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Climate Adaptation Finance for Resilience Outcomes in Coastal Municipality Programs

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Abstract

The escalating impacts of global climate change pose unprecedented existential and economic threats to coastal municipalities worldwide, necessitating the rapid deployment of climate adaptation finance to build localized resilience. While international and domestic funding streams have expanded in recent years, the ability to predict the actual empirical resilience outcomes resulting from specific financial allocations remains an intricate and unresolved challenge. This comprehensive study investigates the complex multidimensional relationship between climate adaptation finance and tangible resilience outcomes through a rigorous comparative case analysis of coastal municipality programs. By analyzing diverse funding mechanisms, program implementation dynamics, and socio-ecological moderating factors, this research identifies the core predictive variables that determine adaptation project efficacy. The analysis leverages a robust methodological framework to evaluate how disparate financial inputs translate into infrastructural, social, and ecological resilience on the ground. The findings reveal that while total financial volume is a fundamental driver of adaptation capacity, the timing of disbursements, community stakeholder engagement models, and preexisting municipal administrative capacity act as critical mediating variables that significantly alter ultimate resilience outcomes. This research provides a scalable predictive framework intended to guide policymakers, urban planners, and international funding agencies in optimizing resource allocation strategies to achieve maximum climate adaptation impact across vulnerable coastal environments.

Keywords: Climate Adaptation Finance; Coastal Resilience; Municipal Policy; Case Comparison; Resilience Outcomes

1. Introduction

1.1 The Imperative of Coastal Climate Adaptation

Coastal municipalities occupy the front lines of the global climate crisis, facing acute vulnerabilities stemming from accelerating sea level rise, increasing frequency of extreme weather events, and progressive coastal erosion. The concentration of human populations, critical infrastructure, and economic activities in these geographic zones magnifies the potential devastation associated with climate-induced disruptions [1]. Over the past two decades, the global discourse surrounding climate change has transitioned from a primary focus on mitigation efforts aimed at reducing greenhouse gas emissions to a dual approach that equally prioritizes adaptation [2]. Adaptation involves proactive and reactive interventions designed to reduce vulnerability and enhance the adaptive capacity of both human and natural systems. Coastal urban environments, owing to their unique geographical exposure and dense socioeconomic networks, require highly tailored adaptation strategies that can withstand complex, compounding climate threats [3]. The design and execution of these localized strategies depend overwhelmingly on the availability, accessibility, and efficient utilization of adaptation finance. Without adequate financial resources, the most meticulously drafted municipal climate action plans remain theoretical, leaving populations exposed to existential risks [4]. Consequently, understanding how adaptation finance operates at the municipal level has emerged as a paramount priority for contemporary environmental researchers and urban policymakers.

1.2 The Role of Adaptation Finance in Urban Resilience

Adaptation finance refers to local, national, or transnational financing drawn from public, private, and alternative sources that seeks to support adaptation actions that mitigate the adverse effects of climate change. Unlike climate mitigation finance, which primarily targets energy transitions and carbon sequestration and is relatively straightforward to measure through standardized metrics such as tons of carbon dioxide equivalent avoided, adaptation finance involves highly context-dependent investments [5]. The architecture of global climate finance has established various multilateral mechanisms, including the Green Climate Fund and the Global Environment Facility, which are intended to channel resources to vulnerable regions [6]. However, the translation of these macro-level funds into micro-level urban resilience outcomes is fraught with bureaucratic, political, and operational complexities. When financial resources are allocated to coastal municipalities, they are typically directed toward a combination of hard infrastructural projects, such as seawalls and storm surge barriers, and soft programmatic initiatives, such as early warning systems, mangrove restoration, and community preparedness education [7]. The central challenge lies not merely in tracking the volume of capital transferred but in determining the extent to which these financial inputs effectively generate sustainable, long-term resilience against unpredictable climate trajectories. The efficacy of adaptation finance is often contingent upon local administrative capacity, stringent oversight mechanisms, and the alignment of funded projects with the most pressing localized vulnerabilities [8].

