

Artificial Trees and Africa's Climate Finance Future: Navigating a Shifting Carbon Mitigation Landscape

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Abstract

Background: The emergence of artificial tree technologies (direct air capture systems) has fundamentally disrupted global carbon markets, potentially threatening Africa's traditional climate finance streams derived from nature-based sequestration projects. As developed nations increasingly invest in technological carbon removal solutions, questions arise about the implications for African countries that have historically leveraged reforestation and conservation initiatives to access carbon markets and climate funding.

Objective: This study examined the implications of artificial tree technology adoption on Africa's access to climate finance and developed strategic recommendations for maintaining competitive advantage in the evolving global carbon mitigation landscape.

Methods: A mixed-methods approach was employed, analyzing 420 carbon mitigation projects across 35 African countries using stratified random sampling with 80% statistical power. Primary data were collected through structured surveys of 385 project stakeholders, while secondary data were extracted from verified carbon registries and international climate finance databases. Statistical analyses included descriptive statistics, bivariate correlations, multiple linear regression predicting climate finance inflows, and logistic regression modeling hybrid strategy adoption, with all model assumptions rigorously tested.

Key Results: The artificial tree investment index demonstrated significant negative correlations with both carbon credit prices ($r=-0.512$, $p<0.001$) and climate finance inflows ($r=-0.398$, $p<0.001$), confirming market displacement effects. Multiple regression analysis explained 62.7% of variance in climate finance flows, with policy environment scores emerging as the strongest predictor (standardized $\beta=0.496$, $p<0.001$), while artificial tree investment showed significant negative effects ($\beta=-0.038$, $p<0.001$). Countries with technology partnerships received USD 1.25 million more annually in climate finance ($p<0.001$). Logistic regression revealed that nations experiencing greater carbon price declines were more likely to adopt hybrid mitigation strategies (OR=1.156, $p=0.005$), with GDP per capita showing the strongest effect (OR=3.435, $p=0.003$).

Conclusion: The study confirmed that artificial tree technology proliferation was associated with declining valuations for African nature-based carbon projects, though the impact was moderated by institutional quality and strategic positioning. Policy environment strength emerged as more critical than technological capacity in determining climate finance access, while hybrid strategies combining nature-based solutions with selective technology partnerships demonstrated superior resilience. The findings revealed concerning intra-African disparities, with wealthier nations better positioned to navigate the transition while resource-constrained countries, particularly in Central Africa, faced marginalization despite superior ecological performance.

Recommendation: African governments should establish a pan-African climate finance coordination mechanism to collectively negotiate carbon market reforms, standardize verification protocols, and prioritize institutional capacity building over direct technology competition, while advocating for carbon pricing frameworks that appropriately value the irreplaceable co-benefits of nature-based solutions.

Keywords: artificial trees, direct air capture, climate finance, carbon markets, Africa, nature-based solutions, carbon credits, hybrid mitigation strategies, policy environment, technology partnerships

Introduction

The global climate crisis has catalyzed unprecedented innovation in carbon mitigation technologies, with artificial trees—sophisticated direct air capture (DAC) systems—emerging as a potentially transformative solution for atmospheric carbon removal. While Africa has traditionally positioned itself as a critical player in climate mitigation through its vast natural resources and nature-based solutions, the rapid advancement and commercialization of artificial carbon capture technologies represent a paradigm shift in the global climate finance architecture (Goula & Vanucchi, 2022; Mngadi et al., 2021; Peichl et al., 2023). This study explores the intersection of technological innovation and climate finance equity, examining how the proliferation of artificial trees might reshape Africa's role in global carbon markets. As international climate finance mechanisms evolve and investment patterns shift toward technologically advanced mitigation solutions, understanding the implications for Africa's climate finance future becomes imperative (Albrich et al., 2023; Keith et al., 2022). The continent stands at a critical juncture where strategic decisions made today will determine whether it remains a competitive participant in carbon markets or becomes marginalized in an increasingly technology-driven mitigation landscape (Mesa-Sierra et al., 2022; Skole et al., 2021). This research seeks to illuminate the challenges and opportunities presented by this transition, providing evidence-based insights to inform policy decisions and strategic positioning for African nations in the changing carbon economy (De Mello & Martinez-Vazquez, 2022; Moreau et al., 2022).

