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BETWEEN ECOLOGICAL VALUE AND LOCAL INCOME: INSTITUTIONAL MEDIATIONS AND LIMITS OF THE FINANCIALIZATION OF NATURE IN THE AMAZON

ENTRE O VALOR ECOLÓGICO E A RENDA LOCAL: MEDIAÇÕES INSTITUCIONAIS E LIMITES DA FINANCEIRIZAÇÃO DA NATUREZA NA AMAZÔNIA

ENTRE EL VALOR ECOLÓGICO Y LOS INGRESOS LOCALES: MEDIACIONES INSTITUCIONALES Y LÍMITES DE LA FINANCIARIZACIÓN DE LA NATURALEZA EN LA AMAZONIA

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ABSTRACT

This theoretical and critical essay analyzes the wealth-poverty paradox in the Brazilian Amazon by investigating the epistemological limits of environmental economic valuation and the risks of exclusion associated with the financialization of nature. Moving away from claims of primary empirical modeling, the study is methodologically structured as a structured critical synthesis of secondary empirical evidence, integrating existing spatial econometrics, input-output, simultaneous equation systems, net present value simulations, and multi-criteria analyses from the literature. Grounded in the Capital Controversy, Amartya Sen's Capabilities Theory, and Ribot and Peluso's Theory of Access, we propose a novel conceptual framework based on three plans of value (ecological value, estimated value, and locally appropriable value) to explain the reproduction of regional poverty systems. The essay concludes that economic and market-based mechanisms are structurally insufficient and potentially exclusive unless subordinated to polycentric governance, customary land-tenure security, and distributive equity, positioning its scholarly contribution at the intersection of Ecological Economics and Regional Development.

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Keywords: Wealth-poverty paradox; Environmental valuation; Resource governance; Amazon basin; Institutional economics.

RESUMO

Este ensaio teórico-crítico analisa o paradoxo riqueza-pobreza na Amazônia brasileira, investigando os limites epistemológicos da valoração econômica ambiental e os riscos de exclusão associados à financeirização da natureza. Afastando-se de pretensões de modelagem empírica primária, o estudo estrutura-se metodologicamente como síntese crítica estruturada e triangulação de evidências empíricas secundárias, integrando análises disponíveis na literatura de econometria espacial, insumo-produto, sistemas de equações simultâneas, valor presente líquido e análise multicritério. Fundamentado na Controvérsia do Capital, na Teoria das Capacidades de Amartya Sen e na Teoria do Acesso de Ribot e Peluso, propõe-se um quadro conceitual baseado em três planos de valor (valor ecológico, valor estimado e valor localmente apropriável) para explicar a reprodução dos sistemas regionais de pobreza. Conclui-se que os mecanismos econômicos e de mercado são estruturalmente insuficientes e potencialmente excludentes, a menos que subordinados à governança policêntrica, à segurança da posse costumeira da terra e à equidade distributiva, situando-se a contribuição do ensaio na intersecção entre Economia Ecológica e Desenvolvimento Regional.

Palavras-chave: Paradoxo riqueza-pobreza; Valoração ambiental; Governança de recursos; Bacia amazônica; Economia institucional.

RESUMEN

Este ensayo teórico y crítico analiza la paradoja de la riqueza y la pobreza en la Amazonía brasileña mediante la investigación de los límites epistemológicos de la valoración económica ambiental y los riesgos de exclusión asociados con la financiarización de la naturaleza. Alejándose de las pretensiones de modelos empíricos primarios, el estudio se estructura metodológicamente como una síntesis

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crítica estructurada de evidencia empírica secundaria (integrando análisis de econometría espacial, matriz de insumo-producto, sistemas de ecuaciones simultáneas, simulaciones de valor presente neto y análisis multicriterio de la literatura). Con base en la Controversia del Capital, la Teoría de las Capacidades de Amartya Sen y la Teoría del Acceso de Ribot y Peluso, proponemos un marco conceptual basado en tres planos de valor (valor ecológico, valor estimado y valor apropiable localmente) para explicar la reproducción de los sistemas de pobreza regional. El ensayo concluye que los mecanismos económicos y de mercado son estructuralmente insuficientes y potencialmente excluyentes a menos que se subordinen a la gobernanza policéntrica, la seguridad de la tenencia consuetudinaria de la tierra y la equidad distributiva, posicionando su contribución académica en la intersección de la Economía Ecológica y el Desarrollo Regional.