1.3 Research Objectives and Scope

Despite the increasing flow of capital directed toward climate adaptation, there remains a critical knowledge gap regarding the predictive relationship between financial inputs and tangible resilience outcomes at the municipal level. Evaluative frameworks often struggle to attribute specific resilience improvements directly to discrete funding streams due to the slow onset of climate impacts and the multifaceted nature of urban development [9]. This study aims to bridge this gap by conducting a rigorous case comparison of diverse coastal municipality programs. The primary objective is to isolate and identify the specific financial and administrative variables that most reliably predict successful resilience outcomes. By systematically comparing municipalities that have received comparable levels of adaptation finance but have achieved divergent resilience trajectories, this research endeavors to uncover the underlying mechanisms of financial efficacy [10]. The scope of the investigation encompasses an analysis of funding typologies, project implementation timelines, and the integration of local ecological knowledge into project design. Ultimately, this comprehensive analysis seeks to construct a predictive paradigm that can inform future financial allocations, ensuring that limited adaptation resources are deployed in the most impactful and scientifically sound manner possible [11].

2. Theoretical Framework and Literature Review

2.1 Conceptualizing Coastal Urban Resilience

The concept of resilience has undergone significant evolution within academic literature, transitioning from its origins in material science and engineering to a foundational theory in socio-ecological systems analysis. In the context of coastal municipalities, resilience is generally understood as the capacity of a system to absorb structural and social disturbances while retaining its essential functions, structure, and identity [12]. Academic frameworks typically divide coastal urban resilience into three interrelated dimensions: infrastructural resilience, socio-economic resilience, and ecological resilience. Infrastructural resilience focuses on the durability and adaptive capacity of the built environment, encompassing transportation networks, water management systems, and protective coastal engineering structures [13]. Socio-economic resilience emphasizes the ability of communities to anticipate, cope with, and recover from climate shocks through financial safety nets, social cohesion, and robust public health systems. Ecological resilience pertains to the preservation and restoration of natural coastal buffers, such as wetlands, estuaries, and coral reefs, which provide vital ecosystem services and natural defense mechanisms against storm surges [14]. Contemporary literature increasingly argues that effective climate adaptation requires a holistic approach that simultaneously addresses all three dimensions, as interventions that isolate one aspect often result in maladaptation or unintended vulnerabilities in others [15].

2.2 The Global Climate Finance Architecture

Understanding the impact of adaptation finance requires a thorough examination of the institutional structures and pathways through which these funds operate. The international climate finance architecture is characterized by a complex web of bilateral and multilateral institutions, development banks, and private financial intermediaries. Scholars have frequently highlighted the chronic underfunding of adaptation relative to mitigation, noting that adaptation projects often struggle to attract private capital due to their public good nature and the lack of easily monetizable return on investment [16]. Consequently, adaptation finance remains heavily reliant on public funds and international grants. At the municipal level, accessing these funds typically involves navigating arduous accreditation processes and formulating highly technical project proposals that align with the strategic priorities of distant funding bodies [17]. Literature evaluating these processes indicates that smaller, resource-constrained coastal municipalities are often systematically disadvantaged, leading to a geographic maldistribution of adaptation finance where funds are concentrated in areas with high administrative capacity rather than areas of highest climate vulnerability [18]. Furthermore, once funds are secured, the modalities of disbursement, whether through direct budget support, project-specific grants, or specialized municipal green bonds, significantly influence the flexibility and speed with which municipalities can implement adaptation measures.

