C3A Annual Symposium
December 2-6, 2024
World Bank Paris

Research Segment

Session 2 - Nature- and Resource-related Transition Risks

Chaired by Jenifer Zungu (SANBI) & Jeffrey Althouse (WB/C3A)

C3A, a program founded and hosted by WORLD BANK GROUP

Session Outline

Presentations (10 mins)

- Concentration of critical mining assets and the geoeconomic fragmentation
    - Hugo Lapeyronie (University of Paris 1), et al.
- Assessing Integrated Assessment Models for Building Global Nature-Economy Scenarios
    - Nepomuk Dunz (World Bank), et al.
- The economic and financial risks of implementing the '30x30' Global Biodiversity Framework targets
    - Katie Kedward (UCL IIPP WB/C3A), & Adam Poupard
- Nature-Related Transition Risks and The Climate-Nature Nexus: an Assessment of Capital Stranding Exposure and Financial Vulnerability in Brazil
    - Gabriel Santos Carneiro (IUSS Pavia), et al.

Discussion (2-5 mins) / Q&A (2-5 mins)

- Gabriel Santos Carneiro (Discussant)
- Hugo Lapeyronie (Discussant)
- Nepomuk Dunz (Discussant)
- Katie Kedward (Discussant)

C3A Annual Symposium
December 2-6, 2024
World Bank Paris

Concentration of critical mining assets and the geoeconomic fragmentation

Authors:

Hugo Lapeyronie, World Bank and Université Paris 1 Panthéon-Sorbonne
Etienne Espagne, World Bank and Université Clermont-Auvergne
Gregor Semieniuk, World Bank and University of Massachusetts Amherst

Contact: hlapeyronie@worldbank.org

Motivations

- **Rising Demand of critical minerals:** The energy transition requires a significant increase in critical mineral supply, necessitating the opening of many new mines.

- **Geographic Concentration:** Production of critical minerals is heavily concentrated (IEA, 2021, 2024).

- **Geo-economic fragmentation:** The global economy faces rising "blockization," with heightened risks of division and potential trade wars, especially with the recent US election.
  - Green industrial policies and protectionism increasingly target critical minerals (see graphs).

Limitations in Current Concentration Studies: Existing studies focus primarily on geographic concentration and overlook critical dimensions of ownership and control structures:

- **Leruth et al. (2022) and Sun et al. (2024):** Examine market concentration from both geographic and equity ownership perspectives.
- **Prina Cerai (2024):** Conduct deep supply chain analyses of lithium, revealing intricate connections between mining companies, investors, and end clients.

Key Gap: Ownership Concentration and Geopolitical Implications

➢ No comprehensive research has yet explored the ownership concentration across various critical minerals and analyzed the geopolitical risks.

Figure 1: Evolution of the number of national strategic policies on critical minerals

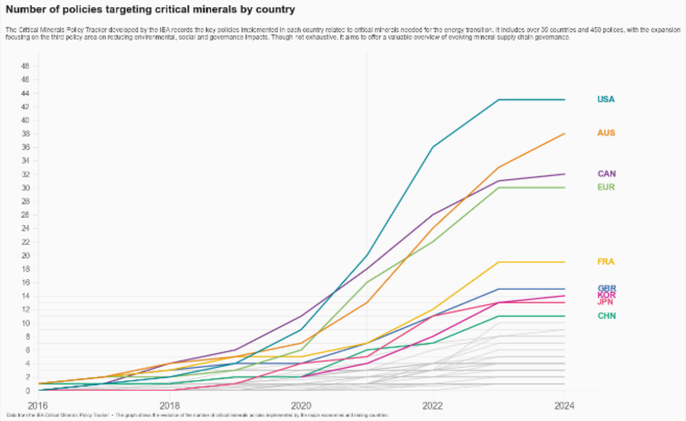
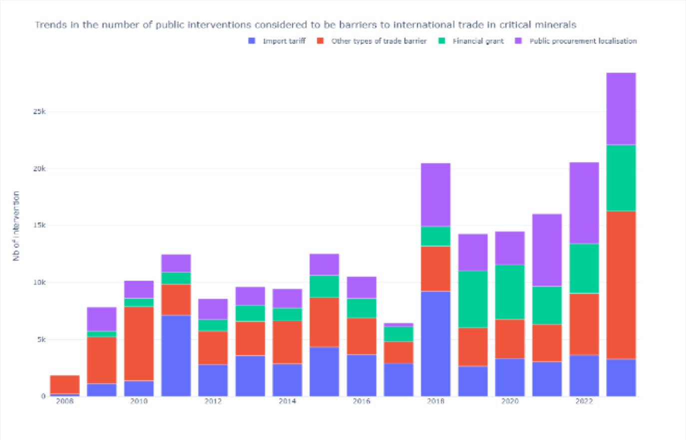


Figure 2: Evolution of the number of trade barriers targeting critical minerals



Methodology

Data

Data on mining assets provided by S&P Metals & Mining (mid 2023):

- ➔ **2142 mining assets** with their location, production level, reserves and ownership.
- ➔ Ownership of mining companies and of any other entities that may have some shares in a mining asset (Car makers, refining companies…).
- ➔ Maximum of ten owners collected by Ownership layers.

Market concentration indicator

We rely on the widely recognized as the standard for measuring market concentration:

$$HHI_m = \sum_{i=1}^{N} S_i^2$$

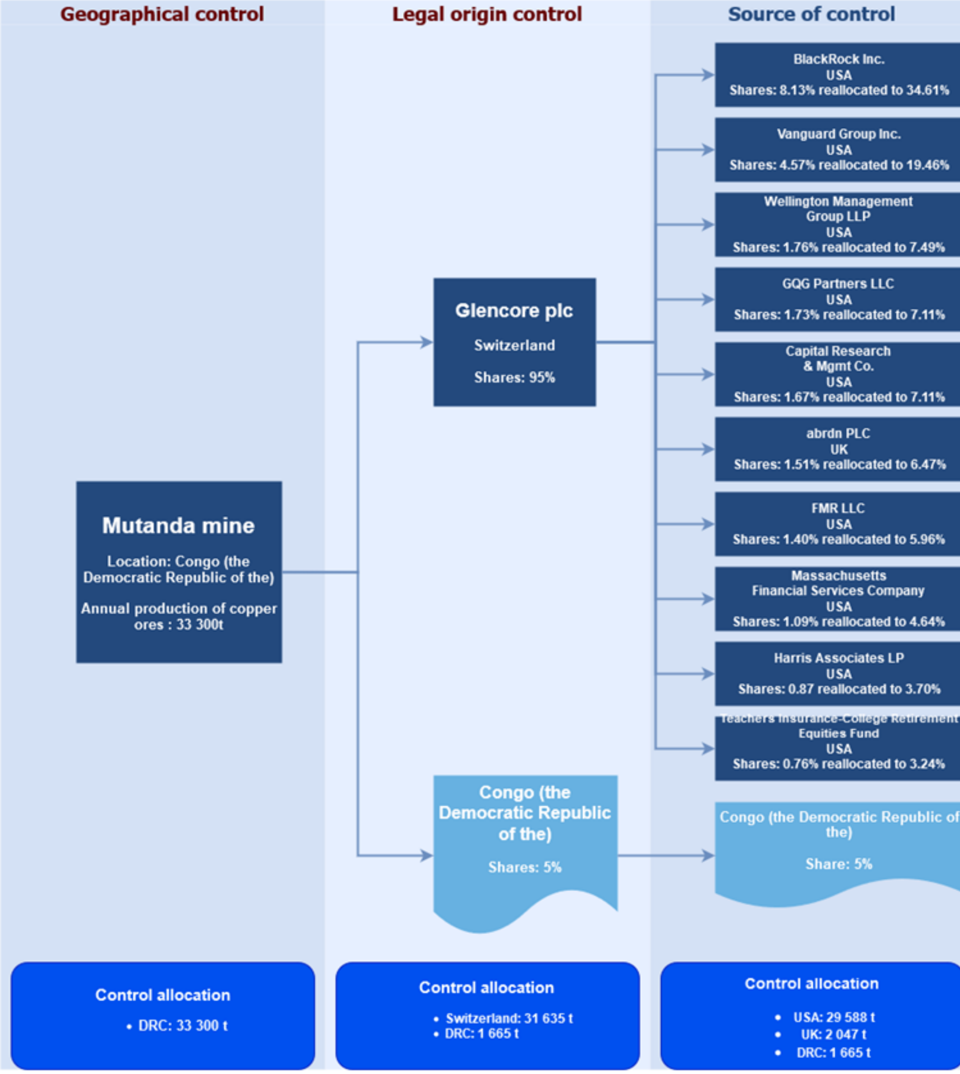
With S_i^2 the squared number of shares of country i in the production of critical mineral m and N the total number of countries on that market.

DoJ (2010) threshold to determine market concentration set to **2500** (10 000 would indicate a monopolistic market).

Defining and assigning control over mining production

Three different assumptions of the control over the production of a mining asset:

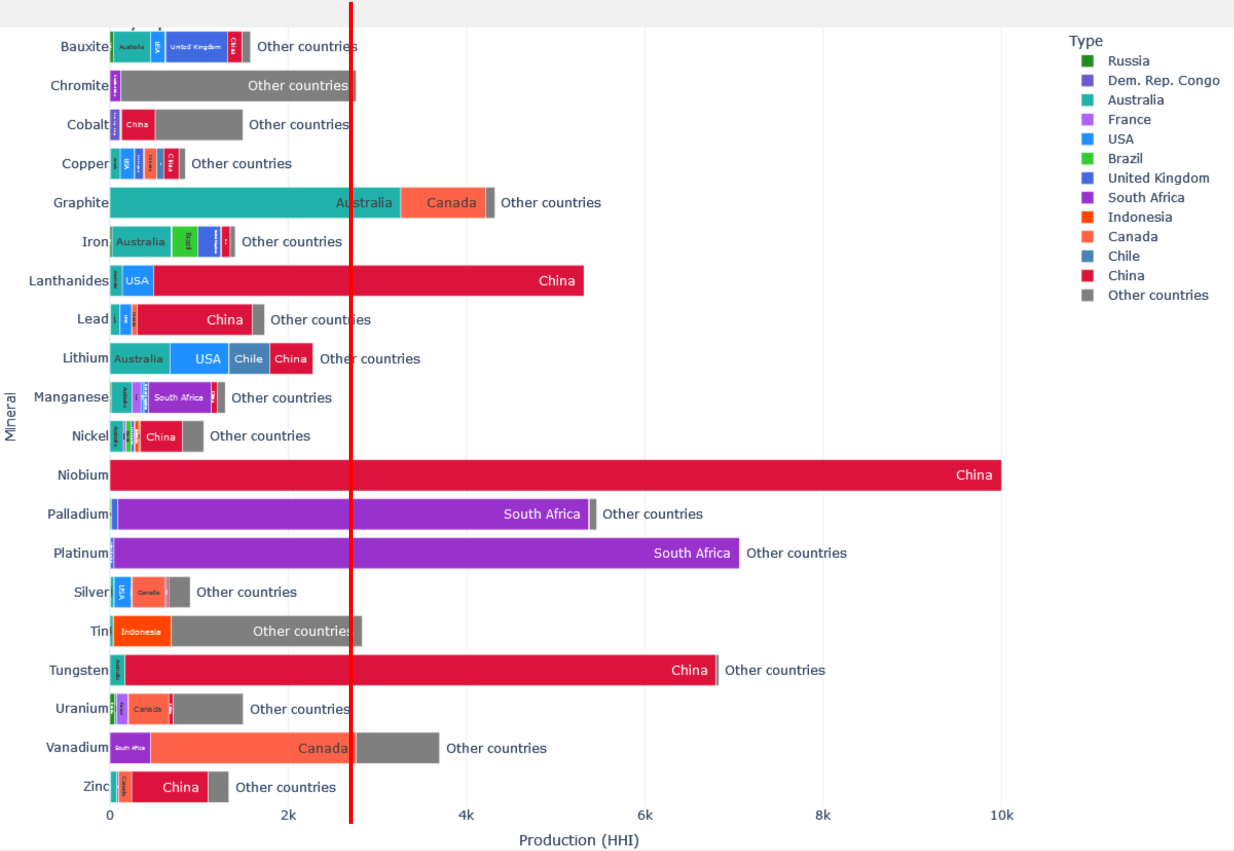
- **Geographical control:** Production of critical minerals is attributed to the country hosting the mine.
- **Direct ownership/Legal origin**: The production of critical minerals is divided between mining companies according to their share in each mining asset.
- **Equity ownership/Source of control:** The production of critical minerals is attributed to the institutional shareholders of the mining companies that control these mining assets.