Palabras clave: Paradoja de riqueza-pobreza; Valoración ambiental; Gobernanza de recursos; Cuenca amazónica; Economía institucional.

1. INTRODUCTION

The recent territorial dynamics of the Brazilian Amazon are characterized by a profound structural contradiction. Over the last few decades, the region has experienced accelerated population growth and urbanization, with the urban population ratio surging from 42% in 1960 to 71% in 2010 (Castelani, 2013). This transition reflects a rapid spatial reorganization, where the urban population of the region grew at an average rate of 4.5% per year over those five decades, despite persistent structural deficits in basic services and environmental quality. This significant socio-spatial rearrangement unfolds over the largest tropical forest on the planet, producing complex environmental and economic repercussions that are frequently overlooked by conventional applied economic analysis.

Urban expansion and population concentration directly affect land use and the regional productive structure. Studies based on inter-regional input-output models reveal an endogenous economic-environmental trade-off: the advancement of urbanization and the consumption of goods and services by households residing

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within the Amazon itself, particularly across its five largest metropolitan areas, accounts for significant portions of annual deforestation (Castelani, 2013). This urban dynamism coexists, however, with severe social and infrastructural deficits. While migratory flows with the rest of the country have reached an equilibrium, internal vegetative growth continues to fuel informal urban expansion, exposing vulnerable populations to critical environmental hazards such as recurrent floods and precarious sanitation, which is historically illustrated by sanitation deficits and epidemiological vulnerability in municipal centers (Mansur et al., 2016; Bruce et al., 2020).

In rural areas, the material reproduction of families and agricultural production still depend heavily on traditional resource-intensive practices, such as slash-and-burn systems. Although this technique is highly rational in the short term for smallholders, due to the microeconomic trade-off between free ash-based soil fertilization and land fallow (Morello, 2013), its perpetuation generates severe negative externalities on public health, air quality, and third-party properties, which are not internalized ex ante in individual land use decisions.

The persistence of structural barriers, such as severe credit constraints, a lack of adequate technical assistance, and highly asymmetric access to markets and logistics networks, drastically limits the transition to high-productivity, low-carbon alternative systems (Morello, 2013; Garrett et al., 2017). This gives rise to the wealth-poverty paradox in the Amazon: the coexistence of a vast global-scale stock of natural and ecosystem capital alongside persistent indicators of multidimensional poverty, precarious housing, and extreme social vulnerability (Nobre et al., 2019; Machado et al., 2023).

To unpack this paradox, this critical essay problematizes the dominant neoliberal conservation discourse that reduces sustainable development to environmental monetization and asset creation (such as carbon credits and PES), ignoring power relations and distributive asymmetries (Tulloch, 2016). We argue that Amazonian poverty is systematically reproduced within the disconnect between three distinct planes of value: intrinsic biophysical ecological value, estimated economic value, and the portion of value that is appropriable by local populations. In doing so, we define

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'neoliberal environmental regimes' by observable institutional characteristics: the primacy of market-based mechanisms over public provisioning, the creation of standardized tradeable assets, the transfer of biophysical risk to marginalized communities, and the subordination of customary rights to private ecological contracts.

2. LITERATURE REVIEW

2.1 Market Failures and the Epistemological Critique of Individualist Economics

Conventional economics conceptualizes environmental degradation and persistent rural poverty as temporary market failures correctable by assigning 'correct prices' to ecosystem services. However, the historical Capital Controversy, spearheaded by Joan Robinson and Piero Sraffa against Paul Samuelson and Robert Solow (Johnson, 2006), proved the theoretical impossibility of a purely technical, neutral theory of intertemporal capital valuation. Robinson and Sraffa demonstrated that capital valuation and profit determination depend on the sociological features of institutions, historical power relations, and distributional property rights, rather than individual preference curves.