Background of the Study

Climate change poses unprecedented challenges to Africa, a continent that contributes minimally to global emissions yet suffers disproportionately from climate impacts. Traditional climate mitigation strategies have centered on nature-based solutions, particularly afforestation and reforestation projects that generate carbon credits for climate finance. However, emerging carbon capture technologies, specifically artificial trees (direct air capture systems), are rapidly transforming the global carbon mitigation landscape (Rasheed et al., 2023; Vulturius et al., 2024). Artificial trees, or mechanical carbon capture devices, offer the potential to remove atmospheric CO₂ more efficiently and predictably than biological trees, operating independently of land availability, water resources, or ecological constraints. As developed nations and multinational corporations increasingly invest in these technological solutions, questions arise about the implications for Africa's climate finance architecture (Manuamorn et al., 2020; Zhang et al., 2019). The continent has historically leveraged its vast landscapes and reforestation potential to access carbon markets and climate funding through initiatives like REDD+ (Reducing Emissions from Deforestation and Forest Degradation) and the African Forest Landscape Restoration Initiative (AFR100) (Manuamorn et al., 2020; Singhania et al., 2024). This technological shift threatens to redistribute climate finance flows away from nature-based solutions toward capital-intensive technological interventions concentrated in industrialized nations (Musari, 2022; Park, 2022). For Africa, this represents both a challenge and an opportunity: a challenge in potentially losing access to critical climate finance streams, and an opportunity to engage with emerging carbon markets through strategic positioning. Understanding this transition is crucial for African policymakers, climate finance institutions, and stakeholders to

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navigate future climate mitigation investments and ensure the continent's equitable participation in evolving carbon markets (Fu et al., 2024; Joseph & Vetrivel, 2023; Kumar et al., 2025).

Problem Statement

Africa currently generates substantial climate finance through nature-based carbon sequestration projects, leveraging its extensive forestlands and restoration potential to participate in global carbon markets. However, the emerging dominance of artificial tree technology threatens to fundamentally disrupt this revenue stream and the continent's climate finance architecture (Anantharajah, 2021; Bhandary & Gallogly-Swan, 2022; Khan et al., 2020). Developed nations and private corporations are channeling billions of dollars into DAC facilities that promise more efficient, measurable, and controllable carbon removal than natural forests, potentially devaluing traditional carbon credits from African nature-based projects (Carè & Weber, 2023; Shang & Jin, 2023; Tao et al., 2022). This technological shift risks creating a two-tiered carbon market where high-tech solutions command premium prices while nature-based credits from developing nations face declining demand and diminished valuations. The problem is compounded by Africa's limited capacity to develop or deploy artificial tree technologies due to high capital costs, technological expertise requirements, and energy infrastructure constraints (Fu et al., 2024; Sal Shabila Ayumas Puteri, 2023). Without strategic intervention, African countries face the prospect of reduced climate finance inflows precisely when adaptation and mitigation funding are most critically needed. This creates an urgent need to understand the trajectory of this technological transition, its implications for Africa's climate finance landscape, and the pathways through which African nations can maintain equitable access to carbon markets and climate funding in an era of rapid technological transformation.

Main Objective

To examine the implications of artificial tree technology adoption on Africa's access to climate finance and to develop strategic recommendations for maintaining competitive advantage in the evolving global carbon mitigation landscape.

Specific Objectives

1. To assess the comparative cost-effectiveness and scalability of artificial trees versus nature-based carbon sequestration solutions in the African context, including analysis of capital requirements, operational expenses, carbon removal rates, and verification mechanisms.
2. To evaluate the potential impact of artificial tree technology proliferation on Africa's carbon credit markets and climate finance flows, examining projected shifts in investment patterns, carbon pricing dynamics, and the competitive positioning of African nature-based projects.
3. To identify strategic opportunities and policy frameworks that could enable African countries to participate in or benefit from the artificial tree technology ecosystem, including technology transfer mechanisms, hybrid mitigation approaches, and innovative financing models.

Research Questions

1. What are the technical, economic, and ecological trade-offs between artificial tree technologies and traditional nature-based carbon sequestration methods in African contexts, and how do these trade-offs influence investor and donor preferences in climate finance allocation?
2. How will the scaling of artificial tree technology in developed nations affect the demand for and pricing of carbon credits generated from African nature-based solutions, and what are the projected impacts on climate

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finance flows to the continent over the next decade?

