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

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Author contributions

K.K. conceived and designed this paper's conceptual framework and wrote the paper. K.K. and A.P. jointly conceived, designed, and analysed this paper's empirical cluster analysis. A.P. assembled the input data and wrote the code, and performed the empirical cluster analysis.

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

Katie Kedward[i] and Adam Poupard[ii]

Abstract[iii]

The Global Biodiversity Framework's '30x30 targets' aim to restore and conserve 30% of degraded ecosystems by 2030, as part of broader efforts to halt and reverse nature loss. The macrofinancial risks of conservation-related land use constraints economies remain underexplored, yet increased competition between land uses calls into question potential trade-offs between economic development and ecosystem protection/restoration. This paper first presents a novel conceptual framework articulating the channels by which a transition to implement the 30x30 targets may affect economic and financial stability. A key finding of this framework is that the importance of productive land to primary commodity production, as well as the specific role land plays within the financial system, means that land-related transition policy shocks impose additional and distinct risk transmission channels compared to climate-related policy shocks. Next, the paper uses a simple cluster analysis approach to explore which countries and regions might be most exposed to increased land competition between conservation and economic activities, indicating where macrofinancial risks might be most likely to emerge. Our results suggests that risks are likely to be disproportionately skewed towards low- and middle-income countries, that generally have a higher proportion of lands of conservation importance, a higher exposure to land competition pressures, and a lower adaptability of the economy to pressures on the food system. Our findings contribute to the growing literature on nature-related transition risks and also provide crucial insights for policymakers advancing green transition strategies.

Keywords: Green Transition; Sustainable Development; Biodiversity; Nature Conservation; Macroeconomic Risks; Nature Scenarios

JEL codes: Q01, Q15, Q24, Q56, Q57, O44

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1. Introduction

The health and integrity of the planet's ecosystems are declining at an alarming rate. Land use change – the conversion of habitats caused by economic activity – is a major driving cause of both climate change and environmental degradation (i.e., "nature loss").[1] It has been proposed that the 'Earth system boundary' of the minimum area of ecosystems required to maintain functioning flows of ecosystem services has already been transgressed globally.[2] Given that human activity is embedded in the biosphere and dependent upon it, the loss of 'ecosystem services' provided by functioning ecosystems may lead to catastrophic economic consequences.[3] Moreover, halting land-based drivers of nature loss can also have potentially large adverse economic impacts. Societies must therefore move rapidly and with great care to be able to safely implement the major "transformative" changes in land use needed to ensure positive socio-economic and environmental outcomes.

In an effort to halt and reverse nature loss, 195 countries came together to sign the Kunming-Montreal Global Biodiversity Framework (GBF) in December 2022.[i] The GBF sets out a series of 23 targets and 4 broader goals to create a society that lives in "harmony with nature" by 2030. Notably, Target 2 aims to restore 30% of all degraded ecosystems and Target 3 seeks to conserve 30% of all land, waters, and seas by 2030 – known as the '30x30 targets'.[4]

While the 30x30 targets are now regularly used as a regulatory standard for likely forthcoming environmental protections, the channels by which such land use constraints might result in macroeconomic and financial risks for some economies remain under-explored. Analysis of the macrofinancial effects of the green transition has so far focused predominantly on the potential for adverse macroeconomic and financial disruptions posed by climate mitigation and adaptation measures,[5,6] and Ministries of Finance are increasingly focused on designing policy strategies to mitigate these "transition risks" of low carbon technology transitions.[7]

Yet there is reason to believe that the land-use constraints provoked by a 30x30 nature transition could bring major macrofinancial risks. Recent analyses suggest that land uses for conservation purposes and economic purposes (particularly food production) are, in some locations, increasingly coming into competition with each other.[8,9] Of the Earth's habitable land area[ii], forests now represent only 30 million km2 (38%), whilst agricultural production – a major contributor to nature loss – now dominates as the single largest category of land uses at 48 million km^2 (45%).[10] Various footprint-based studies have estimated that just under half of Earth's land area is only subject to low or very low human pressures – in theory presenting potential 'easy win' opportunities for area-based conservation measures.[11,12] However, the spatial distribution of human pressures varies greatly across biomes, and the land areas most important for conservation – often referred to as "key biodiversity areas"[iii] or "biodiversity hotspots"[13] - tend to overlap substantially with land areas subject to the most intensive human pressure.[14–16] Indeed, it is estimated that 1.4 million km^2 of cropland occurs within protected areas, 22% of which is within strictly protected areas.[17]