When transposed to ecological economics, this critique reveals that the valuation of an environmental asset is never a neutral, technical exercise. Instead, it is fundamentally conditioned by pre-existing institutional structures, income distributions, and property rights. Neoliberal environmental policies that equate justice with market transactions fail to acknowledge these structural asymmetries, interpreting every real-world friction merely as a failure to implement the competitive ideal, rather than a direct consequence of the commodification process itself (Tulloch, 2016). This means that arbitrary choices of discount rates and capital aggregation methods cannot represent the non-substitutable nature of critical natural capital. This is not a technical debate, but an ontological conflict over the control of territorial assets.

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Amartya Sen's seminal work on the 1943 Bengal famine (Johnson, 2006) provides strong empirical backing for this limit. Sen demonstrated that starvation could occur amidst physical food abundance and rising aggregate supply when the entitlement structure is severely unequal and economic growth is accompanied by market speculation. Consequently, aggregate ecological metrics or abstract natural capital estimates cannot be treated as objective indicators of social welfare, as the very capacity of local populations to access and benefit from vital ecological flows is intrinsically dependent on political power relations, rather than aggregate ecosystem abundance.

2.2 Resource Dependency, 'Dutch Disease', and 'Resource Drag'

Macroeconomic literature on the 'resource curse' and 'Dutch disease' explains why natural resource abundance often fails to improve local welfare (Ansari, 2016; Bontems et al., 2015). Intensive commodity extraction tends to appreciate the real exchange rate, displacing capital and labor from diversified manufacturing and tradable agriculture into low-value-added services or extractive enclaves. This structural regression reduces long-term growth and exacerbates vulnerability to volatile international commodity markets.

At the regional scale, however, this model requires calibration. In the subnational context of the Amazon, Dutch disease does not operate through national currency appreciation. Instead, it manifests as a localized 'resource drag' or 'extractive enclave' mechanism (Alexander, 2014). Large extractive investments generate localized price inflation, crowding out traditional agricultural systems and causing high leakage of financial rents, where value-added is rapidly captured by urban elites and global supply chains (Gboyega et al., 2011). Centralized revenue distribution weakens the regional fiscal contract, encouraging rent-seeking and regulatory capture. This dynamic leads to the rapid depletion of natural capital to fund short-term consumption rather than reinvesting resource rents into local human capital (education and health) or diversified produced capital, directly violating the Hartwick Rule of intertemporal sustainability (Toto Same, 2009).

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2.3 Access Theory and the Neoliberal Discourse of Sustainability

Ribot and Peluso's Theory of Access distinguishes legal property rights from effective access, defined as the 'bundle of powers, capabilities, and relations' that allow actors to benefit from ecological resources (Ribot and Peluso, 2003). Studies in protected areas (Homewood et al., 2004) show that state-led ecological preservation often establishes highly centralized governance regimes that suppress the customary resource rights of traditional populations while redirecting tourism and conservation rents to politically connected local elites and foreign investors.

This dynamic territorial exclusion is actively legitimized by neoliberal reconfigurations of sustainable development. As Lynley Tulloch (2016) notes, the radical Third-World critiques of the 1970s and debates on biophysical limits to growth were co-opted and domesticated into a market-friendly framework. In the contemporary Latin American context, this manifests as 'green grabbing', where corporate pursuits of the 'bioeconomy of sociobiodiversity' conflict with customary land rights and displace peasant and indigenous communities (Ostrom, 2009; Young, 2006; Osborne et al., 2024).

This financialization of nature, through voluntary carbon offsets and ecosystem service assets, creates complex, bureaucratic accounting systems that entail high measurement, registration, and MRV costs. Consequently, remote, technically weak municipalities are pushed into informality or regulatory exclusion, while elite consultants and financial brokers capture the bulk of conservation funding, perpetuating the wealth-poverty paradox.

2.4 Three Planes of Value in the Amazonian Political Economy

To unpack this paradox, we propose an original analytical framework structured around three tensioned, asymmetric planes of value:

1. **Ecological Biophysical Value:** The intrinsic, complex qualitative wealth of the forest and its self-regulating biophysical functions that support the planet's biosphere. Under a strong sustainability paradigm, this value is heterogeneous, non-substitutable, and irreducible to monetary abstraction.