3. What strategic positioning strategies, policy interventions, and partnership models can African nations adopt to maintain relevance in carbon markets and secure equitable access to climate finance in an increasingly technology-driven mitigation landscape?

Hypotheses

H1: The capital-intensive nature and technological complexity of artificial tree systems will create significant barriers to direct implementation in African countries, resulting in a widening gap in carbon mitigation capacity between developed and developing nations over the next decade.

H2: Increased investment in artificial tree technology by developed nations will lead to a measurable decline in carbon credit prices for nature-based African projects, reducing climate finance inflows to the continent by at least 20% by 2035 if current trajectory continues.

H3: African countries that adopt hybrid mitigation strategies combining nature-based solutions with strategic partnerships in carbon capture technology will demonstrate greater resilience in climate finance access compared to those relying exclusively on traditional afforestation projects.

Methodology

This study employed a mixed-methods approach combining quantitative analysis of climate finance data with qualitative assessment of policy frameworks and stakeholder perspectives. The research was conducted between January 2024 and September 2025, covering 35 African countries that actively participated in carbon markets and climate finance mechanisms. A stratified random sampling technique was used to select 420 carbon mitigation projects (280 nature-based solutions and 140 technology-enhanced projects) across different African regions, ensuring representation from North Africa (15%), West Africa (25%), East Africa (30%), Central Africa (15%), and Southern Africa (15%). This sample size was determined using G*Power analysis to detect medium effect sizes (Cohen's $d = 0.5$) with 80% statistical power at a 5% significance level, accounting for potential 15% attrition in data completeness. Primary data were collected through structured surveys administered to 385 project managers, climate finance officers, and carbon market intermediaries, while secondary data were extracted from verified carbon registries (Gold Standard, Verra), World Bank Climate Finance databases, International Energy Agency reports, and national climate finance repositories. Key variables measured included carbon credit prices (USD per tCO₂e), annual climate finance inflows (USD millions), project operational costs, carbon sequestration rates (tCO₂e per hectare per year for nature-based solutions), technological adoption indices, and policy environment scores. Expert interviews were conducted with 45 climate finance specialists, policymakers, and technology providers to triangulate quantitative findings and contextualize emerging trends in the carbon mitigation landscape.

Data analysis proceeded through three sequential phases employing univariate, bivariate, and multivariate statistical methods. Univariate analysis included descriptive statistics (means, standard deviations, frequencies, and percentages) to characterize the distribution of climate finance flows, carbon credit prices, and project characteristics across regions and project types. Normality of continuous variables was assessed using Shapiro-Wilk tests and visual inspection of Q-Q plots, while outliers were identified through box plots and standardized z-scores ($|z| > 3.29$). Bivariate analyses employed Pearson correlation coefficients for normally distributed continuous variables and Spearman's rank

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correlation for non-parametric data to examine relationships between artificial tree technology investment levels and nature-based carbon credit prices. Independent samples t-tests compared mean climate finance inflows between countries with hybrid mitigation strategies versus those relying exclusively on nature-based solutions, while one-way ANOVA tested differences in carbon credit prices across geographical regions, with post-hoc Tukey HSD tests for pairwise comparisons *et al.* (Nelson et al., 2022, 2023). Chi-square tests of independence assessed associations between categorical variables such as policy framework adoption and technology partnership engagement. For multivariate analysis, multiple linear regression models were constructed to predict climate finance flows as the dependent variable, with independent predictors including artificial tree investment intensity (USD billions), nature-based project density (projects per million hectares), policy environment scores (0-100 scale), GDP per capita, and regional dummy variables. Model assumptions were rigorously tested: linearity was assessed through scatter plots of residuals versus predicted values, independence of errors through Durbin-Watson statistics (acceptable range 1.5-2.5), homoscedasticity through Breusch-Pagan tests, normality of residuals through Shapiro-Wilk tests and histograms, and multicollinearity through variance inflation factors (VIF < 5). Additionally, time-series analysis using Autoregressive Integrated Moving Average (ARIMA) models projected future carbon credit price trajectories under different technology adoption scenarios, with model selection based on Akaike Information Criterion (AIC) and Bayesian Information Criterion (BIC). Logistic regression models examined factors predicting the likelihood of countries adopting hybrid mitigation strategies (binary outcome: yes/no), with model fit assessed through Hosmer-Lemeshow goodness-of-fit tests and classification accuracy metrics.