2.3 Predictive Modeling in Climate Adaptation Studies

Predicting the outcomes of climate adaptation interventions is a relatively nascent but rapidly expanding domain within environmental science and public policy research. Early predictive attempts largely relied on deterministic models that linearly extrapolated financial inputs to expected infrastructural improvements based on standardized engineering cost-benefit analyses [19]. However, these models frequently failed to account for the dynamic, non-linear realities of socio-ecological systems and the political economy of urban governance. Recent advancements in the literature emphasize the necessity of incorporating complex systems thinking and probabilistic modeling into outcome prediction. Researchers have begun to utilize qualitative comparative analysis and machine learning algorithms to process large datasets of historical adaptation projects, seeking to identify the combinations of conditions that lead to successful project execution [20]. Despite these advancements, predicting localized resilience outcomes remains challenging due to the scarcity of standardized, long-term post-project evaluation data. Many adaptation projects are evaluated immediately upon completion based solely on the delivery of outputs, such as the number of meters of seawall constructed, rather than the actual long-term outcomes, such as the reduction in flood-related economic losses over a decadal timescale [21]. This study builds upon the existing literature by establishing a case comparison methodology that prioritizes long-term outcome evaluation over short-term output measurement.

3. Methodology for Case Comparison Analysis

3.1 Research Design and Case Selection

This research employs a rigorous qualitative and quantitative case comparison methodology, specifically leveraging a Most Similar Systems Design to isolate the variables that determine adaptation success. The Most Similar Systems Design approach is particularly suited for municipal comparative studies, as it allows researchers to select cases that share numerous background characteristics, thereby controlling for confounding variables, while differing fundamentally in the independent variables of interest and the final outcomes [22]. For this investigation, coastal municipalities were selected based on a strict set of control criteria to ensure baseline comparability. All selected municipalities possess a population size ranging between one hundred thousand and five hundred thousand residents, depend heavily on coastal economic activities such as fisheries or tourism, and exhibit high baseline vulnerability to sea level rise and tropical cyclone inundation [23]. To construct a robust comparative matrix, the study selected cases that varied significantly in their approaches to securing and managing adaptation finance. The selection encompasses municipalities that relied primarily on large-scale international multilateral grants, those that utilized localized municipal taxation and bond issuance, and those that depended on national government budgetary allocations [24].

Table 1: Municipal Case Selection Criteria and Demographic Profiles

Municipality Identifier	Population Baseline	Dominant Economic Sector	Primary Adaptation Finance Source	Base Vulnerability Index
Coastal Hub Alpha	215000	Port Logistics	Multilateral Climate	Very High

Municipality Identifier	Population Baseline	Dominant Economic Sector	Primary Adaptation Finance Source	Base Vulnerability Index
			Funds	
Coastal Hub Beta	185000	Coastal Tourism	National Sovereign Grants	High
Coastal Hub Gamma	340000	Fisheries and Aquaculture	Municipal Green Bonds	Very High
Coastal Hub Delta	120000	Mixed Commercial	Bilateral Development Aid	High
Coastal Hub Epsilon	410000	Heavy Coastal Industry	Public-Private Partnerships	Moderate
Coastal Hub Zeta	290000	Port Logistics	Multilateral Climate Funds	High

3.2 Evaluation Metrics for Resilience Outcomes

The measurement of resilience outcomes necessitates the deployment of a multidimensional metric system that captures the full spectrum of adaptation success. To move beyond superficial output tracking, this methodology establishes distinct evaluation rubrics for infrastructural, social, and ecological resilience. Infrastructural resilience is evaluated by analyzing the structural integrity of implemented projects during subsequent severe weather events, measuring the reduction in physical damage costs compared to historical baselines [25]. This involves detailed reviews of municipal engineering reports and post-disaster damage assessments. Social resilience is quantified through longitudinal community surveys and demographic stability indicators, assessing factors such as post-disaster displacement rates, the continuity of local essential services, and the speed of economic recovery for small and medium-sized coastal enterprises [26]. Ecological resilience is measured using geospatial analysis and remote sensing data to track the health, expansion, or degradation of natural coastal buffers following the implementation of finance-backed restoration projects. By aggregating these distinct dimensions, the study constructs a composite resilience outcome index for each municipality. This index serves as the primary dependent variable in the predictive analysis, allowing for a standardized comparison of how effectively different financial strategies translated into holistic urban protection [27].