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2. **Estimated Economic Value:** The monetized value calculated through discount rates, PES, and REDD+ methodologies. This plane operates under weak sustainability assumptions, pretending that natural capital can be perfectly substituted by manufactured capital. However, Capital Controversy lessons show that this valuation is heavily conditioned by pre-existing power dynamics and arbitrary discount rates, thereby masking structural exploitation.
3. **Locally Appropriable Value:** The actual portion of material and financial wealth retained locally by traditional communities, riverine fishers, and peri-urban populations. This plane is blocked by logistical, bureaucratic, and territorial barriers (Ribot and Peluso, 2003).

We explicitly disaggregate the components of Locally Appropriable Value to avoid conceptual conflation. Retained monetary income refers to the cash flow effectively captured by local actors; material access to resources denotes the physical capacity to harvest, manage, and use ecological flows; customary territorial rights indicate the legal and institutional protections governing access to resource zones; and capabilities and human well-being capture the final conversion of these resources into freedoms, health, and social opportunities in Sen's sense. Frictions and blockages in access therefore prevent biophysical assets from Plane 1 and estimated monetary values from Plane 2 from being converted into concrete local capabilities in Plane 3.

These blockages do not operate in isolation; they form a self-reinforcing loop of institutional exclusion. Legal-territorial land insecurity prevents smallholders from obtaining formal registration (CAR), which creates a bureaucratic blockage to public credit (PRONAF). This credit exclusion forces smallholders to rely on local middlemen (*atravessadores*) for advance working capital and transport assets (logistical blockage), culminating in political dependency and debt-peonage (*aviamento*) that locks communities into low-value-added primary extraction.

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Table 1. Self-reinforcing mechanisms blocking local environmental income.

Blockage Mechanism	Conceptual Description	Specific Risk of Exclusion	Empirical Case Study
Logistical Blockage	Oligopolistic control of transport and cold storage assets by urban middlemen in isolated chains.	Asymmetric capture of commercial margins and suppression of local compensation.	Managed Pirarucu fishery chain in *Mamirauá* and *Uacari* (fishers retain only 16.6% of market value).
Bureaucratic Blockage	High transaction and compliance costs imposed by state registries, licensing, and complex MRV.	Invalidation of remote smallholders and municipalities whose administrative constraints push them into regulatory exclusion.	Complex compliance (DAP/CAF, CAR, and 80% Legal Forest Reserve) to access rural credit (PRONAF).
Financial Blockage	Barriers to accessing working capital, combined with structural dependence on credit under exogenous rules.	Concentration of green funding in capitalized peri-urban producers, preventing technological transition on frontiers.	Selection bias in the regional distribution of subsidized credit (PRONAF) and ecological fiscal transfers (Ecological ICMS).
Political Blockage	Asymmetric power relations and transactional dependence between local political elites and communities.	Capture of ecological funds by urban elites, diverting environmental resources to perpetuate structures of electoral dominance.	Agrarian and fishery clientelism in riverine communities and highly centralized decisions in the Amazon Fund.
Epistemic Blockage	Substitution and invisibilization of traditional knowledge and qualitative values by abstract market metrics.	Devaluation of ancestral community practices and imposition of exogenous technological standards.	Reduction of conservation to purely accounting criteria and voluntary corporate certification.
Legal-Territorial	Land-tenure insecurity and exclusion of customary resource rights justified by state or private preservation.	Forced displacement, land dispossession, and repression of subsistence productive activities.	Land conflicts in Protected Areas and analogies with coercive conservation (Ngorongoro/NCAA).

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3. METHODOLOGICAL DESIGN & EVIDENCE SELECTION

To ensure methodological transparency and avoid any false claims of primary authorship over the econometric estimations, we explicitly present this study as a theoretical-reflective essay based on a structured synthesis of secondary empirical evidence. We do not perform primary data collection or original statistical estimations. Instead, we select, analyze, and systematically integrate five seminal quantitative models from the literature, treating them as a coherent empirical corpus. This allows us to contrast abstract policy goals with concrete local territorial dynamics.