Geographic HHI - Decomposition by Country

- **Average HHI score for critical mineral production: 3478**
- On average, the concentration of critical mineral producers is **high**, in line with the rest of the literature.
- Production of critical minerals is geographically concentrated in **groups of countries that vary with each mineral.**

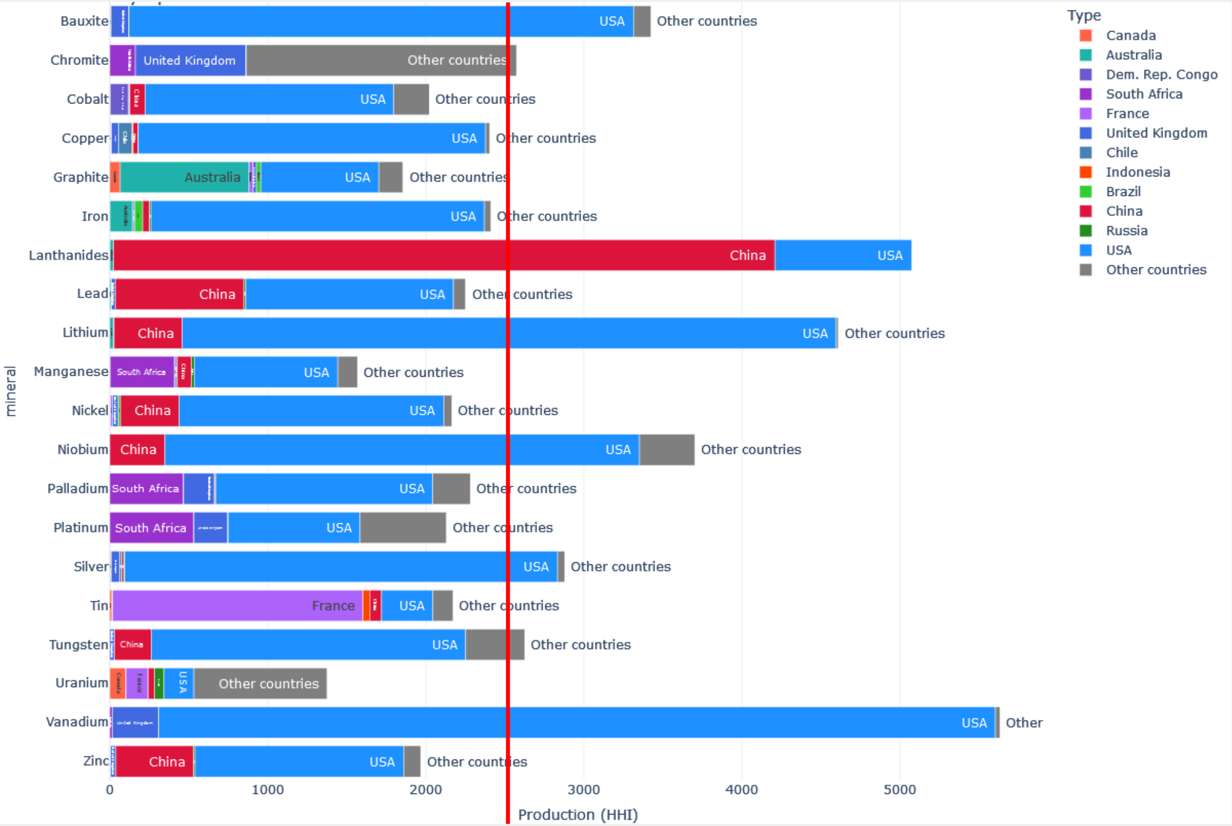
Direct ownership HHI - Decomposition by Country



Average HHI score for critical mineral production: 3183

- On average, the concentration of critical mineral producers is **high, but lower than in the geographic approach.**
- The direct ownership approach **reduces the risk of producers concentration for some critical minerals**. (Ex: Cobalt)
- **But reduces the variety of producers**. Domination of BRICS and Anglo-Saxon countries (except USA). Two “opposite blocks…”

Equity ownership HHI - Decomposition by Country



- **Average HHI score for critical mineral production: 2754**
- On average, the concentration of critical mineral producers is **high, but close to the market concentration threshold.**
- The equity ownership approach drastically reduces **the average** market concentration but shows significant American and Chinese dominance.
- Domination of financial institutions that have massively invested in mining companies.

Assessing the risks related to geoeconomic fragmentation

The HHI alone cannot account for the variation in geopolitical risk between producers.

Previous literature has sometimes weighted the HHI with governance quality indicators to assess the geopolitical risk associated with the failure of a key producing countries.

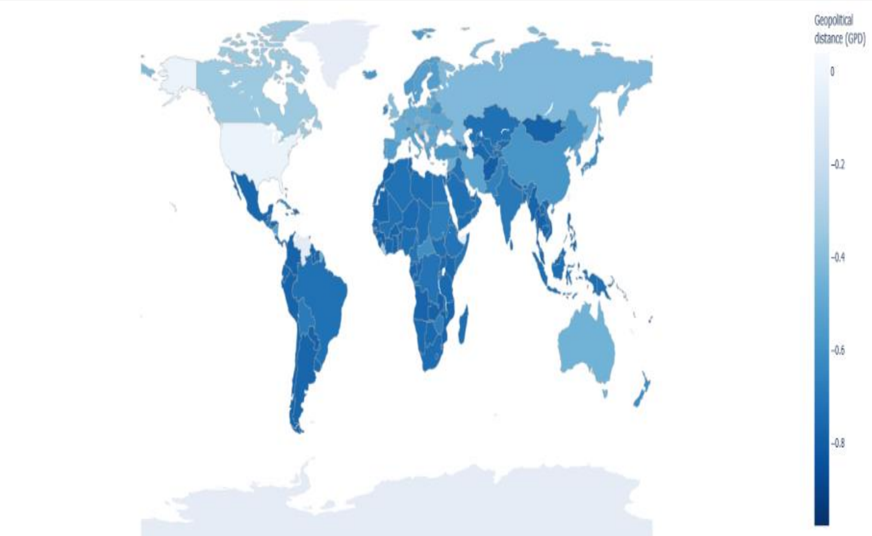
- **But this approach is not helpful to integrate the risks related to the geo-economic fragmentation**

Following Aiyar et al., (2023) we develop a proxy for Geopolitical Risk based on the average **Geopolitical Distance** of countries:

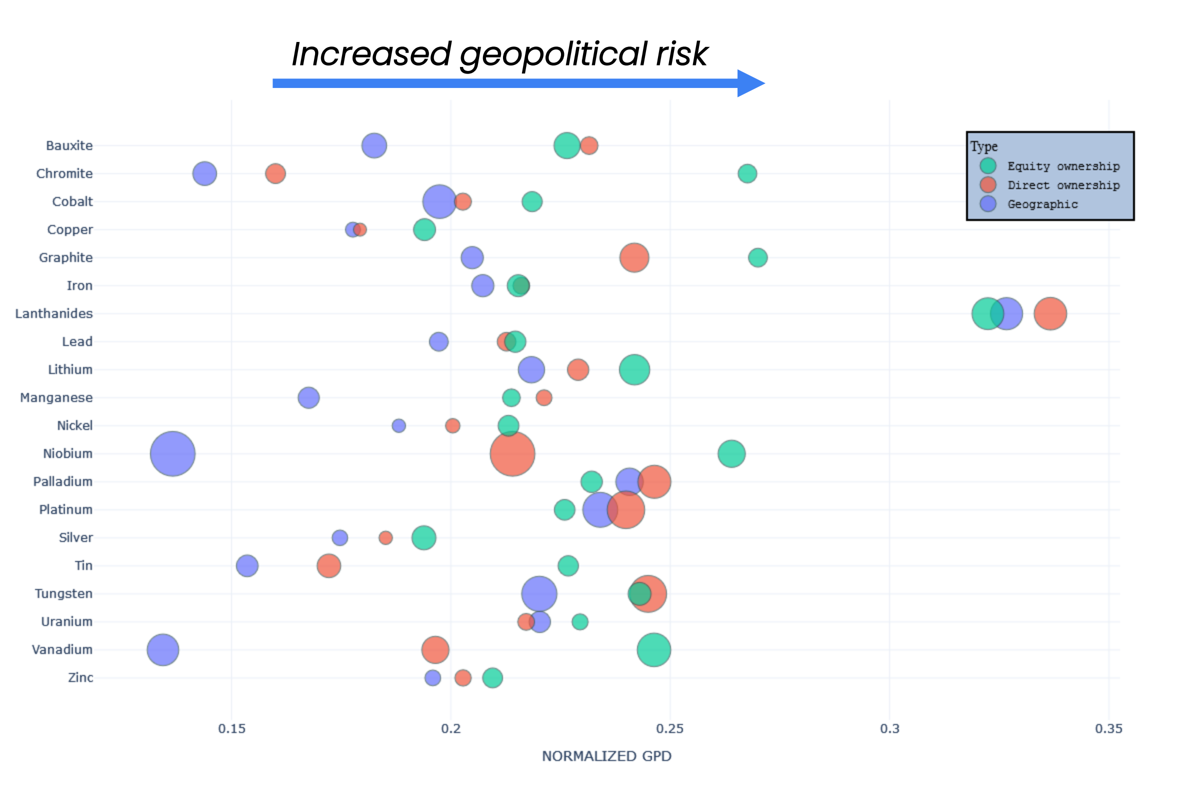
$$GPD_{a,b} = -1 \times \left[1 - \frac{\sum_v (X_{av} - X_{bv})^2}{\frac{1}{2}\sum_v (d_{max})^2}\right]$$

- Where Xav denotes voting behavior (v) of country a and Xbv the voting behavior (v) of country b in the UN.
- X refers to votes (yea=1, abstain=2, and nay=3),
- $dmax$ stands for the maximum possible distance between the country pairs (which is 3–1=2 in this case).

Average Geopolitical Distance of countries



Assessing the risks related to geoeconomic fragmentation



Two dimensions of risk:

- Size of the bubble, producer concentration
- X-axis, average geopolitical distance (GPD) between countries controlling mining production.

➢ By assigning control over production to the ownership, we observe **more geopolitical risk for most critical minerals**.

Ex: For Bauxite, geopolitical risk is higher when control over production is assigned to the mine direct and equity ownership ownership.