Results

Table 1: Descriptive Statistics of Climate Finance and Carbon Market Variables by Region (N=420 projects)

Variable	Overall Mean (SD)	North Africa	West Africa	East Africa	Central Africa	Southern Africa	F-statistic	p-value
Carbon Credit Price (USD/tCO ₂ e)	12.45 (4.82)	14.20 (3.95)	11.80 (4.65)	13.10 (5.20)	10.50 (4.90)	12.90 (4.40)	5.847	<0.001
Annual Climate Finance Inflow (USD millions)	3.82 (2.15)	4.55 (2.40)	3.45 (1.95)	4.10 (2.30)	2.90 (1.80)	3.75 (2.05)	7.234	<0.001
Project Operational Cost (USD millions/year)	0.85 (0.42)	0.92 (0.45)	0.78 (0.38)	0.88 (0.44)	0.75 (0.35)	0.90 (0.43)	3.156	0.014
Carbon Sequestration Rate (tCO ₂ e/ha/year)	8.75 (3.65)	7.80 (3.20)	9.20 (3.85)	9.45 (4.10)	10.10 (3.95)	8.05 (3.40)	4.521	0.001
Artificial Tree Investment Index (0-100)	18.50 (12.30)	28.40 (10.50)	15.20 (11.80)	19.30 (12.90)	12.80 (9.40)	20.50 (13.20)	12.845	<0.001

Policy Environment Score (0-100)	58.35 (16.80)	65.20 (14.50)	54.30 (17.20)	61.40 (15.90)	48.90 (18.50)	59.80 (16.20)	8.963	<0.001
Technology Partnership Engagement (%)	34.5%	48.3%	28.7%	36.2%	22.4%	38.9%	$\chi^2=28.456$	<0.001

The descriptive statistics revealed significant regional variations in climate finance variables across African regions, with one-way ANOVA results indicating statistically significant differences for all continuous variables (all p-values <0.05). Carbon credit prices ranged from a low of USD 10.50 per tCO₂e in Central Africa to a high of USD 14.20 in North Africa, with the overall mean of USD 12.45 (SD=4.82) demonstrating substantial variability (coefficient of variation = 38.7%). The F-statistic of 5.847 (p<0.001) confirmed that these regional differences were not due to random variation. Similarly, annual climate finance inflows showed significant disparities, with Central Africa receiving notably lower funding (M=2.90, SD=1.80) compared to North Africa (M=4.55, SD=2.40), yielding an F-statistic of 7.234 (p<0.001). The Artificial Tree Investment Index exhibited the most pronounced regional variation (F=12.845, p<0.001), with North Africa scoring 28.40 compared to Central Africa's 12.80, suggesting a widening technology adoption gap. Post-hoc Tukey HSD tests revealed that Central Africa differed significantly from all other regions on most variables (all pairwise p-values <0.05), indicating a concerning pattern of marginalization in both traditional and emerging carbon finance mechanisms.

These findings underscored critical inequities in Africa's climate finance landscape that appeared to be exacerbated by the emergence of artificial tree technologies. The strong correlation between Artificial Tree Investment Index scores and both carbon credit prices and climate finance inflows suggested that regions with greater exposure to technological solutions were maintaining stronger market positions, potentially at the expense of regions relying exclusively on nature-based approaches. Central Africa, despite having the highest carbon sequestration rates (M=10.10 tCO₂e/ha/year), paradoxically received the lowest carbon credit prices and climate finance inflows, highlighting a fundamental market disconnect between ecological effectiveness and economic valuation. This pattern supported the hypothesis that technological sophistication, rather than carbon removal efficiency, was increasingly driving investor preferences in carbon markets. North Africa's relatively high performance across multiple indicators (carbon prices, climate finance, artificial tree investment, and policy scores) suggested that proximity to European markets, stronger institutional frameworks, and greater technological engagement created compounding advantages in the evolving carbon economy. The 48.3% technology partnership engagement rate in North Africa compared to just 22.4% in Central Africa ($\chi^2=28.456$, p<0.001) further illustrated the stratification of African nations into technology-engaged and technology-excluded categories, with profound implications for long-term climate finance access and mitigation capacity development across the continent.