The corpus was established through a structured search in Scopus, Web of Science, and the CAPES Theses Database. The search strategy utilized the keywords 'Amazon', 'transaction costs', 'spatial econometrics', 'deforestation', 'access theory', and 'smallholder credit', covering studies published between 2000 and 2026. Studies were selected based on three criteria:

(i) rigorous use of georeferenced microdata or regional macro-matrices in the Amazon region;

(ii) explicit focus on the socio-spatial frictions of the low-carbon transition;

(iii) peer-reviewed or doctoral-level validation.

Studies lacking spatial dimensions or focusing purely on biophysical parameters without socio-economic feedback loops were excluded. Five seminal works were chosen as the analytical pillars of this synthesis, as detailed in Table 2.

Table 2. Analytical fronts and secondary models mobilized in the synthesis.

Analytical Front	Secondary Model & Estimator	Data Scale	Primary Sources	Key Variables	Application in This Essay
Spatial Modeling	General Nesting Spatial (GNS) SARAR GMIV	Municipal (645 municipalities of the Legal Amazon)	Castelani (2013)	Wy, WX, Wξ (Spatial autoregressive effects)	Synthesized to evaluate the relationship between urbanization and economic growth.

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Input-Output Matrix	Inter-regional Leontief Input-Output Matrix with land use vectors	Regional / Metropolitan (Five largest MAs)	Castelani (2013)	Deforestation coefficient: AGR_DC, LIV_DC	Synthesized to track how final household demand indirectly drives deforestation.
Systems of Equations	Seemingly Unrelated Regression (SUR) Estimator	Agricultural Lot / Farm Establishment	Morello (2013)	Simultaneous land allocation and agricultural fire notifications	Synthesized to evaluate microeconomic land allocation and spatial fire interactions.
Net Present Value	NPV Financial Simulation with Spatial Transaction Costs	Smallholder Family Farm	Morello (2013)	Farmgate price: Pp = Pm - t*d; Input cost: Pi = Pm' + t'*d	Synthesized to evaluate financial attractiveness of fire-free transition under transport friction.
Multi-Criteria Analysis	Analytic Hierarchy Process (AHP) Weighting Method	Submunicipal / Intraurban (Amazon Delta/Estuary)	Mansur et al. (2016)	Vulnerability Index: Infrastructure, Sensitivity, Exposure	Synthesized to map socio-ecological vulnerability in estuarine zones with focus on sanitation.

3.1 Municipal Spatial Econometric Modeling

To evaluate how urbanization and municipal economic growth interact while controlling spatial dependencies across the Amazon, we mobilize the results of Castelani (2013), who utilized a General Nesting Spatial (GNS) model. This specification allows the simultaneous analysis of spatial lags in the dependent variable, exogenous spatial interactions, and spatial autocorrelation in the residuals (following Punzo et al., 2022):

$$y = \rho Wy + X\beta + WX\theta + \xi \quad (1)$$

$$\xi = \lambda W\xi + \varepsilon \quad (2)$$

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In these equations, originally estimated by Castelani (2013), W is a row-standardized spatial weight matrix based on the Euclidean distances between municipal urban centers. To address potential simultaneity between the spatial lag Wy and the error terms, the author applied the robust SARAR GMIV estimator based on Generalized Spatial Two-Stage Least Squares (GS2SLS), utilizing spatial lags of exogenous covariates as instrumental variables.

3.2 Inter-regional Input-Output Model (IO)

To track how consumption patterns within the Amazon metropolitan areas affect the agricultural frontier, we integrate the inter-regional Leontief Input-Output model developed by Castelani (2013). This model couples intersectoral trade matrices across Brazilian regions with sector-specific deforestation vectors. This framework allows the calculation of direct and indirect land-use change coefficients, specifically focusing on the final demand of households residing in the five largest metropolitan areas of the Legal Amazon.

3.3 Systems of SUR Equations

To analyze the simultaneous decisions of smallholders regarding agricultural land-use and the use of fire under spatial risks, we mobilize the microeconomic framework of Morello (2013). This model uses an Iterated Seemingly Unrelated Regression (SUR) system to analyze georeferenced lot-level microdata in Santarém, Belterra, and Paragominas, testing how historical accidental damage or perceived fire risks from neighboring lots of shape individual farming strategies.