Conclusion

- Assigning control over production to the ownership **decreases the average concentration of critical mineral producers… but increases the geopolitical risk.**
- Direct and equity ownership of critical mineral assets is largely dominated by **multinational mining companies** and **financial institutions based in leading economies**.
- This dynamic raises two critical issues:
  - **Missed Opportunities for Developing Economies:** Significant economic benefits often **escape** from host countries to foreign stakeholders.
  - **Accountability Challenges:** It is more difficult to held accountable mining companies when their headquarters and majority owners are located in different jurisdictions.
- **Potential Vulnerability of Leading Economies:** Leading economies may be more exposed than expected to downturns in critical mineral markets. For example, a **bust** in the cobalt market could disproportionately impact these countries due to concentrated equity interests.

C3A Annual Symposium
December 2-6, 2024
World Bank Paris

Thank you

C3A, a program founded and hosted by WORLD BANK GROUP

Q&A
Discussion

C3A Annual Symposium
December 2-6, 2024
World Bank Paris

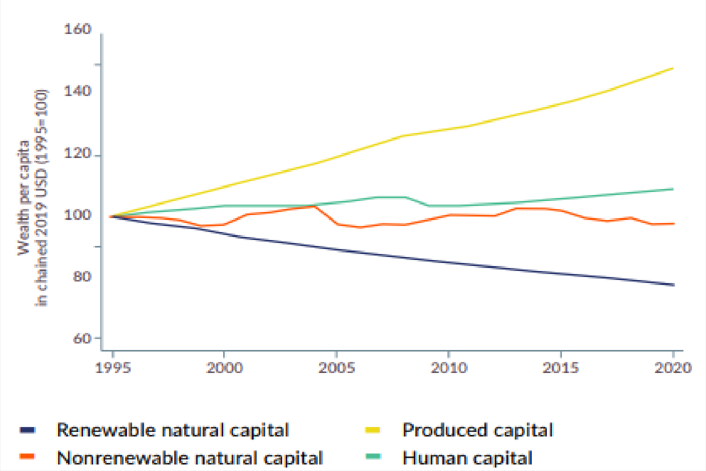
Assessing Integrated Assessment Models for building global nature-economy scenarios

Mathilde Salin, Katie Kedward, Nepomuk Dunz

Contact: ndunz@worldbank.org | LinkedIn profile: Nepomuk Dunz

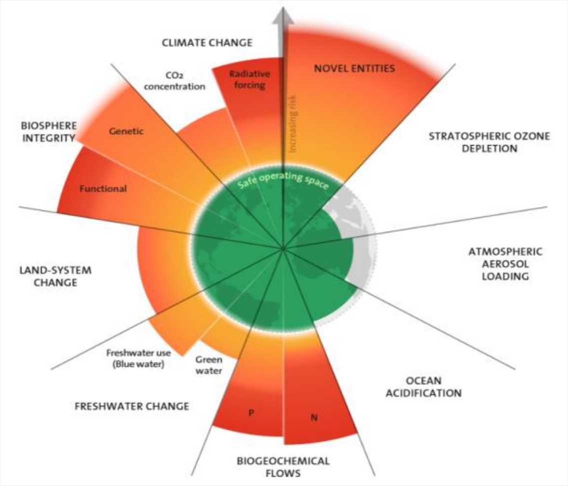
Environmental issues are rapidly growing across the world

Trends in global wealth per capita, by asset category, 1995–2020 (1995=100)



Source: [World Bank 2024]

6 of 9 of planetary boundaries are already crossed suggesting that Earth is now well outside of the safe operating space for humanity.

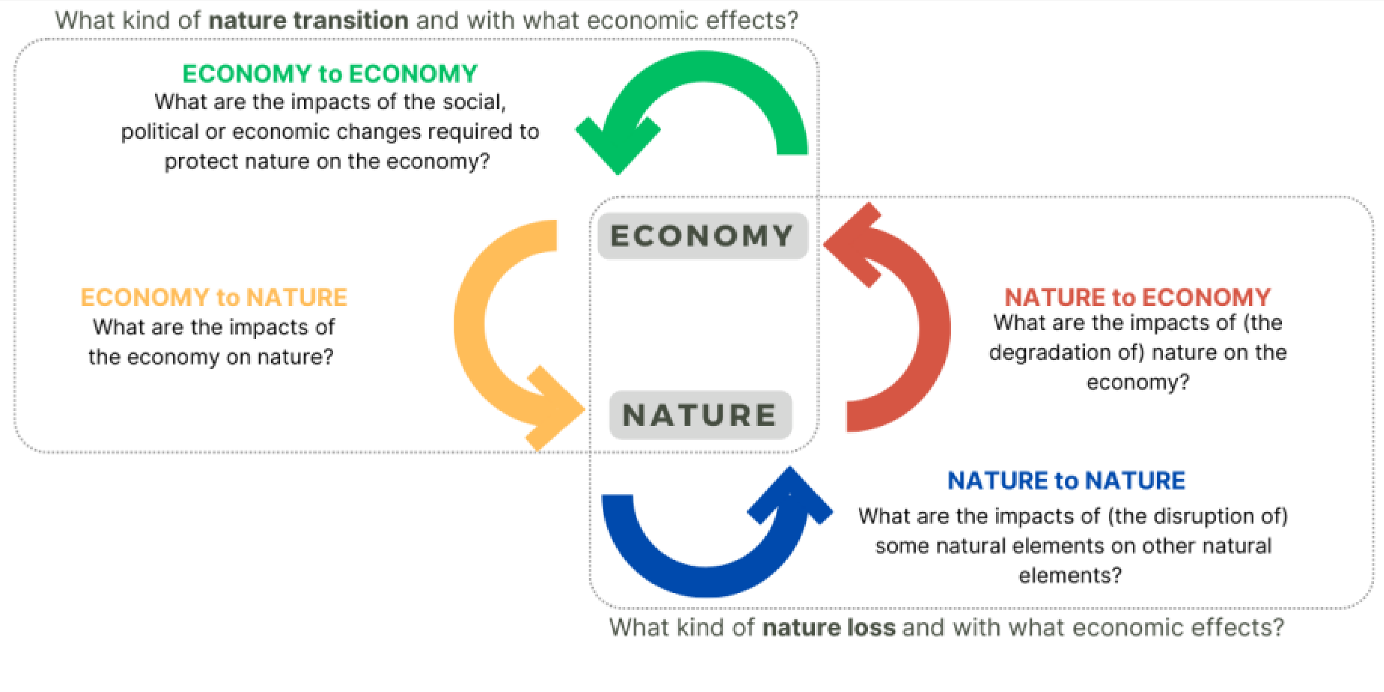


Source: [Richardson et al. (2023)]

Paper contribution

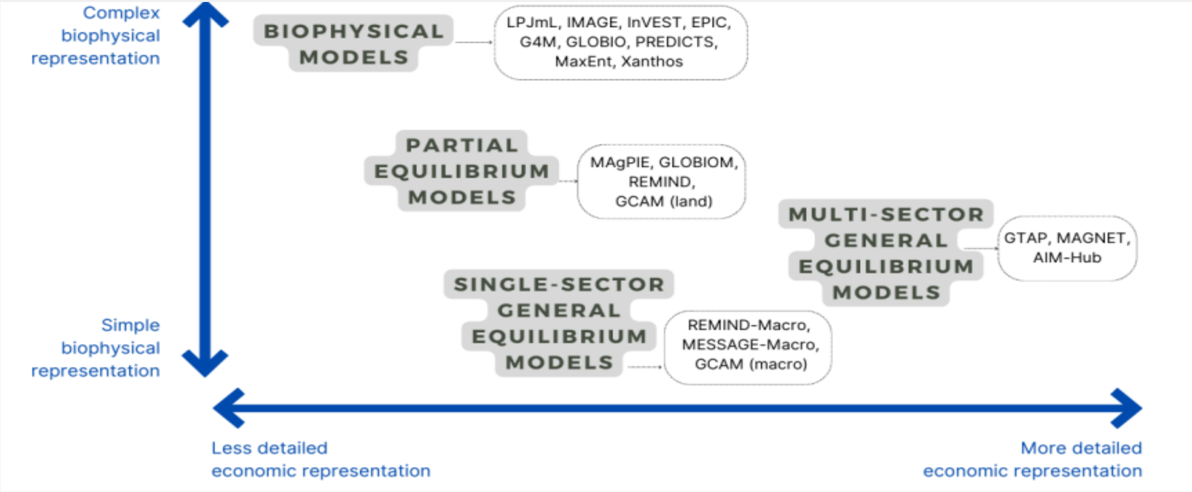
- Elucidates how ‘stylized’ and ‘applied’ nature-economy models **conceive "nature" and its relationship with the macroeconomy**, contributing to macroeconomics and environmental economics.
- **Informs policy applications of ‘applied’ IAMs** for understanding economic impacts of nature loss and policies, **aiding scenario design**.
- **Identifies limitations in current modeling approaches** and suggests avenues for developing 'nature-economy' models.

Analytical framework



Source: Authors

Scope and characteristics of reviewed models



Source: Authors

- Model sample comprised 8 ‘stylized’ IAMs and 6 ‘applied’ IAMs
- Assessment relied on standardized criteria from official documentation, peer-reviewed articles, and interviews with modeling teams.

Main findings – Stylized IAMs

- Introducing natural capital, ecosystem services, or biodiversity significantly affects:
  - **Optimal growth path** (all reviewed models)
  - **Structural change** (MAVA model)
  - **Optimal carbon price** and **associated temperature** (DICE-type models)

- **Strong uncertainty regarding parameters and functional forms**

- **Substitutability and efficiency gains are crucial but highly uncertain parameters**

Main findings – Applied IAMs

- **Applied IAMs** focus more on **provisioning ecosystem services** (food, water, bioenergy) and **less on regulating/maintenance services** (soil quality, pest control, flood protection), except for pollination and climate regulation.

- **Transition policies in models mainly address land-use and climate change**, neglecting other nature loss drivers like pollution and invasive species.

- **Core macroeconomic assumptions in models** (input substitution, rapid tech change) **may downplay the macroeconomic impacts** of nature loss and transition policies, contrasting with stylized models that show significant impacts.

    - Economies adapt to shocks through price changes, substitution, and trade, governed by elasticity parameters (with sensitivity analysis showing relevance of assumption).
    - Assumed high degree of adaptability may limit economic impacts to the sector's share in GDP (e.g., agriculture).
    - Most models assume rapid technological development with exogenous productivity trajectories, potentially missing radical changes from high-impact nature-related shocks.

Summary of main findings

- **Discrepancy between stylized and applied models in representation of economy-nature interactions:**

- **Stylized models:** high aggregation, but allow for endogenized feedbacks, sensitivity to substitution parameters is analyzed but often uncertain calibration

- **Applied models:** Detailed ecosystem services and transition policies, more precise calibration, but fewer connections to macroeconomy

Explore reconciling these approaches to enhance the modeling of nature-economy interactions for future scenarios and policy-making.

Suggested avenues going forward

- Develop more **explicit nature-to-economy transmission channels** in global applied models (e.g. build on endogenous feedback mechanisms between nature and the macroeconomy developed in stylized models), calibrate models on **a broader range of exogenous growth pathways**, including less optimistic scenarios (e.g. SSP3), and explore incorporating a **more dynamic understanding of substitution** in applied global models.

- Complement **global models with disaggregated economic models** to assess specific nature-related shocks and enable **precise calibration of economic impacts in particular areas.**

- Recognize the complexity and uncertainty in nature-economy modeling, **using a combination of qualitative and quantitative approaches for policy decisions**, and explore qualitative scenarios with stylized models.