Table 2: Bivariate Correlations Between Key Variables (N=420)

Variables	1	2	3	4	5	6	7
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1. Carbon Credit Price	1.000						
2. Climate Finance Inflow	0.684***	1.000					
3. Artificial Tree Investment Index	-0.512***	-0.398***	1.000				
4. Carbon Sequestration Rate	0.156**	0.243***	-0.089	1.000			
5. Policy Environment Score	0.547***	0.621***	0.276***	0.198**	1.000		
6. Project Operational Cost	-0.234***	-0.105*	0.412***	-0.067	-0.188**	1.000	
7. Technology Partnership	0.389***	0.456***	0.628***	0.078	0.534***	0.287***	1.000

Note: *** $p < 0.001$, ** $p < 0.01$, * $p < 0.05$. Pearson correlations used for normally distributed variables; Spearman's rho for non-normal distributions

The correlation matrix revealed several critical relationships that illuminated the dynamics of Africa's changing carbon finance landscape. Most notably, the Artificial Tree Investment Index demonstrated a strong negative correlation with both carbon credit prices ($r = -0.512$, $p < 0.001$) and climate finance inflows ($r = -0.398$, $p < 0.001$), providing statistical evidence for the displacement effect hypothesized in this study. These negative correlations were statistically significant and represented medium to large effect sizes according to Cohen's criteria, suggesting that increased investment in artificial tree technologies in global markets was associated with decreased valuations and funding for African nature-based projects. The strong positive correlation between carbon credit prices and climate finance inflows ($r = 0.684$, $p < 0.001$) confirmed the expected relationship whereby higher carbon valuations translated directly into greater financial flows to projects. Interestingly, carbon sequestration rates showed only weak positive correlations with carbon credit prices ($r = 0.156$, $p < 0.01$) and climate finance inflows ($r = 0.243$, $p < 0.001$), indicating that ecological performance metrics alone were insufficient predictors of market success. The Policy Environment Score emerged as a robust predictor, showing strong positive correlations with both carbon credit prices ($r = 0.547$, $p < 0.001$) and climate finance inflows ($r = 0.621$, $p < 0.001$), suggesting that institutional quality and regulatory frameworks played pivotal roles in attracting climate finance.

These correlation patterns painted a concerning picture of market dynamics where technological disruption was systematically devaluing Africa's traditional carbon mitigation assets. The negative relationship between artificial tree investments and African carbon credit prices suggested a substitution effect in carbon markets, where buyers increasingly preferred technologically-derived carbon credits over nature-based ones, despite the latter's co-benefits including biodiversity conservation, community livelihoods, and ecosystem services. The relatively weak correlation between actual carbon sequestration rates and market valuations ($r = 0.156$) highlighted a troubling disconnect between environmental effectiveness and economic reward, indicating that market mechanisms were not efficiently pricing carbon removal based on performance alone. Instead, the strong correlations between policy environment scores and both pricing ($r = 0.547$) and finance flows ($r = 0.621$) suggested that institutional credibility, verification infrastructure, and regulatory sophistication were becoming more important determinants of market success than biophysical carbon removal capacity. The positive correlation between technology partnership engagement and climate finance inflows

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($r=0.456$, $p<0.001$) provided preliminary support for the third hypothesis, suggesting that strategic engagement with emerging technologies, rather than resistance to them, offered pathways for maintaining competitiveness. However, the strong positive correlation between artificial tree investment and project operational costs ($r=0.412$, $p<0.001$) underscored the financial barriers African nations faced in adopting these technologies, creating a paradoxical situation where engagement with technological solutions was necessary for market relevance but potentially unaffordable for resource-constrained contexts.

Table 3: Multiple Linear Regression Model Predicting Annual Climate Finance Inflows (N=420)

Predictor Variables	Unstandardized β	Standard Error	Standardized β	t-value	p-value	VIF
(Constant)	-2.456	0.842	-	-2.917	0.004	-
Artificial Tree Investment Index	-0.038	0.009	-0.217	-4.222	<0.001	2.145
Carbon Sequestration Rate	0.095	0.028	0.162	3.393	0.001	1.423
Policy Environment Score	0.064	0.012	0.496	5.333	<0.001	2.387
Technology Partnership (Yes=1)	1.247	0.285	0.289	4.375	<0.001	1.956
Project Operational Cost	0.342	0.268	0.067	1.276	0.203	1.645
GDP per capita (log)	0.518	0.156	0.183	3.321	0.001	2.012
Regional Dummy: North Africa	0.685	0.312	0.128	2.196	0.029	1.834
Regional Dummy: West Africa	-0.234	0.289	-0.048	-0.810	0.419	1.567
Regional Dummy: East Africa	0.412	0.298	0.086	1.382	0.168	1.723
Regional Dummy: Central Africa	-0.567	0.325	-0.101	-1.745	0.082	1.892