3.4 Net Present Value (NPV) and Spatial Transaction Costs Modeling

To evaluate the financial feasibility of transitioning to fire-free farming systems (e.g., using mechanized land preparation instead of slash-and-burn), we adopt the NPV simulation model developed by Morello (2013). The model incorporates labor opportunity costs and spatial transaction costs, modeling the local net farmgate price (Pp) and the agricultural input cost (Pi) as linear functions of geographical distance (d) to the nearest urban market center:

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$$P_p = P_m - t \cdot d \quad (3)$$

$$P_i = P_m' + t' \cdot d \quad (4)$$

In these equations, originally formulated by Morello (2013), Pm and Pm' are prevailing urban market prices, and t' represent spatial transport costs per kilometer for products and inputs respectively.

3.5 Multi-Criteria Territorial Vulnerability Index (VI)

To address submunicipal socio-ecological vulnerability, we integrate the Analytic Hierarchy Process (AHP) index developed by Mansur et al. (2016). The index synthesizes biophysical flood exposure with socio-economic sensitivity and infrastructure quality, applying the following weighting vector:

$$VI = 0.7 \cdot Infrastructure + 0.2 \cdot Sensitivity + 0.1 \cdot Exposure \quad (5)$$

This weighting, originally validated by Mansur et al. (2016), reflects the primary role of infrastructure deficits and sanitational sensitivity in determining the vulnerability of estuarine communities.

4. RESULTS AND DISCUSSION

4.1 Logistical Asymmetry and Margin Capture: The Case of Managed Pirarucu

The disconnect between potential ecological assets and local well-being is illustrated by the managed pirarucu fishery (Arapaima gigas) in the estuarine and floodplain complexes of Mamirauá and Uacari (Bartkus et al., 2021). Microdata from 2018 reveals that local fishers capture only about one-sixth (16.6%) of the final market value of the fish. Monopolistic control over transport and cold-storage assets by urban middlemen (*atravessadores*) drives this highly unequal distribution. Urban intermediaries operate large refrigerated vessels, capitalizing on extreme tropical humidity, prohibitive local fuel costs, and the lack of decentralized ice factories. This creates an insurmountable barrier for isolated fishers, allowing intermediaries to cartelize prices during annual planning meetings in Tefé that exclude local producers.

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The causal role of logistical barriers in perpetuating poverty was illustrated by the 2018 impact evaluation of an intervention by the Amazonas Sustainable Foundation (FAS) (Bartkus et al., 2021). Financed by Bolsa Floresta funds, refrigerated transport boats were acquired for associations of 8 to 10 communities in selected sustainable use reserves. Econometric results showed that overcoming this logistical barrier significantly increased local net incomes and reduced transport costs, without requiring an increase in fishing hours or an expansion of pressure on natural fish stocks. The community boat directly reduced spatial transaction costs, breaking the middleman's oligopolistic capture and showing how community-scale logistical integration is a pre-condition for local value retention.

4.2 Productive Asymmetry in Family Farming and Barriers to High-Value Markets

A similar exclusion mechanism operates in family farming in the eastern Amazon. High-value crops (such as citrus, black pepper, and fresh vegetables) can generate financial returns up to 10 times higher per hectare than traditional manioc (Garrett et al., 2017). However, adoption is highly concentrated in peri-urban areas close to road axes. In remote areas lacking cold storage and transport infrastructure, transport friction absorbs any potential profits, forcing smallholders back into slash-and-burn manioc or extensive cattle ranching, which are the only land uses that tolerate poor logistics and long transport times. This is why we must avoid treating 'rural populations' as a homogeneous group: peri-urban smallholders have different market access, capital accumulation, and risk profiles compared to isolated riverine communities and indigenous populations.