- The complexity of nature loss calls for a **multi-dimensional approach** to nature scenarios, **rather than a 'one model fits all approach**

C3A Annual Symposium
December 2-6, 2024
World Bank Paris

Thank you

C3A, a program funded and hosted by WORLD BANK GROUP

Q&A
Discussion

C3A Annual Symposium
December 2-6, 2024
World Bank Paris

IIPP UCL Institute for Innovation and Public Purpose

The economic and financial risks of implementing the ‘30x30’ Global Biodiversity Framework targets

Katie Kedward and Adam Poupard

C3A Annual Symposium, Friday 6th December 2024

C3A, a program founded and hosted by WORLD BANK GROUP

Background

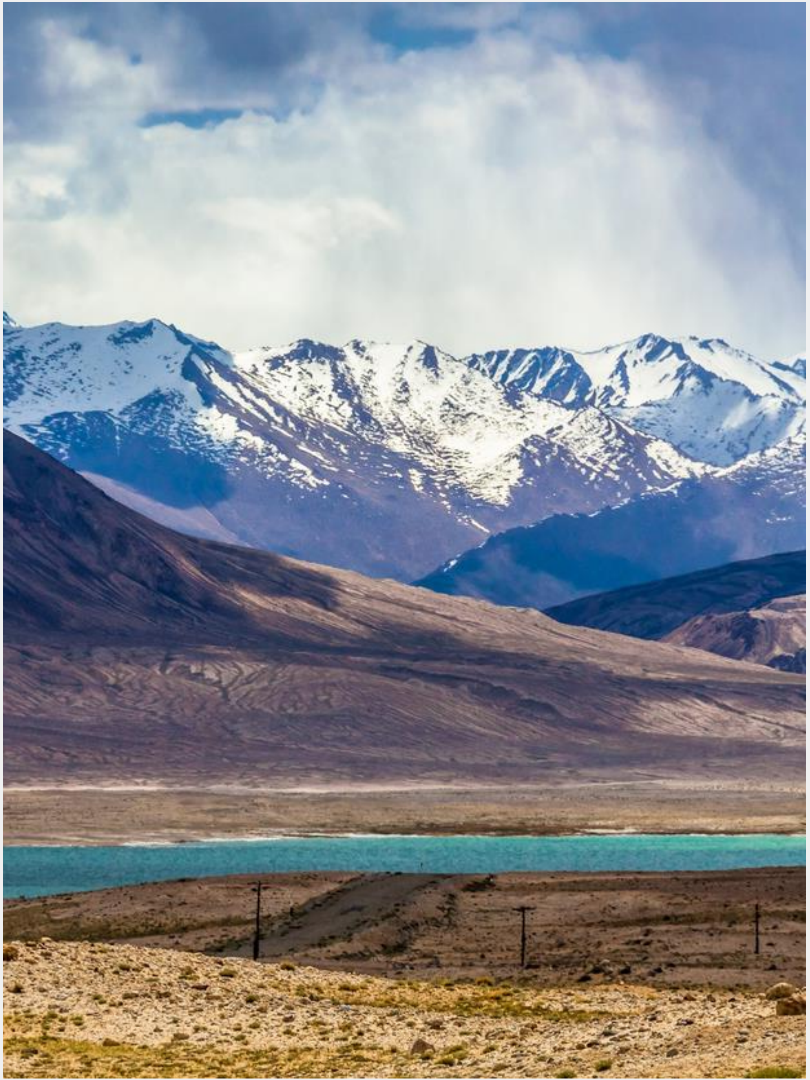
- Global Biodiversity Framework (GBF) signed by 195 countries aims to halt and reverse nature loss
- '30x30 targets' aim for a rapid shift in land uses to protect nature:
- **Target 2: restore 30% all degraded ecosystems by 2030**
- **Target 3: conserve 30% all land, waters, and seas by 2030**
- Yet, land use patterns are far from where they need to be to reverse nature loss (Díaz et al., 2019)
- Footprint analyses suggest conservation and economic land uses coming into competition: 1.4 million km^2 cropland is in PAs, of which 22% in strictly protected areas (Vijay and Armsworth, 2021)
- The most highly biodiverse ecosystems mainly located in developing and emerging economies, often also dependent on primary commodity exports from land-intensive economic activity
- Meeting 30x30 targets may present significant disruptions to economic activities in some regions over a short time frame.

Literature review

- Few studies look at economic consequences of nature conservation policies using IAMs
- Johnson et al. (2021) estimate opportunity cost of implementing 30x30 (vs developing land to most profitable use) is $115 billion globally by 2030 (0.1% global GDP)
- Naso et al. (2022) model reducing agricultural land use by 37.5% over 15 years and find social welfare losses to represent around 1% global GDP
- DNB (2023) 'half earth scenario' (50% earth as protected area) would lead to 17% increase in agricultural product prices but only limited GDP declines globally.
- Waldron et al. (2020) did a cost-benefit analysis of 30x30: finds agri, forestry, fisheries sectors would benefit from increased revenues ($64-454bn by 2050) with costs of implementation at $103-178bn
- **Overall, these studies don't find significant macroeconomic impacts from 30x30 targets**

Limitations of existing studies

- Land scarcity → relative price effects → labour/capital allocation shifts to agriculture
- Arbitrary choice of elasticities of substitution, exogenous growth components
- 'Weak sustainability' perspective of substitutability of land with human forms of capital
- Fixed supply and location-specific qualities of land (Smith, Ricardo, Stuart Mill, etc.)
- Limits to improving agricultural productivity: climate impacts, land degradation, diminishing returns, exacerbation of water scarcity/soil infertility, rebound effects
- Policy analysis focuses on marginal changes
- Economic impacts estimated at point of *equilibrium*
- Short-term adjustments to policy shock, and hysteresis effects not captured
- These 'blind spots' matter for understanding macrofinancial dynamics of 30x30 targets

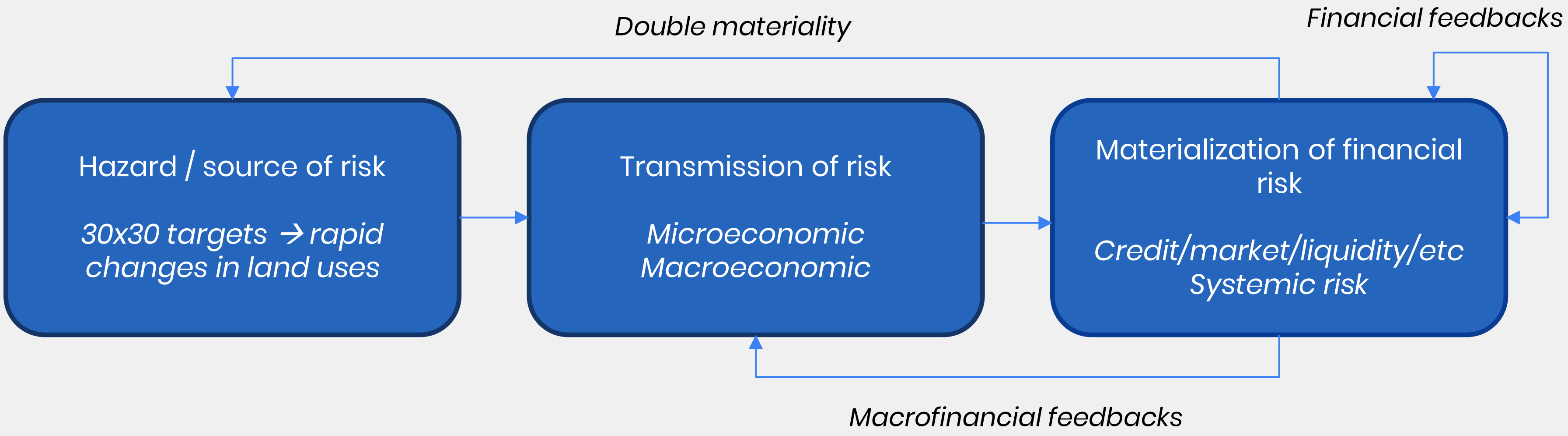


Research questions

1. What kinds of macroeconomic and financial risks might arise from rapid shifts in land use to meet the 30x30 targets?
2. Which economies and regions might be most affected?

Conceptual framework

- Adapted from framework developed by Svartzman et al., (2021) and NGFS (2024)



30x30 targets as source of transition risk

- 30x30 targets are not compatible with large-scale, intensive economic activity – even if managed "sustainably". Sustainable use provision is limited to low-impact subsistence level activities.
- Implies increased competition between economic land uses and nature conservation.
- 'Hard stop' of some agri/mining/forestry activities at commodity frontier to meet 30x30 targets
- Unfavourable dynamics influencing demand for and 'supply' of productive land

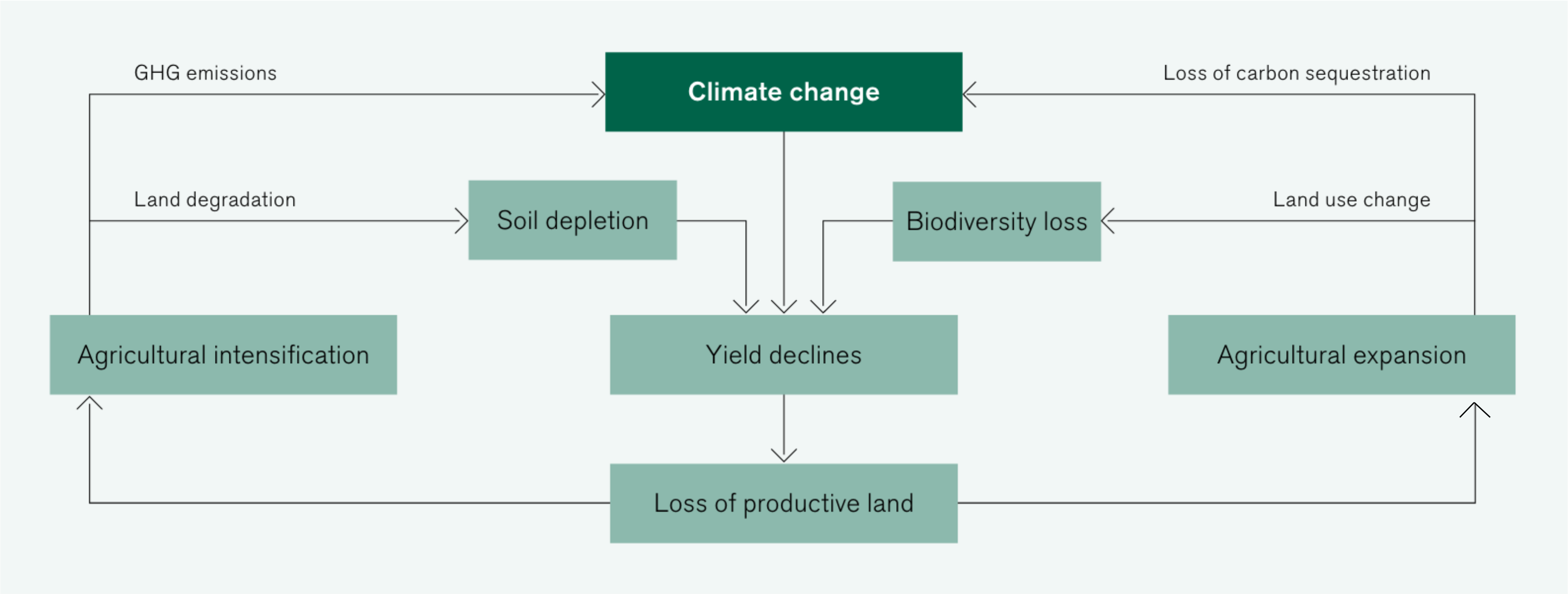
Demand side

- Future food demand
- Land-based CO_2 removal & BECCS
- Urbanization
- Mining (e.g., for critical minerals)

