market participants.

Therefore, while stakeholders demonstrate a willingness to participate, the successful implementation of a carbon market in Anambra State hinges on addressing the technical and governance-related readiness gaps. Enhancing MRV systems, investing in transparent technological solutions, and fostering stakeholder confidence through clear policy enforcement will be crucial in translating willingness into active participation. These findings offer a strategic framework for policymakers, outlining the necessary interventions to bridge the readiness–willingness gap and establish a credible and functional carbon market in Anambra State.

Recommendations

To successfully implement a subnational carbon market in Anambra State, this study recommends the following strategic actions:

1. Prioritize technological readiness and MRV capacity Development

The findings highlight the critical role of technological capacity and MRV systems in determining stakeholders' willingness to participate. The state must invest in MRV infrastructure to enhance transparency and credibility. Capacity-building initiatives should focus on equipping relevant agencies with the necessary technical skills to ensure accurate emission tracking and compliance with global standards.

2. Addressing stakeholder skepticism through governance teforms

The weak correlation between readiness indicators and willingness underscores a fundamental lack of trust in governance structures. Policymakers must prioritize institutional transparency, regulatory stability, and anti-corruption measures to build stakeholder confidence. Strengthening enforcement mechanisms, streamlining administrative processes, and ensuring fair market participation are crucial for sustained engagement.

3. Leveraging climate finance and international support

While financial constraints did not significantly predict willingness, they remain an underlying concern. The government should explore international climate finance mechanisms, such as the Green Climate Fund (GCF), carbon credit initiatives, and private sector partnerships, to secure necessary funding for infrastructure development. Clear financial policies and incentives should be introduced to encourage early adopters and reduce entry barriers for businesses and industries.

4. Strengthening coordination between the government and the private Sector

Stakeholders' concerns about coordination between government agencies and private enterprises indicate a need for improved collaboration. Establishing a multi-stakeholder governance body to oversee carbon market implementation, including representatives from industry, academia, and regulatory institutions, will foster trust and cooperation. This body should be tasked with aligning market regulations with international best practices while addressing localized challenges.

5. Increasing stakeholder education and engagement

The study highlights a disconnect between perceived readiness and actual willingness, suggesting that stakeholders require more clarity on the practical benefits and mechanics of a carbon market. Awareness campaigns, workshops, and policy dialogs should be implemented to ensure that businesses, policymakers, and civil society fully understand the opportunities and responsibilities associated with carbon trading. Providing accessible and practical knowledge will drive informed participation.

6. Embedding political commitment into climate policy priorities

Drawing from previous research on governance challenges in Nigeria, successful carbon market implementation will require sustained political commitment. Policymakers must ensure that carbon trading aligns with broader economic and development goals, integrating it into the state's long-term policy framework. High-level political backing is essential to overcoming bureaucratic inertia and ensuring a stable, long-term regulatory environment.

By addressing these recommendations, Anambra State can bridge the readiness–willingness gap, fostering a credible and functional carbon market that aligns with both local and global climate action priorities while supporting economic growth and sustainability.

Areas for further research

Future research should focus on exploring how targeted policy incentives, such as tax breaks or subsidies, could influence stakeholder readiness and willingness to participate in a subnational carbon market. Given the economic constraints highlighted in this study, understanding the role of financial and regulatory incentives could reveal pathways to bolster both enthusiasm and operational readiness, especially in developing regions such as Anambra State. By clarifying the effectiveness of these incentives, policymakers could design strategies that bridge readiness gaps and promote sustainable engagement in the carbon market.

Declaration of generative AI use

Authors acknowledge the use of Chat GPT's consensus AI (https://chatgpt.com/g/g-bo0FiWLY7-consensus) to find and summarize scholarly literature as well as Chat GPT to reword my discussion for clarity. The prompts used include "reword this paragraph to become clearer without changing its meaning, rewrite this paragraph to lay more emphasis on education and awareness without significantly changing its meaning, reword my explanation to this table to sound clearer without changing its meaning". The output from these prompts was used to ensure that there were no errors or typos within the manuscript and to make the manuscript easier to read and understand.

The generative AI used in this literature was confined to rewriting the content for clarity and ease of reading and not as a substitute for academic writing.

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