4.3 Bureaucratic Barriers and Administrative Exclusion in Rural Credit (PRONAF)

Even when state-subsidized credit instruments like PRONAF are introduced (offering nominal interest rates of approximately 1% to 4% per year during the study period), administrative barriers exclude the most vulnerable producers (Garrett et al., 2017). Accessing these funds requires obtaining a Declaration of Aptitude (DAP/CAF),

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enrollment in the Environmental Rural Registry (CAR), and proving compliance with the Forest Code's 80% Legal Reserve requirement. Remote smallholders and indigenous communities facing geographic isolation and lacking technical support cannot afford the georeferencing and administrative costs of compliance, resulting in an institutional selection bias where peri-urban capitalized farmers capture green credit.

4.4 Limits of Financialization and the Governance of Externalities

Neoliberal conservation agendas propose addressing environmental degradation in the Amazon by expanding markets for intangible environmental assets, particularly REDD+ carbon credits and payments for ecosystem services (Tulloch, 2016). This approach assumes that the monetization of ecological functions can generate efficient preservation incentives and channel voluntary funding toward remote communities. However, the argument requires a clearer institutional distinction among related but different processes. Environmental valuation refers to the analytical estimation of non-market ecological values; commodification involves the creation of standardized and tradable units; assetization transforms such units into financial assets; and financialization integrates these assets into broader circuits of global capital. By contrast, PRONAF, as a public rural credit policy, and the Ecological ICMS, as an intergovernmental fiscal transfer that redistributes tax revenues according to conservation criteria, are state-mediated mechanisms rather than market-traded environmental assets. Treating these instruments as part of a single financialization process would obscure their distinct institutional logic, even though all of them may reproduce exclusion when administrative capacity, distributive safeguards, and local participation are weak (Ostrom, 2009; Verde Selva et al., 2019).

4.5 Fire Use as a Microeconomic Rationality and Coasian Ineffectiveness

The persistence of slash-and-burn agriculture illustrates how coordination and enforcement failures undermine purely market-based solutions (Morello, 2013). For smallholders, fire is an indispensable, low-cost technical tool. Burning secondary vegetation provides rapid, free fertilization with phosphorus and potassium from ash,

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bypassing commercial chemical inputs while minimizing the need for mechanical labor in the context of a scarce family labor force. SUR models estimated by Morello (2013) show that past accidental damage or future risk does not systematically alter fire allocation decisions.

The Coase Theorem posits that, with well-defined property rights and zero transaction costs, private bargaining would resolve such externalities. A potential victim would pay the burning neighbor up to the expected loss threshold to adopt a fire-free alternative. In the Amazon, however, this model collapses due to three factors:

(i) high transaction and monitoring costs across geographic distances;

(ii) information asymmetries and wind volatility making it impossible to predict or prove fire origins;

(iii) weak state enforcement of controlled burning laws. While informal neighbor notification agreements exist (used by 78% of farmers in the sample of Morello, 2013), they are insufficient to prevent the widespread spread of accidental fires or to compensate the poorest victims (Morello, 2013).

This Coasian failure has profound implications for global conservation markets. If private bargaining fails to resolve a visible, local physical externality due to transaction costs and information asymmetries, global carbon markets and REDD+ contracts face even higher hurdles. Their complex MRV requirements concentrate revenue among financial intermediaries and consultancies while transferring biophysical constraints and land-use limits onto local populations, indicating a structural limit of market-based governance.

4.6 Zoning and Exclusion Risks in Carbon Governance

Carbon financialization reproduces these power asymmetries at the international level. Territories with high ecological value but weak technical and administrative capacities are excluded from global conservation funding due to complex auditing requirements. Heuristically, the classic case of the Ngorongoro Conservation Area Authority (NCAA) in East Africa (Homewood et al., 2004) serves as an illustrative external case of coercive conservation. In Ngorongoro, high conservation and

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ecotourism revenues coexist with extreme marginalization and violent dispossession of local populations. The NCAA restricts local participation and grazing rights, channeling revenues into paramilitary enforcement, while funding for local education, health, and sanitation remains far below national averages.