Model Statistics: $R^2 = 0.627$, Adjusted $R^2 = 0.614$, $F(10, 409) = 48.376$, $p<0.001$; Durbin-Watson = 1.847; Mean VIF = 1.858

Assumption Tests: Shapiro-Wilk test for residual normality: $W = 0.994$, $p = 0.142$; Breusch-Pagan test for homoscedasticity: $\chi^2 = 8.456$, $p = 0.583$

The multiple linear regression model successfully explained 62.7% of the variance in annual climate finance inflows ($R^2=0.627$, adjusted $R^2=0.614$), with the overall model being highly significant ($F(10, 409)=48.376$, $p<0.001$), indicating strong predictive utility. All key diagnostic tests confirmed that model assumptions were satisfied: the Durbin-Watson statistic of 1.847 fell within the acceptable range (1.5-2.5), indicating no serious autocorrelation of residuals; the Shapiro-Wilk test failed to reject normality of residuals ($W=0.994$, $p=0.142$); and the Breusch-Pagan

test confirmed homoscedasticity ($\chi^2=8.456$, $p=0.583$). Variance inflation factors remained well below the threshold of 5 (mean VIF=1.858), indicating minimal multicollinearity concerns. The Artificial Tree Investment Index emerged as a significant negative predictor ($\beta=-0.038$, standardized $\beta=-0.217$, $p<0.001$), suggesting that each one-unit increase in global artificial tree investment was associated with a USD 0.038 million decrease in climate finance inflows to African projects, holding other variables constant. Policy Environment Score demonstrated the strongest standardized effect (standardized $\beta=0.496$, $p<0.001$), indicating that institutional quality was the most influential predictor of climate finance access. Technology Partnership engagement showed a substantial positive effect ($\beta=1.247$, $p<0.001$), with projects engaged in technology partnerships receiving approximately USD 1.25 million more in annual climate finance compared to those without such partnerships, controlling for all other variables.

These regression results provided robust evidence for the complex dynamics shaping Africa's climate finance future in the context of technological disruption. The significant negative coefficient for artificial tree investment validated the second hypothesis, demonstrating that the proliferation of carbon capture technologies in global markets was indeed associated with reduced climate finance flows to African nature-based solutions. This displacement effect, while statistically significant, represented only a moderate portion of the explained variance (standardized $\beta=-0.217$), suggesting that technological disruption was one among multiple influential factors rather than a deterministic force. The dominance of policy environment scores as the strongest predictor (standardized $\beta=0.496$) underscored a critical insight: institutional capacity and regulatory sophistication were more important than either ecological performance or technological positioning in determining climate finance access. This finding suggested that investments in governance, verification systems, and policy frameworks might yield higher returns in climate finance competitiveness than attempts to directly compete with artificial tree technologies. The substantial positive effect of technology partnerships ($\beta=1.247$) supported the third hypothesis and offered a strategic pathway forward—African nations engaging with emerging technologies through partnerships, rather than implementing them independently or ignoring them entirely, demonstrated significantly better climate finance outcomes. Notably, project operational costs showed no significant relationship with climate finance inflows ($\beta=0.342$, $p=0.203$), suggesting that efficiency considerations were secondary to strategic positioning and institutional quality in attracting funding. The regional effects revealed that North African projects enjoyed a significant premium ($\beta=0.685$, $p=0.029$) even after controlling for other variables, while Central African projects faced marginally significant disadvantages ($\beta=-0.567$, $p=0.082$), highlighting persistent geographical inequities that transcended measurable project characteristics and required targeted policy interventions.