Supply side

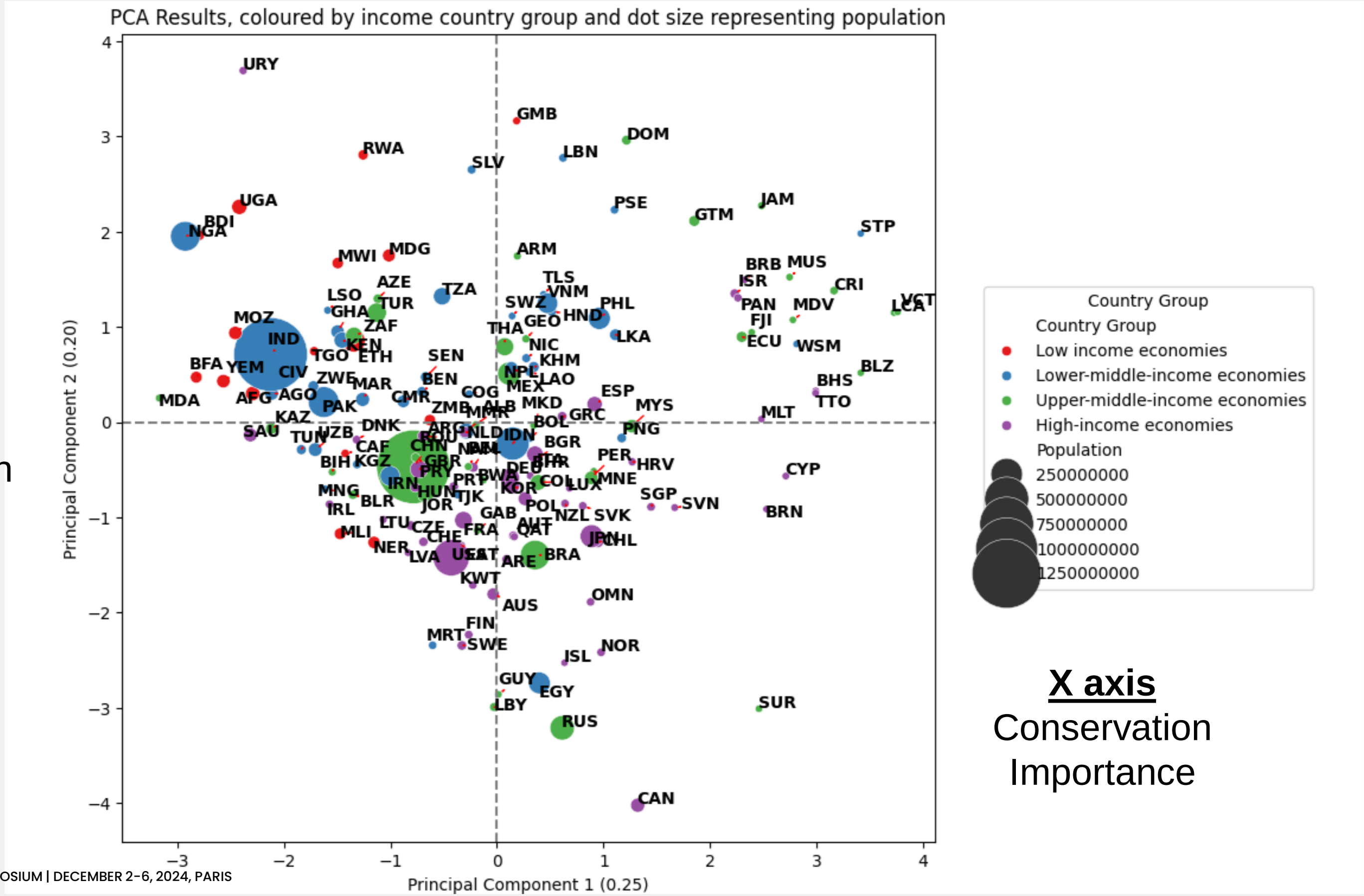
- Effects of climate change (rainfall, temperatures, water scarcity)
- Land degradation, loss of pollinators
- Sea level rise

Figure 2. Loss of productive land can be compounded by both agricultural intensification and land use change.



Adapted from Benton et al. (2021).[63]

Which countries might be affected by competition btw conservation/economic land uses?



Y axis

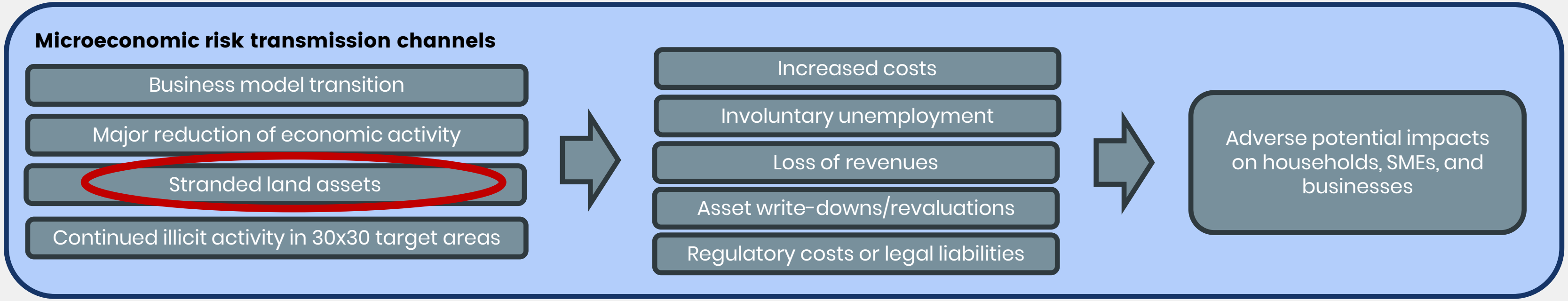
Land Competition Pressures

X axis

Conservation Importance

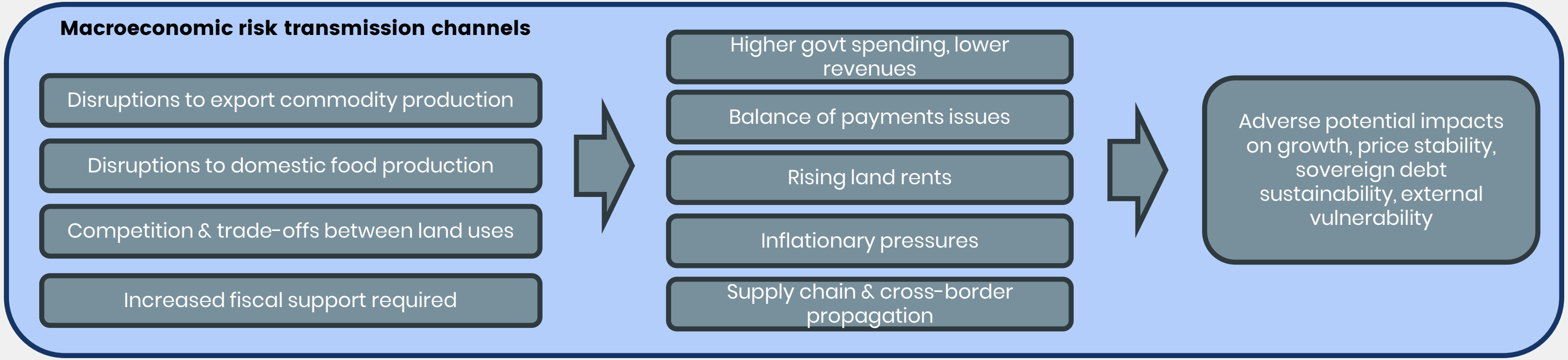
Micro effects: stranded land assets

- Recent efforts to reduce deforestation-linked commodities (e.g., EU Deforestation Regulation)
- Implies future increases in **stranded land assets** : undevelopable land holdings / mining concessions
- Adverse consequences for land-intensive firms operating at commodity frontier – whether write-down assets or continue to develop them (market and litigation risks)
- Lack of disclosures on extent of potential stranded land: some estimates of 29% oil palm concessions incompatible with NDPE standards in Indonesia (6.1 million ha).
- 'Nature markets' as a solution?
- Lack of empirical evidence of conservation effectiveness, high greenwash risk (difficult to demonstrate additionality), ongoing challenges to implementation/scalability (zu Ermgassen et al. 2019)



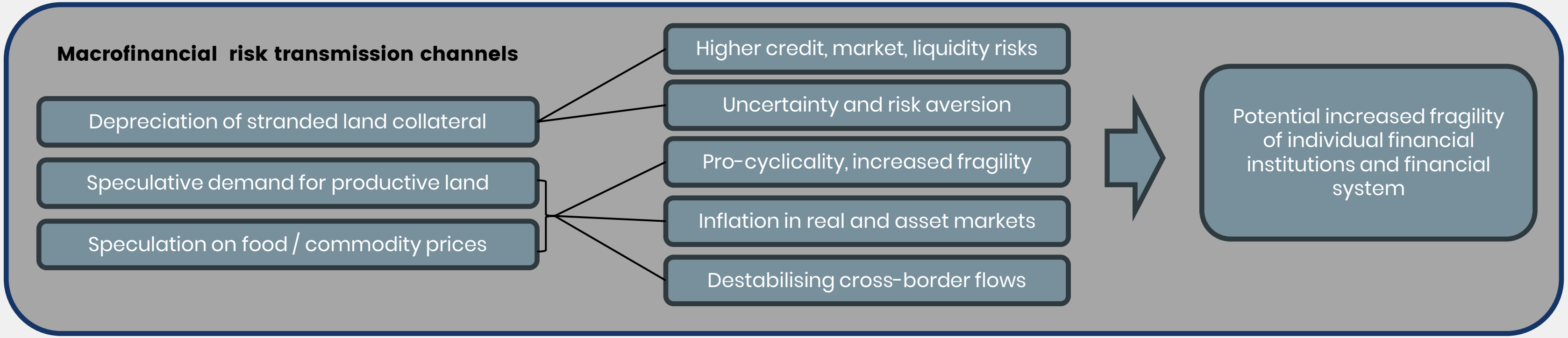
Macro effects: external vulnerability

- Economies dependent on primary commodity exports: balance of trade, current account, fiscal revenues, access to dollar liquidity → increase in external vulnerability
- In land-scarce countries:
- Tricky trade-offs allocating land between domestic food production and export commodity production
- Higher prices/rents of productive land outside of conservation zones → inflationary pressures
- Food price shocks → fiscal stress for food importers → cascading effects across regions (export bans, hoarding)