4. Empirical Implementation and Data Analytics

4.1 Data Aggregation from Financial and Ecological Repositories

The empirical phase of this research required the systematic aggregation of expansive datasets spanning a temporal period of fifteen years, providing sufficient lead time to observe the long-term effects of financial interventions. Data collection procedures involved the extraction of financial disbursement records from international climate finance tracking portals, national treasury databases, and municipal audit reports. This financial data was meticulously coded to categorize the funding by source, scale, intended purpose, and degree of local administrative control. To correlate these financial inputs with physical and ecological outcomes, the study integrated high-resolution satellite imagery and geographic information system mapping [28]. This spatial data allowed for the precise longitudinal tracking of coastal inundation zones, shoreline erosion rates, and the physical footprint of new adaptation infrastructure. Furthermore, demographic and socio-economic data were harvested from national census bureaus and regional economic development boards. The integration of these disparate data streams into a centralized analytical repository constituted a significant methodological challenge, requiring advanced data harmonization techniques to ensure that financial timelines aligned accurately with corresponding ecological and social observational periods.

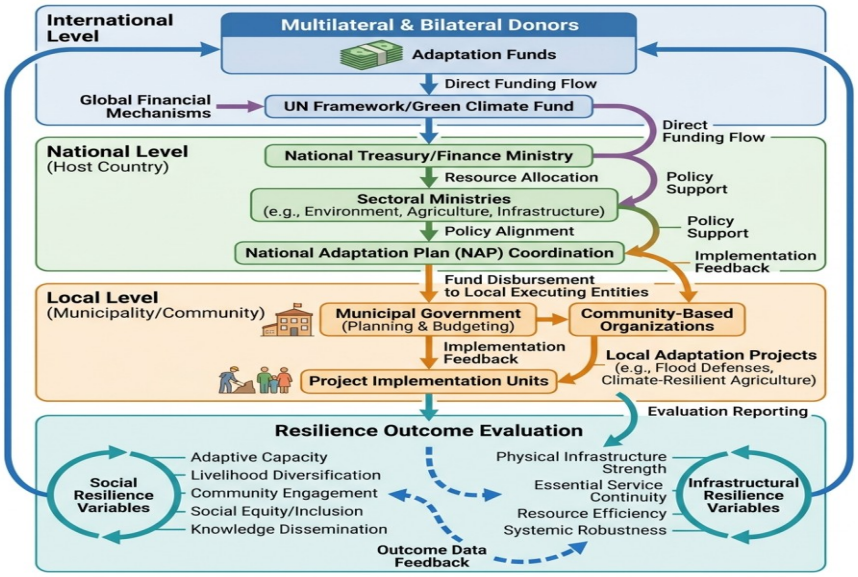

Figure 1: Comprehensive Schematic of Climate Finance Flow and Resilience Outcome Evaluation Architecture

4.2 Qualitative and Quantitative Synthesis

Following the aggregation of raw data, the study employed a mixed-methods analytical framework to synthesize the information and identify predictive patterns. The quantitative component utilized multivariate regression models to test the statistical significance of various financial parameters against the composite resilience outcome index. Independent variables included the total per capita adaptation funding, the ratio of hard infrastructure spending to soft programmatic spending, and the temporal lag between project approval and final financial disbursement. Concurrently, the qualitative component involved an extensive review of municipal policy documents, project completion reports, and semi-structured interviews with urban planners and local government officials. This qualitative analysis was crucial for contextualizing the statistical findings and uncovering the nuanced institutional dynamics that quantitative data alone could not capture. Through iterative coding and thematic analysis, the study identified recurring administrative bottlenecks, stakeholder engagement challenges, and instances of political interference that served to moderate the effectiveness of adaptation finance. The synthesis of these quantitative and qualitative insights forms the foundation of the predictive model, establishing a comprehensive understanding of how and why specific financial interventions succeed or fail in diverse municipal contexts.