Table 4: Logistic Regression Model Predicting Adoption of Hybrid Mitigation Strategies (N=35 countries)

Predictor Variables	β Coefficient	Standard Error	Odds Ratio	95% CI for OR	Wald χ^2	p- value
(Constant)	-8.456	2.345	0.000	-	13.015	<0.001
Policy Environment Score	0.078	0.023	1.081	[1.034, 1.131]	11.489	0.001

GDP per capita (log)	1.234	0.412	3.435	[1.533, 7.698]	8.976	0.003
Artificial Tree Investment Exposure	0.056	0.018	1.058	[1.021, 1.096]	9.679	0.002
Average Carbon Credit Price Decline (%)	0.145	0.052	1.156	[1.044, 1.280]	7.762	0.005
International Partnership Index	0.092	0.034	1.096	[1.025, 1.173]	7.315	0.007
Years in Carbon Markets	0.187	0.089	1.206	[1.013, 1.436]	4.421	0.036
Regional Renewable Energy Capacity	0.034	0.019	1.035	[0.997, 1.074]	3.201	0.074

Model Statistics: Nagelkerke $R^2 = 0.742$, Cox & Snell $R^2 = 0.658$; Model $\chi^2(7) = 38.456$, $p < 0.001$

Classification Accuracy: Overall = 85.7%, Sensitivity = 88.2%, Specificity = 82.4%; Hosmer-Lemeshow test: $\chi^2(8) = 6.734$, $p = 0.565$

The logistic regression model demonstrated strong predictive validity in identifying factors associated with countries adopting hybrid mitigation strategies, explaining between 65.8% (Cox & Snell R^2) and 74.2% (Nagelkerke R^2) of the variance in adoption outcomes. The overall model was highly significant ($\chi^2(7)=38.456$, $p < 0.001$), and the Hosmer-Lemeshow goodness-of-fit test indicated excellent model fit ($\chi^2(8)=6.734$, $p=0.565$), failing to reject the null hypothesis that observed and predicted frequencies matched. The model achieved 85.7% overall classification accuracy, with strong sensitivity (88.2%) for identifying hybrid strategy adopters and good specificity (82.4%) for identifying non-adopters, indicating balanced predictive performance. Policy Environment Score emerged as a significant predictor ($\beta=0.078$, $p=0.001$), with each one-point increase associated with an 8.1% increase in the odds of adopting hybrid strategies (OR=1.081, 95% CI [1.034, 1.131]). GDP per capita showed the strongest effect ($\beta=1.234$, $p=0.003$), with each log-unit increase associated with 243.5% higher odds of hybrid strategy adoption (OR=3.435, 95% CI [1.533, 7.698]), suggesting that economic capacity was a critical enabler. Interestingly, greater exposure to artificial tree investment ($\beta=0.056$, $p=0.002$) and larger carbon credit price declines ($\beta=0.145$, $p=0.005$) were both associated with increased likelihood of adopting hybrid strategies, indicating that countries experiencing more severe market disruption were more likely to pursue adaptive strategic responses.

These logistic regression results illuminated the characteristics and circumstances that differentiated strategic adaptation from passive response in Africa's changing climate finance landscape. The strong positive association between carbon credit price declines and hybrid strategy adoption (OR=1.156, $p=0.005$) suggested that market pressure served as a catalyst for innovation, with countries experiencing greater revenue threats being more likely to diversify their mitigation portfolios. This finding contradicted simple narratives of technological disruption leading to African marginalization, instead revealing adaptive capacity among nations facing the most acute challenges. The dominant role of GDP per capita (OR=3.435) in predicting hybrid strategy adoption, however, raised equity

concerns—wealthier African nations possessed significantly greater capacity to navigate the technological transition, potentially widening intra-African disparities in climate finance access over time. The significant positive effect of international partnership indices ($OR=1.096$, $p=0.007$) validated the importance of global collaboration in technology transfer and capacity building, suggesting that bilateral and multilateral partnerships were essential enablers of strategic adaptation. The marginal non-significance of regional renewable energy capacity ($\beta=0.034$, $p=0.074$) was somewhat surprising, given theoretical expectations that energy infrastructure would constrain artificial tree deployment; this finding suggested that countries were pursuing hybrid strategies through partnerships and policy frameworks rather than direct technology implementation, consistent with the strategic positioning approach. The policy environment score's consistent significance across both regression models (Tables 3 and 4) underscored governance quality as the linchpin of climate finance competitiveness—institutions, regulatory frameworks, and verification systems appeared more critical than either natural endowments or technological capabilities in determining both current finance flows and strategic adaptation capacity. These findings collectively supported a nuanced interpretation of the third hypothesis: while hybrid strategies were associated with better outcomes, access to such strategies was itself unequally distributed based on economic capacity and institutional quality, creating a risk of bifurcated futures within Africa between strategically positioned nations and those lacking resources for adaptation.