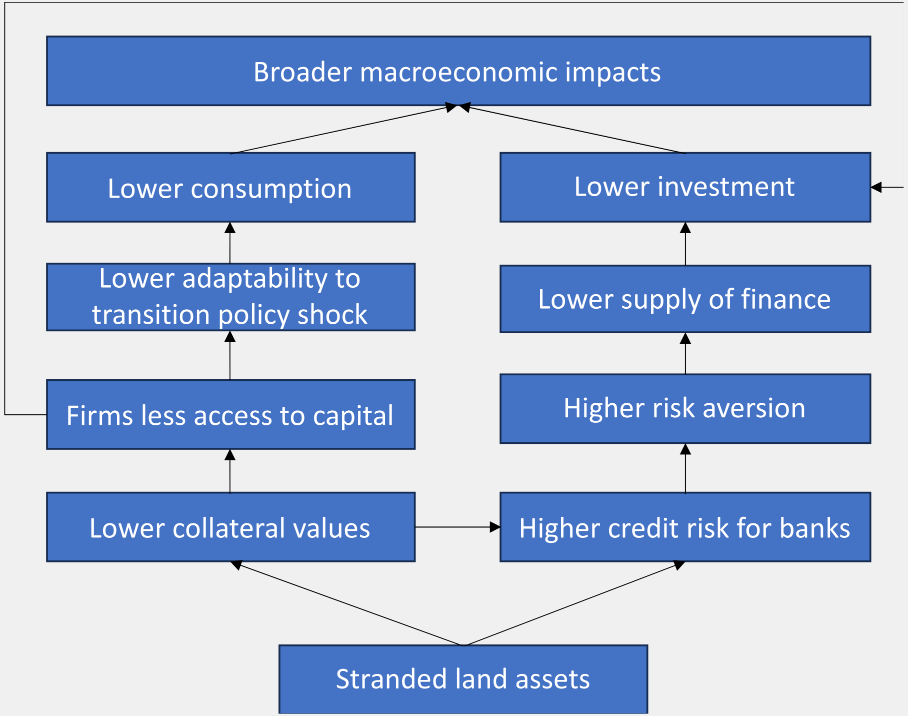
Macrofinancial effects

- 'Special' role fulfilled by land in financial system could result in additional feedback effects
- As well as productive use value, land has:
- *Speculative value*: land values tend to appreciate relative to other assets and growth over long run (Knoll et al., 2017) → role as "safe" portfolio asset
- *Liquidity value* → role as "reliable" collateral for financial system



Stranded land and loan collateral

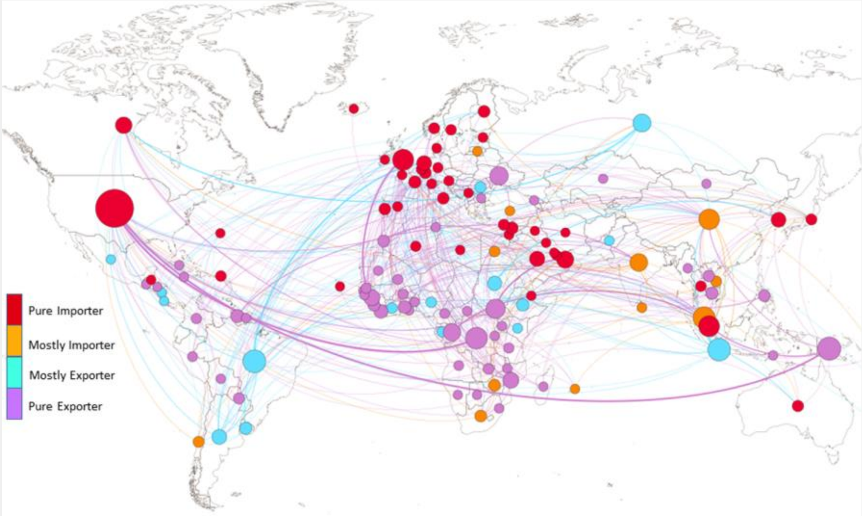
- Stranded land = depreciating collateral
- Exacerbate real economy shock through increased risk aversion & less access to finance
- These effects well-documented for residential housing assets (e.g., Schmalz et al., 2017)
- Same dynamics for agricultural land or land-based concessions?



Land scarcity and speculative effects

- Increasingly scarce productive land = appreciating asset
- Interaction of fixed supply of land & more elastic supply of credit = source of pro-cyclicity (Ryan-Collins, 2021)
- Speculative rush for agricultural land in Global South early 2000s
- 76% LSLAs non-domestic actors with financial institutions prominently involved (Mechiche-Alami et al., 2019)
- On the horizon: "green grabbing" – carbon/biodiversity offsets and credits

Large-scale agricultural land acquisitions, 2000-2014



Source: Mechiche-Alami et al., 2019

Conclusions and next steps

- Land-use related transition policy shocks may impose additional risk transmission channels related to competition between land uses and role of land in financial system
- Our conceptual analysis and high-level PCA suggests risks skewed to low/middle-income countries
- More empirical work needed to understand how risks materialize within particular local contexts
- Important data gaps remain: e.g., magnitude and exposures to potentially stranded land assets

Scenario modeling

Explore dynamics identified in non-equilibrium–based macro models.

E.g., dynamic input-output models, eco-SFC models

Role for ministries of finance

To assess and design strategies to manage development/conservation trade-offs

Distributional measures

To support rapid land use transitions in countries dependent on land-intensive commodity exports

C3A Annual Symposium
December 2-6, 2024
World Bank Paris

Working paper available at:

https://www.ucl.ac.uk/bartlett/public-purpose/publications/2024/oct/economic-and-financial-risks-implementing-30x30-global-biodiversity-framework


INSTITUTE FOR INNOVATION AND PUBLIC PURPOSE

UCL

The economic and financial risks of implementing the '30x30' Global Biodiversity Framework targets

Katie Kedward
UCL Institute for Innovation and Public Purpose
and Coalition for Capacity on Climate Action (C3A)

Adam Poupard
Coalition for Capacity on Climate Action (C3A)

UCL IIPP Institute for Innovation and Public Purpose

WORKING PAPER
2024/013

Thank you

C3A, a program founded and hosted by WORLD BANK GROUP

References

- Benton et al. 2021. Food System Impacts on Biodiversity Loss: Three Levers for Food System Transformation in Support of Nature. Chatham House Policy Report.
- Díaz, S., et al. 2019. Pervasive human-driven decline of life on Earth points to the need for transformative change. Science. 366(6471), p.eaax3100.
- DNB. 2023. The economic and financial stability repercussions of nature degradation for the Netherlands: Exploring scenarios with transition shocks. De Nederlandsche Bank.
- Johnson, J.A., et al. 2021. The Economic Case for Nature: A Global Earth-Economy Model to Assess Development Policy Pathways [Online]. Washington, DC: World Bank.
- Knoll, K., Schularick, M. and Steger, T. 2017. No Price Like Home: Global House Prices, 1870-2012. The American Economic Review. 107(2), pp.331–353.
- Mechiche-Alami, A., Piccardi, C., Nicholas, K.A. and Seaquist, J.W. 2019. Transnational land acquisitions beyond the food and financial crises. Environmental Research Letters. 14(8), p.084021.
- Naso, P., Haznedar, O., Lanz, B. & Swanson, T. A macroeconomic approach to global land use policy. Resource and Energy Economics 69, 101302 (2022).
- Oakleaf, J., et al. 2024. Mapping global land conversion pressure to support conservation planning. Scientific Data. 11(1), p.830.
- Ryan-Collins, J. 2021. Private Landed Property and Finance: A Checkered History. The American Journal of Economics and Sociology. 80(2), pp.465–502.
- Schmalz, M.C., Sraer, D.A. and Thesmar, D. 2017. Housing Collateral and Entrepreneurship. The Journal of Finance. 72(1), pp.99–132.
- Vijay, V. & Armsworth, P. R. 2021. Pervasive cropland in protected areas highlight trade-offs between conservation and food security. Proceedings of the National Academy of Sciences 118.
- Waldron, A. et al. 2020. Protecting 30% of the Planet for Nature: Costs, Benefits and Economic Implications.
- zu Ermgassen et al. 2019. The ecological outcomes of biodiversity offsets under “no net loss” policies: A global review. Conservation Letters. 12(6), p.e12664.

Annex –

Principal Component Analysis Method and Results

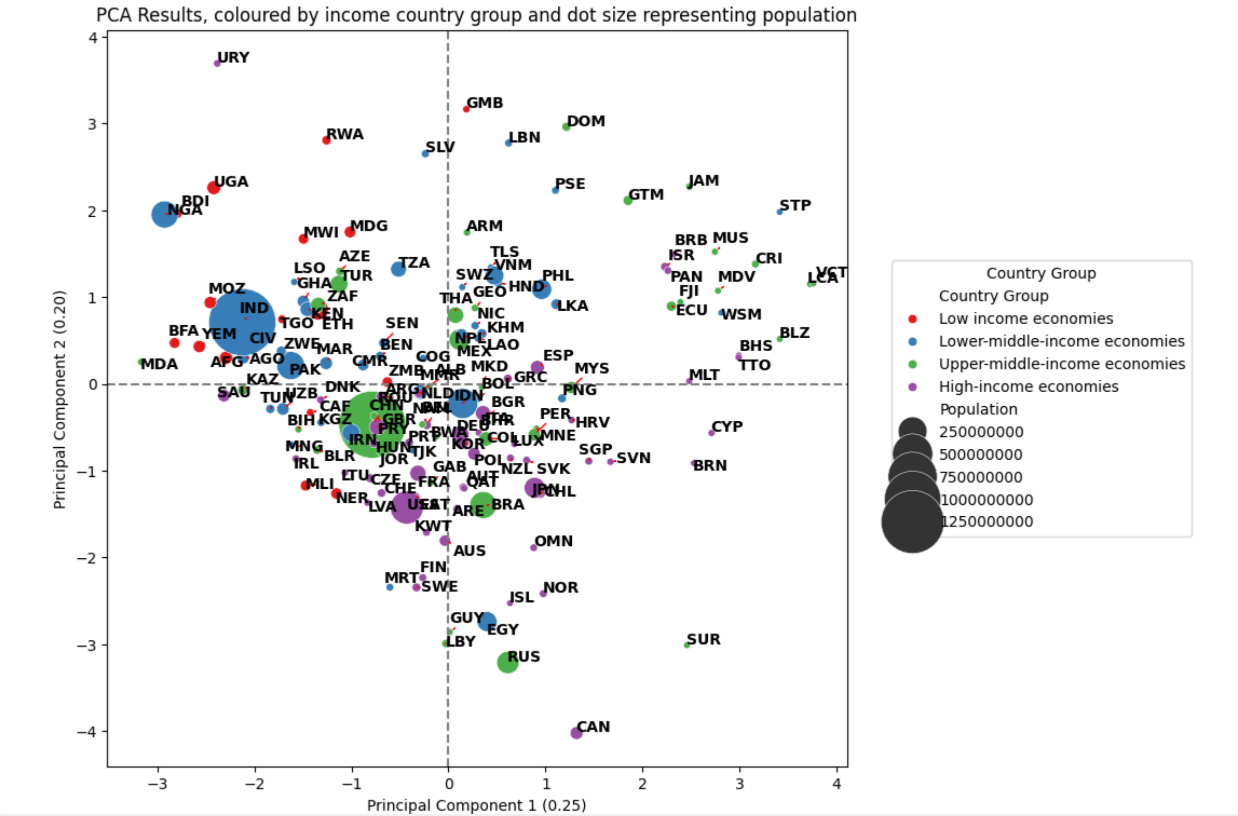
Country-level cluster analysis

- Which countries and regions are likely to be most affected by increased competition between conservation/economic land uses?
- Identified key indicators:
- Extent of land in each country identified as important for conservation: existing PAs plus Key Biodiversity Areas (KBAs), Ecologically Intact Areas (EIAs), and 'New Priority' conservation areas → Allen et al., (2022)
- Area of conservation-priority land projected to be at risk of habitat conversion by 2030 (under SSP2 scenario)
- Extent of agricultural land area (as % total area); share of population employed in agricultural sector
- Food system resilience: food insecurity of population
- Coverage of 150 countries across 9 variables
- All data normalized → performed Principal Component Analysis