5. Results and Discussion of Resilience Outcomes

5.1 Comparative Analysis of Financial Efficacy

The comparative analysis of the selected coastal municipalities yielded profound insights into the disparate efficacy of various adaptation finance strategies. The results demonstrate definitively that the sheer volume of adaptation finance, while necessary, is an insufficient predictor of positive resilience outcomes. Municipalities that received massive, uncoordinated influxes of capital following disaster events often exhibited lower long-term resilience scores compared to municipalities that received smaller, consistent, and highly targeted financial streams over an extended period. For instance, Coastal Hub Alpha, which relied on large multilateral grants, struggled with severe implementation delays due to the rigorous international compliance standards, resulting in a prolonged period of vulnerability during which the intended infrastructure was not yet operational. Conversely, Coastal Hub Gamma, which utilized locally issued municipal green bonds, demonstrated rapid deployment of funds and achieved substantial improvements in infrastructural resilience, largely due to the alignment of funding timelines with local construction capabilities and immediate civic priorities. The analysis also revealed a strong threshold effect in ecological resilience investments; minor, fragmented funding for mangrove restoration or wetland preservation failed to achieve measurable resilience outcomes, whereas large-scale, contiguous ecological funding generated exponentially higher protective benefits against storm surges.

Table 2: Predictive Variable Impact Assessment Matrix

Predictive Variable Category	Primary Indicator Assessed	Correlation to Infrastructure Resilience	Correlation to Social Resilience	Statistical Significance Level
Financial Volume	Per Capita Adaptation Investment	Strong Positive	Moderate Positive	High
Disbursement Efficiency	Time from Approval to Execution	Strong Negative	Strong Negative	Very High
Investment Typology	Ratio of Hard to Soft Interventions	Variable Contextual	Weak Negative	Moderate
Administrative Capacity	Local Bureaucratic Efficiency Index	Strong Positive	Strong Positive	Very High
Stakeholder Integration	Community Participation Metric	Moderate Positive	Strong Positive	High

5.2 Identifying Predictive Determinants of Success

Through the synthesis of the comparative data, several core predictive determinants of adaptation success emerged. The most significant predictive variable is local administrative capacity, defined by the municipality's ability to navigate complex procurement processes, enforce rigorous engineering standards, and maintain infrastructure post-construction. Without high administrative capacity, even the most generous financial allocations consistently failed to translate into durable resilience. A second critical determinant is the integration of community stakeholder participation in the design and execution of adaptation projects. The data indicated that top-down infrastructure projects that bypassed local community input frequently faced severe operational challenges, including community resistance, vandalism, and a failure to address the most localized vulnerabilities. Consequently, social resilience scores were significantly higher in municipalities where adaptation finance mandated community-led design processes. Furthermore, the temporal predictability of financial flows emerged as a crucial predictor. Municipalities that could rely on guaranteed, multi-year funding programs were able to engage in comprehensive, phased coastal planning, whereas those reliant on ad-hoc, unpredictable grant cycles were forced to implement fragmented, disjointed projects that ultimately provided inferior comprehensive protection. These identified determinants provide a robust foundation for predicting the probable success of future adaptation interventions based on the characteristics of the funding mechanism and the recipient municipality.

6. Conclusion and Future Trajectories

6.1 Summary of Findings

This comprehensive comparative analysis has systematically investigated the complex mechanisms through which climate adaptation finance translates into empirical resilience outcomes within highly vulnerable coastal municipalities. By moving beyond traditional output-based evaluation metrics and employing a multidimensional assessment of infrastructural, social, and ecological resilience, this study has illuminated the profound disparities in how financial inputs are utilized at the local level. The central finding of this research is that the architecture of financial delivery and the preexisting administrative environment of the recipient municipality are far more predictive of adaptation success than the gross volume of capital invested. The comparative cases demonstrated that delayed disbursements, fragmented funding streams, and exclusionary planning processes severely degrade the efficacy of adaptation projects. Conversely, stable, predictable financing combined with high municipal administrative competence and robust community engagement consistently yields superior, long-lasting resilience outcomes against compounding climate threats.