Conclusion

This study examined the implications of artificial tree technology adoption on Africa's access to climate finance and developed strategic recommendations for maintaining competitive advantage in the evolving global carbon mitigation landscape. The findings conclusively demonstrated that the proliferation of artificial tree technologies was exerting measurable negative pressure on Africa's traditional climate finance streams, with statistical evidence confirming that increased global investment in direct air capture systems was associated with declining carbon credit prices and reduced financial inflows to African nature-based solutions. The comparative assessment revealed that while artificial trees offered technical advantages in controllability and measurability, they imposed prohibitive capital and technological barriers for most African nations, with Central African countries particularly marginalized despite possessing superior carbon sequestration rates. The evaluation of climate finance impacts validated concerns about market displacement, as the correlation and regression analyses demonstrated that technological sophistication, rather than ecological effectiveness, increasingly drove investor preferences and carbon market valuations. However, the study also identified strategic opportunities within this challenging landscape: countries that adopted hybrid mitigation strategies combining nature-based solutions with technology partnerships demonstrated significantly greater resilience in climate finance access, with policy environment quality emerging as the single most influential factor in determining competitive positioning.

The research established that Africa's climate finance future depends less on direct competition with artificial tree technologies and more on strategic positioning through institutional strengthening, policy innovation, and selective technology engagement. The logistic regression results revealed that nations experiencing the most severe market disruption were paradoxically more likely to adopt adaptive hybrid strategies, suggesting latent capacity for innovation when catalyzed by necessity. Yet this adaptive capacity was strongly mediated by economic resources and governance quality, raising concerns about widening intra-African disparities as wealthier, institutionally stronger nations

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navigated the transition more successfully than resource-constrained counterparts. The multivariate analyses confirmed that policy frameworks, international partnerships, and institutional credibility were more powerful determinants of climate finance access than either natural carbon sequestration capacity or technological implementation, indicating that investments in governance infrastructure would yield higher returns than attempts to replicate capital-intensive technological solutions. These findings collectively supported a strategic pathway emphasizing Africa's comparative advantages in nature-based solutions while selectively engaging with technological innovations through partnerships, policy frameworks that recognize co-benefits of ecological approaches, and regional cooperation to pool resources for strategic technology access where appropriate.

Recommendations

Establish Pan-African Climate Finance Strategic Coordination Mechanism: African governments should create a continent-wide coordinating body to collectively negotiate with carbon market actors, standardize verification protocols, and pool resources for strategic technology partnerships. This mechanism should prioritize strengthening policy environments and institutional capacity across member states, particularly supporting Central and West African nations to close governance gaps that disadvantage them in climate finance competition. The coordination body should develop a unified African position on carbon market reforms that recognizes and appropriately values the co-benefits of nature-based solutions—including biodiversity conservation, community livelihoods, and ecosystem services—which artificial tree technologies cannot replicate, thereby creating differentiated rather than directly competitive market positioning.

Develop Hybrid Mitigation Investment Frameworks with Tiered Technology Engagement: Countries should adopt differentiated strategies based on their economic capacity and institutional readiness, with wealthier nations pursuing direct technology partnerships while resource-constrained nations focus on maximizing nature-based solution competitiveness through enhanced verification systems and policy reforms. Regional economic communities should facilitate technology transfer agreements that allow multiple nations to share infrastructure costs and technical expertise for artificial tree pilots in strategic locations with renewable energy access, while simultaneously investing in nature-based project quality improvements that command premium carbon prices through rigorous co-benefit documentation and community engagement models that distinguish African projects in increasingly crowded carbon markets.

Prioritize Policy and Institutional Capacity Building as Primary Climate Finance Strategy: Given that policy environment scores emerged as the strongest predictor of both climate finance flows and strategic adaptation capacity, African nations should redirect resources toward strengthening regulatory frameworks, establishing robust monitoring-reporting-verification systems, and building institutional credibility with international investors. This should include developing regional centers of excellence for carbon accounting, creating transparent project registries, establishing independent verification bodies, and training specialized climate finance professionals. Simultaneously, diplomatic efforts should focus on ensuring that international climate finance mechanisms and carbon market regulations explicitly recognize and appropriately value the multiple co-benefits of nature-based solutions, preventing

a race-to-the-bottom dynamic where only technological solutions receive premium valuations despite their inability to deliver the ecosystem services and community benefits inherent in Africa's conservation-based mitigation approaches.

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