Environmental zoning and carbon offsets thus run the risk of functioning as 'green grabbing', where ecological values are translated into global corporate assets while the traditional communities that coproduced these ecosystem services are reduced to passive recipients of restrictions or are violently displaced (Homewood et al., 2004; Tulloch, 2016; Osborne et al., 2024). Without polycentric, participatory governance and robust safeguards, financialization functions as a neo-colonial extractive cycle that drains resource rents from the periphery to benefit global-center bureaucracies. While this external case is not a direct equivalent of Amazonian reserves, it serves as a critical warning of what happens when conservation is separated from human rights and customary tenure.

5. CONCLUSION & POLICY PROPOSITIONS

This critical essay analyzed the mechanisms underlying the wealth-poverty paradox in the Brazilian Amazon. Far from constituting a transient market failure corrigible by simple pricing adjustments, the Amazonian poverty system is a durable, structurally reproduced configuration maintained by the systematic disconnect between potential ecological assets and the portion of value retained locally by traditional and urban communities. Breaking this cycle of regional poverty requires abandoning the exclusive focus on market-based environmental pricing and implementing four coordinated policy propositions:

1. **Strengthen local administrative capacity:** Build technical capacities in municipal governments to enable the equitable and transparent distribution of ecological fiscal transfers, such as the Ecological ICMS (Verde Selva et al., 2019).
2. **Redesign and simplify financial engineering:** Replace complex, bureaucratic credit requirements (such as DAP/CAF and CAR) with direct municipal

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contracting, small interest-free micro-loans, and decentralized technical support adapted to remote rural realities (Garrett et al., 2017).

3. **Participatory governance and customary land tenure:** Establish polycentric, multi-scalar governance networks with binding safeguards for free, prior, and informed consent (FPIC), while prioritizing collective and customary land-tenure security over simple individual property titling, ensuring that traditional populations act as active decision-makers and the primary beneficiaries of conservation efforts (Torralba et al., 2023).
4. **Integrate mixed-use logistical infrastructure:** Support smallholder value chains by investing in small-scale refrigerated transport, decentralized clean energy, and community processing units, coupled with structural investments in urban sanitation and basic infrastructure to reduce socio-ecological vulnerability (Bartkus et al., 2021; Mansur et al., 2016).

These propositions should be treated as policy recommendations derived logically from our structural synthesis, rather than empirically validated solutions. Their practical effectiveness and ethical legitimacy are strictly contingent on the pre-existence of robust distributive safeguards, polycentric governance, land tenure security, and community sovereignty over monitoring data. Accounting models cannot substitute for public investments, state capacity, and the guarantee of historical territorial rights. Only by subordinating market tools to equity and democratic land planning can the Amazon's immense biophysical wealth be transformed into social emancipation and well-being for the populations that keep the forest standing.

5.1 Limitations and Territorial Heterogeneity

Finally, we must reject any homogenizing view of the region as a single socio-ecological system. The Legal Amazon is a highly diverse mosaic, characterized by three distinct territorial segments with unique dynamics, actors, and policy needs:

1. **The Urban Amazon:** Areas of rapid vegetative growth and informal urban sprawling, characterized by extreme sanitation, water, and housing deficits (such as the metropolitan areas of Belém and Manaus) (Castelani, 2013; Mansur et al.,

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2016). In these areas, the focus must be on municipal public investment and basic infrastructure.

2. **The Riverine and Extractivist Amazon:** Territories inhabited by traditional riverine populations where livelihood security depends on communal resource management and fisheries, which oligopolistic logistical intermediaries in floodplain reserves currently frustrate (Bartkus et al., 2021). Here, the focus must be on municipal contracting, customary rights, and collective logistics.
3. **The Agricultural and Commodity Frontier Amazon:** Areas shaped by large-scale cattle ranching, grain cultivation, and logging frontiers (such as southern Pará), which suffer from acute land disputes, deforestation pressures, and agricultural fire conflicts (Morello, 2013; Garrett et al., 2017). In this segment, the focus must be on strict land regulation, enforcement of the Forest Code, and the provision of technical alternatives to agricultural fire.

The effectiveness of any ecological policy is inseparable from this spatial segmentation, requiring all regulatory and financial designs to be strictly calibrated to the land tenure and socio-economic peculiaries of each sub-region, under pain of deepening territorial and social inequalities.

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