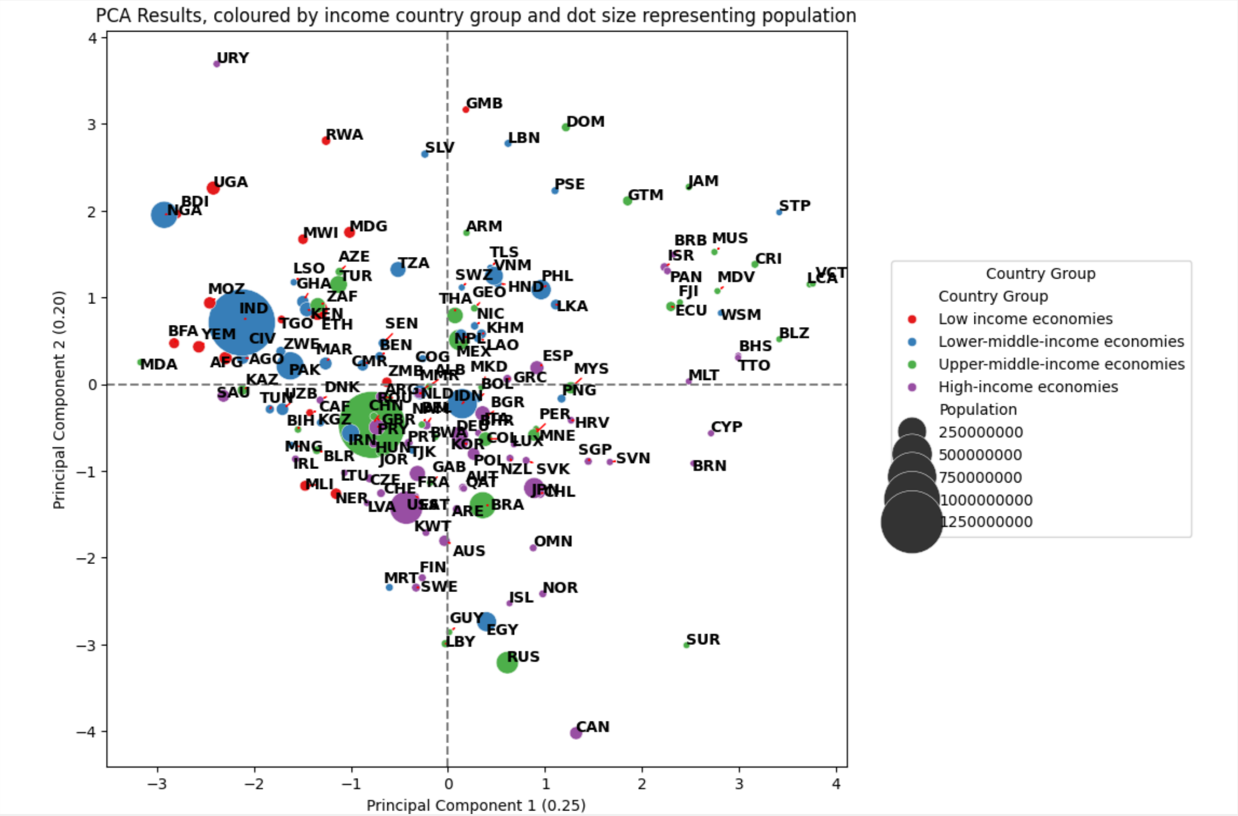
Correlation factors for principal components

Data code	Description and reference year of underlying data	PC1: "Conservation Importance"	PC2: "Land competition"	PC3: "Economic Adaptability"	Data source
	Variance explained by the PC	25%	20%	17%	
PA	Existing Protected Areas, (% of country land area) (20.5 Mkm^2) (Yr. 2020)	0.22	-0.06	-0.39	Allan et al. 2022
KBA	Key Biodiversity Areas (% of country land area) (11.6 Mkm^2) (Yr. 2020)	0.43	0.28	-0.18	Allan et al. 2022
EIA	Ecologically Intact Areas, (% of country land area) (35.1 Mkm^2) (Yr. 2020)	0.04	-0.46	0.42	Allan et al. 2022
New P	Additional Conservation Priorities to promote species persistence, (% of country land area) (12.4 Mkm^2) (Yr. 2020)	0.36	0.43	0.28	Allan et al. 2022
Cons	Total land defined as important for conservation (PA + KBA + EIA + New P removing overlapping areas) (% of country land area) (64.1 Mkm^2) (Yr. 2020)	0.56	0.19	0.28	Allan et al. 2022
HabLoss30	Proportion of intact land requiring conservation in each country projected to be at risk of habitat conversion by 2030 under SSP2 (middle-of-road)	-0.16	0.46	-0.18	Allan et al. 2022
AGRI_EXT	Extent of agricultural land area (% of country land area) (Yr. 2021)	-0.39	0.38	-0.22	World Bank
Emp Sh	Employment in agriculture (% of total employment) (Yr. 2021-2022)	-0.31	0.28	0.39	World Bank (modelled ILO estimate)
Food Ins	Prevalence of severe food insecurity (% population) (Yr. 2021)	-0.21	0.20	0.50	World Bank Food Security Outlook

Conservation importance (PC1) vs Land Competition (PC2)



Land Competition (PC2) vs Economic Adaptability (PC3)



Limitations of our PCA

- We don't account for potential mitigating role of technology and closing yield gaps
- Due to lack of broad global data coverage on yield gaps (particularly small island states)
- PCA doesn't consider interconnections between countries: trade, cross-border financial dynamics
- Top-down approach abstracts from diverse institutional and geopolitical contexts

Q&A
Discussion

C3A Annual Symposium
December 2-6, 2024
World Bank Paris

AFD Agence Française de Développement
PhD SDC Sustainable Development and Climate Change
IUSS Scuola Universitaria Superiore Pavia

Nature-Related Transition Risks and The Climate-Nature Nexus: an Assessment of Capital Stranding Exposure and Financial Vulnerability in Brazil

Angela Modica Scala (IUSS Pavia)
Gabriel Santos Carneiro (IUSS Pavia)
Alessandro Caiani (IUSS Pavia)

Contact: gabriel.santos@iusspavia.it

Table of contents

The Climate-Nature-Society Nexus in Brazil

Brazil: ambiguous GHG emissions and biodiversity loss profile:

- 44.8%of its energy mix and 84.8% of its electricity mix composed of renewable energy sources (Brasil, 2023)
- Most biodiverse country in the world
- 6th largest GHG emitter in 2022, accounting for 2.44% of total global annual emissions
- On the verge of crossing multiple ecosystem's tipping points

Intricate climate-nature-society nexus:

- Similar economic activities pressure both climate and biodiversity
- Geospatial component connects local biodiversity loss effects with global climate change effects
- Major pressuring sectors compose a large share of Brazilian GDP, particularly exports, and are significant sources of wages and employment

Objective, Data and Methodology

Objective: Perform a risk assessment of the Brazilian economy to transition risks affecting economic activities that are the major drivers of GHG emissions and biodiversity loss

- Focus on the exposure to capital stranding and vulnerability to financial instability

Data sources:

- Combined 2014 data from the World Input-Output database (WIOD) and 2020 OECD Inter-Country Input-Output (ICIO) data
- Economatica and Orbis data on financial condition of Brazilian firms

Methodology:

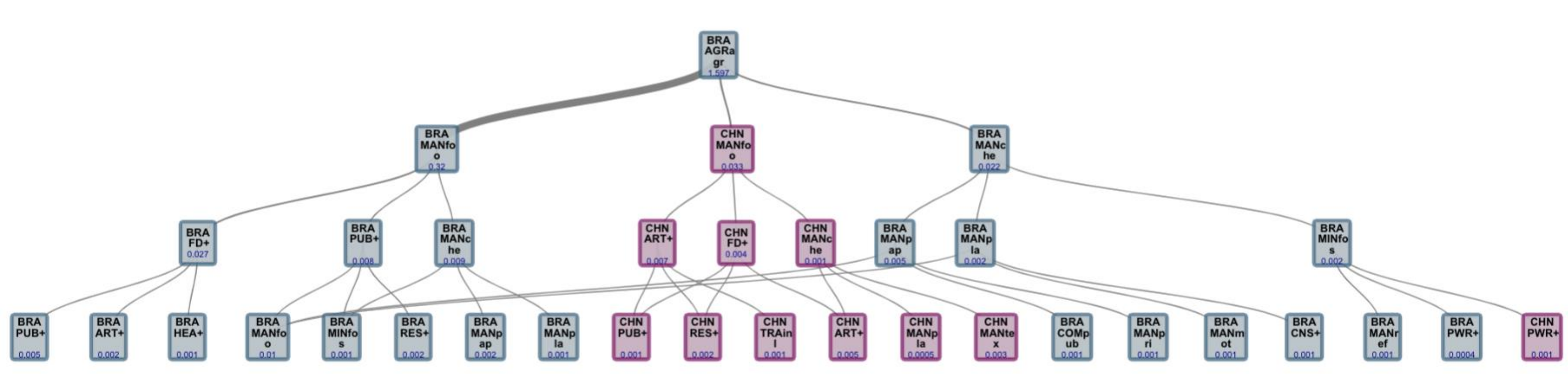
- Based on the IPCC SREX risk assessment framework

The Framework of Nature-Related Risks (NRRs)

Risk Assessment Framework

Hazard: Climate and Nature events	Exposure	Vulnerability
• Two different shock sizes: $1 marginal shock and 1% of sectoral output • Shock applied to the sectors of Agriculture, Forestry and Mining of Fossil Fuels • 3 different scenarios in which a different selection of these 3 sectors are shocked.	• Extended and adapted Input-Output assessment based on Cahen-Fourot et al. (2021) • Information on sectoral capital stocks is employed to build "sectoral stranding multipliers" matrices • Assessment of both upstream (Leontief) and downstream (Ghosh) indirect effects.	• Sectoral financial fragility assessment based on Modica Scala et al. (2024) • Application of a Minskyian cash-flows analysis to firms and aggregation into sectoral clusters • Brazilian sectors are classified in 5 categories: Hedge, Hedge-Speculative, Speculative, Speculative-Ponzi, and Ponzi.