6.2 Policy Recommendations and Practical Implications

The predictive framework developed in this study offers critical guidance for international climate finance institutions, national governments, and municipal planning authorities. To optimize the impact of limited global adaptation resources, funding agencies must transition away from purely project-based grant allocations toward long-term programmatic funding models that prioritize institutional capacity building alongside physical infrastructure development. Municipalities should focus on issuing localized financial instruments and improving bureaucratic efficiency to ensure rapid deployment of adaptation measures. Future research trajectories must prioritize the continuous refinement of resilience outcome metrics, particularly concerning

the long-term ecological impacts of localized adaptation finance. As the climate crisis accelerates and the operational environment for coastal municipalities becomes increasingly volatile, the ability to accurately predict and ensure the success of adaptation investments will be the defining factor in preserving the habitability and economic viability of the global coastal zone.

References

1. Williamson, P.; Gattuso, J.P. Carbon removal using coastal blue carbon ecosystems is uncertain and unreliable, with questionable climatic cost-effectiveness. Front. Clim. 2022, 4, 853666.

2. Bruno, E.M.; Jessoe, K. Designing water markets for climate change adaptation. Nat. Clim. Change 2024, 14, 331–339.

3. Taskforce on Nature and Nature Finance (TNNF). Global Nature Markets Landscaping Study. Taskforce on Nature and Nature Finance. 2022. Available online: https://www.naturemarkets.net/publications/global-nature-markets-landscaping-study (accessed on 5 November 2025).

4. West, T.A.; Wunder, S.; Sills, E.O.; Börner, J.; Rifai, S.W.; Neidermeier, A.N.; Frey, G.P.; Kontoleon, A. Action needed to make carbon offsets from forest conservation work for climate change mitigation. Science 2023, 381, 873–877.

5. Oprisan, O.; Pirciog, S.; Ionascu, A.E.; Lincaru, C.; Grigorescu, A. Economic Resilience and Sustainable Finance Path to Development and Convergence in Romanian Counties. Sustainability 2023, 15, 14221.

6. United Nations Environment Programme (UNEP). State of Finance for Nature: The Big Nature Turnaround—Repurposing $7 Trillion to Combat Nature Loss; United Nations Environment Programme: Nairobi, Kenya, 2023.

7. Flammer, C.; Giroux, T.; Heal, G.M. Biodiversity Finance. J. Financ. Econ. 2025, 164, 103987.

8. Taskforce on Nature and Nature Finance (TNNF). Nature in an Era of Crises; Taskforce on Nature and Nature Finance: London, UK, 2022; Available online: https://www.naturemarkets.net/publications/nature-in-an-era-of-crises (accessed on 5 November 2025).

9. Shao, S.; Ge, L.; Zhu, J. How to Achieve the Harmony Between Humanity and Nature: Environmental Regulation and Environmental Welfare Performance from the Perspective of Geographical Factors. Manag. World 2024, 40, 119–146.

10. Zhang, R. Promoting Common Prosperity through Ecological Environment Protection: Era Connotation, Value Connotation and Implementation Path. Guangxi Soc. Sci. 2023, 26–33.

11. Cui, Y.; Huang, Y.; Li, J.; Liu, H.; Jia, X.; Zhou, Y. Implementation Path of Collaborative Treatment of Rural Domestic Sewage in Beijing-Tianjin- Hebei in the New Era. Chin. J. Environ. Manag. 2025, 17, 30–39.