The Cascading Network of Impacts



- As the indirect effects take time to spread through the productive network, assessing only the final quantity of indirect effects overlooks important features of the traverse between pre- and post- shock positions

Upstream Exposure for 1% Scenarios

Cluster	Low-carbon transition ($)	Biodiversity protection transition ($)	Climate/Nature transition ($)	Financial position in 2020
Mining-energy	3388.91	218.05	3606.95	Hedge
Food	4.57	3206.93	3211.49	Speculative
Real estate, Entertainment	49.69	130.50	180.19	Ponzi
Chemical, Plastic	9.48	130.29	139.77	Speculative
Mining-no energy	54.78	75.65	130.43	Hedge-Speculative
Wholesale and retail	11.74	91.55	103.29	Speculative
Publishing, Professional activities	40.31	57.61	97.92	Hedge-Speculative
Electricity, gas and steam supply	4.62	71.34	75.96	Hedge-Speculative
Land transport	16.25	48.20	64.45	Hedge
Paper, Water transport	20.40	39.73	60.13	Ponzi
Telecommunication, Administration, Education	20.75	20.41	41.16	Ponzi
Finance and insurance, IT, Public administration	13.50	27.01	40.51	Ponzi
		...		
Total stranding	**3676.91**	**4205.39**	**7882.31**	

- **Indirect effects lead to high exposure of both polluting and non-polluting sectors**
- Food cluster, a major driver of GHG emissions and biodiversity loss in Brazil, is **both highly exposed and financially vulnerable** (speculative)
- **Multiple indirectly exposed clusters in ponzi or speculative positions**. Ex: Real estate, Entertainment; Paper, Water transport; Chemical, Plastic

Downstream Exposure for 1% Scenarios

Cluster	Low-carbon transition ($)	Biodiversity protection transition ($)	Climate/Nature transition ($)	Financial position in 2020
Food	73.68	3802.67	3876.35	Speculative
Mining-energy	3749.87	18.05	3767.92	Hedge
Chemical, Plastic	31.88	72.67	104.55	Speculative
Accommodation, Food services, Air transport, Other services	15.67	83.44	99.11	Hedge-Speculative
Paper, Water transport	25.79	62.30	88.09	Ponzi
Electricity, gas and steam supply	82.61	3.15	85.76	Hedge-Speculative
Finance and insurance, IT, Public administration	31.42	52.56	83.98	Ponzi
Mining-no energy	59.35	20.25	79.60	Hedge-Speculative
Land transport	67.68	4.39	72.07	Hedge
Wholesale and retail	19.71	30.11	49.82	Speculative
Wood, Machinery	7.93	40.73	48.66	Speculative
Real estate, Entertainment	22.78	23.67	46.45	Ponzi
		...		
Total stranding	**4265.24**	**4295.01**	**8560.25**	

- **Initial direct shocks increase up to 3.50 and 3.22 times** when indirect effects are accounted

- **<u>Beyond stranding capital:</u>** clusters of Mining-energy and Food are highly relevant for the Brazilian economy in terms of employment, wages, fiscal revenues and for the generation of foreign exchange reserves and are also **providers of basic final demand needs** of the Brazilian society such as **food** and **energy**

Limitations

- We do **not distinguish between critical and non-critical inputs** when estimating upstream exposure
- Also, we do **not account for import substitution** and smoothing effects from **excess capacity and inventories** when estimating downstream exposure
- In general, we expect upstream effects to be more certain to effectively materialize than downstream ones, as they are the result of a reduction in demand in the economy

- **Linear assumptions** of input-output models -> no scale effects

- Stranding cascading effects are, equally, an effect of both the capital intensity of the sector and its importance in the upstream/downstream production network measured with the coefficients of the Leontief/Ghosh Inverse

- **Need to better calibrate the "hazard" aspect (ex: volume and sectors affected) of the assessment in order to create more realistic policy scenarios.**

Key Messages and Next Steps

- **Transition policies in Brazil targeting economic sectors which are major GHG emitters and biodiversity loss drivers should be designed taking into consideration the indirect macro-financial effects that they may generate**

- Multiple indirectly exposed sectors are also financially vulnerable

- Next steps: <u>**include households in the model**</u> and account for direct and indirect effects in the form of **unemployment, loss of wages and lower consumption**

- **Explore the unequal effects of nature-related risks in Brazil affecting different income groups**

- **Explore financial instability effects stemming from households' position of financial vulnerability**

C3A Annual Symposium
December 2-6, 2024
World Bank Paris

Thank you

Q&A
Discussion

C3A Annual Symposium
December 2-6, 2024
World Bank Paris

Nature-Related Transition Risks and The Climate-Nature Nexus: an Assessment of Capital Stranding Exposure and Financial Vulnerability in Brazil

Angela Modica Scala (IUSS Pavia)
Gabriel Santos Carneiro (IUSS Pavia)
Alessandro Caiani (IUSS Pavia)

Contact: gabriel.santos@iusspavia.it

Table of contents

The Climate-Nature-Society Nexus in Brazil

Brazil: ambiguous GHG emissions and biodiversity loss profile:

- 44.8%of its energy mix and 84.8% of its electricity mix composed of renewable energy sources (Brasil, 2023)
- Most biodiverse country in the world
- 6th largest GHG emitter in 2022, accounting for 2.44% of total global annual emissions
- On the verge of crossing multiple ecosystem's tipping points

Intricate climate-nature-society nexus:

- Similar economic activities pressure both climate and biodiversity
- Geospatial component connects local biodiversity loss effects with global climate change effects
- Major pressuring sectors compose a large share of Brazilian GDP, particularly exports, and are significant sources of wages and employment

Objective, Data and Methodology

Objective: Perform a risk assessment of the Brazilian economy to transition risks affecting economic activities that are the major drivers of GHG emissions and biodiversity loss

- Focus on the exposure to capital stranding and vulnerability to financial instability

Data sources:

- Combined 2014 data from the World Input-Output database (WIOD) and 2020 OECD Inter-Country Input-Output (ICIO) data
- Economatica and Orbis data on financial condition of Brazilian firms

Methodology:

- Based on the IPCC SREX risk assessment framework

The Framework of Nature-Related Risks (NRRs)

Risk Assessment Framework

Hazard: Climate and Nature events

- Two different shock sizes: $1 marginal shock and 1% of sectoral output
- Shock applied to the sectors of Agriculture, Forestry and Mining of Fossil Fuels
- 3 different scenarios in which a different selection of these 3 sectors are shocked.

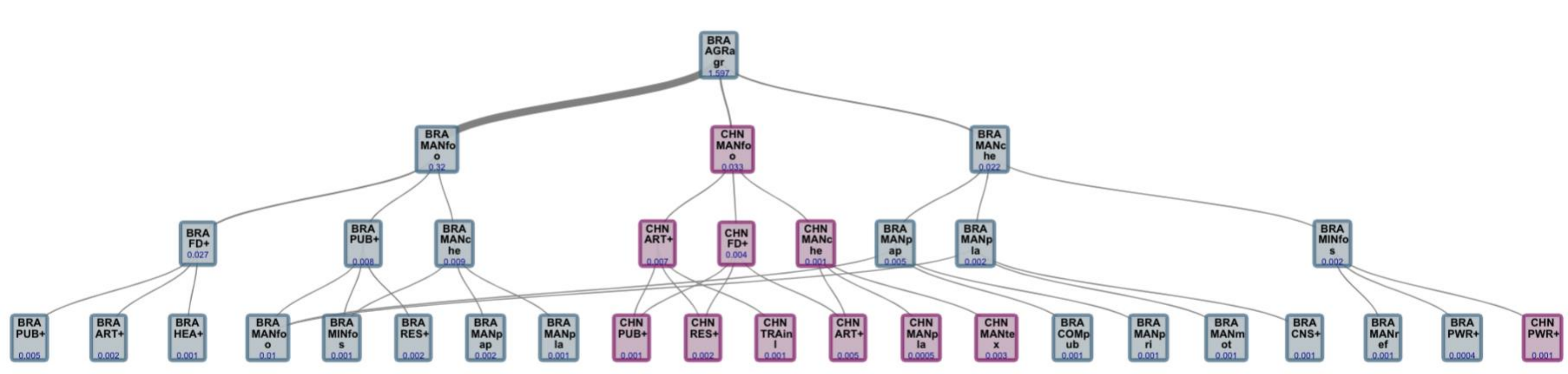
Exposure

- Extended and adapted Input-Output assessment based on Cahen-Fourot et al. (2021)
- Information on sectoral capital stocks is employed to build "sectoral stranding multipliers" matrices
- Assessment of both upstream (Leontief) and downstream (Ghosh) indirect effects.

Vulnerability

- Sectoral financial fragility assessment based on Modica Scala et al. (2024)
- Application of a Minskyian cash-flows analysis to firms and aggregation into sectoral clusters
- Brazilian sectors are classified in 5 categories: Hedge, Hedge-Speculative, Speculative, Speculative-Ponzi, and Ponzi.

The Cascading Network of Impacts



- As the indirect effects take time to spread through the productive network, assessing only the final quantity of indirect effects overlooks important features of the traverse between pre- and post- shock positions

Upstream Exposure for 1% Scenarios

Cluster	Low-carbon transition ($)	Biodiversity protection transition ($)	Climate/Nature transition ($)	Financial position in 2020
Mining-energy	3388.91	218.05	3606.95	Hedge
Food	4.57	3206.93	3211.49	Speculative
Real estate, Entertainment	49.69	130.50	180.19	Ponzi
Chemical, Plastic	9.48	130.29	139.77	Speculative
Mining-no energy	54.78	75.65	130.43	Hedge-Speculative
Wholesale and retail	11.74	91.55	103.29	Speculative
Publishing, Professional activities	40.31	57.61	97.92	Hedge-Speculative
Electricity, gas and steam supply	4.62	71.34	75.96	Hedge-Speculative
Land transport	16.25	48.20	64.45	Hedge
Paper, Water transport	20.40	39.73	60.13	Ponzi
Telecommunication, Administration, Education	20.75	20.41	41.16	Ponzi
Finance and insurance, IT, Public administration	13.50	27.01	40.51	Ponzi
		…		
Total stranding	**3676.91**	**4205.39**	**7882.31**	

- **Indirect effects lead to high exposure of both polluting and non-polluting sectors**
- Food cluster, a major driver of GHG emissions and biodiversity loss in Brazil, is **both highly exposed and financially vulnerable** (speculative)
- **Multiple indirectly exposed clusters in ponzi or speculative positions**. Ex: Real estate, Entertainment; Paper, Water transport; Chemical, Plastic

Downstream Exposure for 1% Scenarios

Cluster	Low-carbon transition ($)	Biodiversity protection transition ($)	Climate/Nature transition ($)	Financial position in 2020
Food	73.68	3802.67	3876.35	Speculative
Mining-energy	3749.87	18.05	3767.92	Hedge
Chemical, Plastic	31.88	72.67	104.55	Speculative
Accommodation, Food services, Air transport, Other services	15.67	83.44	99.11	Hedge-Speculative
Paper, Water transport	25.79	62.30	88.09	Ponzi
Electricity, gas and steam supply	82.61	3.15	85.76	Hedge-Speculative
Finance and insurance, IT, Public administration	31.42	52.56	83.98	Ponzi
Mining-no energy	59.35	20.25	79.60	Hedge-Speculative
Land transport	67.68	4.39	72.07	Hedge
Wholesale and retail	19.71	30.11	49.82	Speculative
Wood, Machinery	7.93	40.73	48.66	Speculative
Real estate, Entertainment	22.78	23.67	46.45	Ponzi
		...		
Total stranding	**4265.24**	**4295.01**	**8560.25**	

- **Initial direct shocks increase up to 3.50 and 3.22 times** when indirect effects are accounted

- **Beyond stranding capital:** clusters of Mining-energy and Food are highly relevant for the Brazilian economy in terms of employment, wages, fiscal revenues and for the generation of foreign exchange reserves and are also **providers of basic final demand needs** of the Brazilian society such as **food** and **energy**

Limitations

- We do **not distinguish between critical and non-critical inputs** when estimating upstream exposure
- Also, we do **not account for import substitution** and smoothing effects from **excess capacity and inventories** when estimating downstream exposure

- **Linear assumptions** of input-output models -> no scale effects

- Stranding cascading effects are, equally, an effect of both the capital intensity of the sector and its importance in the upstream/downstream production network measured with the coefficients of the Leontief/Ghosh Inverse

- **Need to better calibrate the "hazard" aspect (ex: volume and sectors affected) of the assessment in order to create more realistic policy scenarios.**

Key Messages and Next Steps

- **Transition policies in Brazil targeting economic sectors which are major GHG emitters and biodiversity loss drivers should be designed taking into consideration the indirect macro-financial effects that they may generate**

- Multiple indirectly exposed sectors are also financially vulnerable

- Next steps: **include households in the model** and account for direct and indirect effects in the form of **unemployment, loss of wages and lower consumption**

- **Explore the unequal effects of nature-related risks in Brazil affecting different income groups**

- **Explore financial instability effects stemming from households' position of financial vulnerability**

Q&A
Discussion

C3A Annual Symposium
December 2-6, 2024
World Bank Paris

Thank you

Indirect effects and Capital Stranding in a model closed for Households