12. Guida-Johnson, B.; Zuleta, G.A. Riparian Rehabilitation Planning in an Urban–Rural Gradient: Integrating Social Needs and Ecological Conditions. Ambio 2017, 46, 578–587.

13. Zhang, Y.; Chen, Y.; Xiang, B. Evolution of integrated urban-rural development pattern and its influencing factors in the Yangtze River Delta urban agglomeration. Sci. Geogr. Sin. 2024, 44, 1955–1965.

14. Zhou, M.; Han, Y. Spatiotemporal Evolution, Influencing Factors, and Prediction of the Coupling Coordination between Urban-Rural Integration and Habitat Quality. Environ. Sci. 2026, 1–17, online ahead of print.

15. Yang, J.; Cui, X.; Zhang, G. Spatio-Temporal Evolution and Influencing Factors of Coupling Coordination Between Urban-Rural Integration and Carbon Emission in Urban Agglomeration in the Middle Reaches of the Yangtze River. Resour. Environ. Yangtze Basin 2024, 33, 2474–2487.

16. United Nations Environment Programme (UNEP). State of Finance for Nature: Restoration Finance Report. Growing the Green: Why and How Restoration Finance Needs to Quadruple by 2030; United Nations Environment Programme: Nairobi, Kenya, 2024.

17. RePlanet. Wildlife Biodiversity Credit Projects; RePlanet: San Francisco, CA, USA, 2025; Available online: https://www.replanet.org.uk/project/biodiversity-led-projects/ (accessed on 5 November 2025).

18. Krastev, B.; Krasteva-Hristova, R. Challenges and Trends in Green Finance in the Context of Sustainable Development—A Bibliometric Analysis. J. Risk Financ. Manag. 2024, 17, 301.

19. Belton, B.; Baldiga, L.; Justice, S.; Minten, B.; Narayanan, S.; Reardon, T. Can the global drone revolution make agriculture more sustainable? Science 2025, 389, 972–976.

20. Shapiro, J.S. The Environmental Bias of Trade Policy. Q. J. Econ. 2021, 136, 831–886.

21. Drupp, M.A.; Hänsel, M.C.; Fenichel, E.P.; Freeman, M.; Gollier, C.; Groom, B.; Heal, G.M.; Howard, P.H.; Millner, A.; Moore, F.C.; et al. Accounting for the increasing benefits from scarce ecosystems. Science 2024, 383, 1062–1064.

22. Li, N.; Li, Z. On Establishing Urban-Rural Ecological Governance Community under the Background of Rural Revitalization. Contemp. Econ. Manag. 2022, 44, 42–48.

23. Croci, E.; Lucchitta, B.; Cusa, M. Biodiversity credits schemes: A comparative analysis. J. Clean. Prod. 2025, 523, 146382.

24. Sun, Y.; Yang, Q.; Liu, J. Spatio-Temporal Evolution and Influencing Factors of Integrated Urban–Rural Development in Northeast China under the Background of Population Shrinkage. Buildings 2023, 13, 2173.

25. Trove Research. The Role of "Reduction" and "Removal" Projects in the Voluntary Carbon Market—An Economic Analysis; Trove Research: London, UK, 2023; Available online: https://www.msci.com/www/research-report/the-role-of-reduction-and/04832433783 (accessed on 5 November 2025).

26. Mao, X.; Wang, F. Reconstruction of Rural Environmental Governance System from the Perspective of Urban-rural Integration. J. Southwest Minzu Univ. (Hum. Soc. Sci. Ed.) 2022, 43, 190–196.

27. Zhong, Z.; Xie, D.; Zhai, Z. Strategic Orientation and Key Policies of China's Agricultural and Rural Modernization during "14th

Five-Year Plan". Jianghai Acad. J. 2021, 113–119+254.

28. Zhang, S.; Collins, A.R.; Etienne, X.L.; Ding, R. Environmental Effects of International Trade in China. Sustainability 2021, 13, 6895.