Increased competition between land uses calls into question the feasibility of 30x30 target implementation in the face of potential trade-offs between economic development and ecosystem protection/restoration. The GBF text is clear that the 30x30 targets do not represent a 'land sparing'[iv]

i Additionally, at COP26 in Glasgow in 2021, 145 countries committed to halting and reversing forest loss and land degradation by 2030 as part of efforts to limit global average temperature increases to 1.5°C.

ii Terrestrial land area excluding glaciers, deserts, salt flats, beaches, and dunes – estimated to be around 107 million km^2, according to UN FAO data.

iii https://www.keybiodiversityareas.org/

iv 'Land sparing' refers to the complete separation of conservation and economic activities, with the exclusion of human populations from any access to land areas under ecosystem protection or restoration measures (e.g., the creation of 'wilderness areas') and food production enabled by intensive, high-yield practices. At the other end of the spectrum, 'land sharing' describes approaches that aim to integrate patches of low-intensity, nature-friendly food production within areas of conservation importance, rather than keeping agriculture and wilderness separate.[18] For more on land sparing versus land sharing debates in the context of nature loss, see Bateman and Balmford (2023).[19]

approach to conservation, and that the implementation of the targets must recognize and respect in particular "the rights of indigenous peoples and local communities, including over their traditional territories".[4] Yet, Target 3 also requires that any "sustainable use" must be "fully consistent with conservation outcomes". Subsequent guidance on the 30x30 targets compiled by the IUCN World Commission on Protected Areas specifies that:

> "The focus of Target 3 is on area-based conservation of biodiversity as described under the CBD. **Large scale, intensive commercial and/or industrial exploitation (in agriculture, fishing, and forestry) even if managed sustainably is not compatible with Target 3** and is already covered under GBF Targets 5, 9 and 10. While some types of sustainable use legitimately occur in protected areas, these are specifically intended at the "least impact" end of the use continuum"[20] (Emphasis added).

Given that the trajectories of ongoing land use change remain very far from where they need to be to reverse nature loss,[21] implementing the 30x30 targets may present significant disruptions to some economic activities over the short time frame remaining until 2030.[v] Most notably, land use constraints may create 'stranded land assets' in some locations, where land assets in ecologically important biomes can no longer be used to their maximum productive and profitable potential. Spatial distributions are highly relevant, as not all countries will need to protect and restore 30% of their ecosystems whilst others may have to conserve far more than 30%. Indeed, the most highly biodiverse remaining ecosystems are mainly located in developing and emerging countries, that are often also dependent on primary commodity exports from land-intensive economic activity to ensure macrofinancial stability.[23] What kinds of macroeconomic and financial stability risks might arise from rapid shifts in land use to meet the 30x30 targets? And which economies and regions are likely to be most affected?

This report sets out to explore these questions, addressing a prominent gap in the academic and policy literature on reversing nature loss. To do so, our analysis makes some simplifying assumptions. First, we assume *a priori* that the 30x30 targets will be achieved and thus abstract away from the various political and institutional challenges, as well as structural drivers of ongoing land use change, that might prevent that from happening.[24] Second, we assume for the purposes of our analysis that land uses for economic development are broadly incompatible with land uses for nature conservation and restoration. Of course this greatly simplifies the complex and 'messy' reality of interactions between land uses: small-scale farming, for example, can be either very beneficial or very harmful for nature depending on the locally-specific context of how and where it takes place.[25] However, we deploy these simplifications so as to illuminate the potential risk transmission channels by which rapid land use change trajectories might affect economic and financial stability. In doing so, we seek to contribute to an emerging literature on nature-related 'transition risks'.[26–28]

We start by reviewing the recent academic and policy literature that has explored the potential macroeconomic impacts of 30x30 target scenarios in integrated assessment models (IAMs) and discussing these results in the context of the broader theoretical literature. We identify that various adverse macrofinancial effects occurring in the short-term aftermath of a transition policy shock, before economies have time to adapt and adjust, are not captured in these models. Failing to account

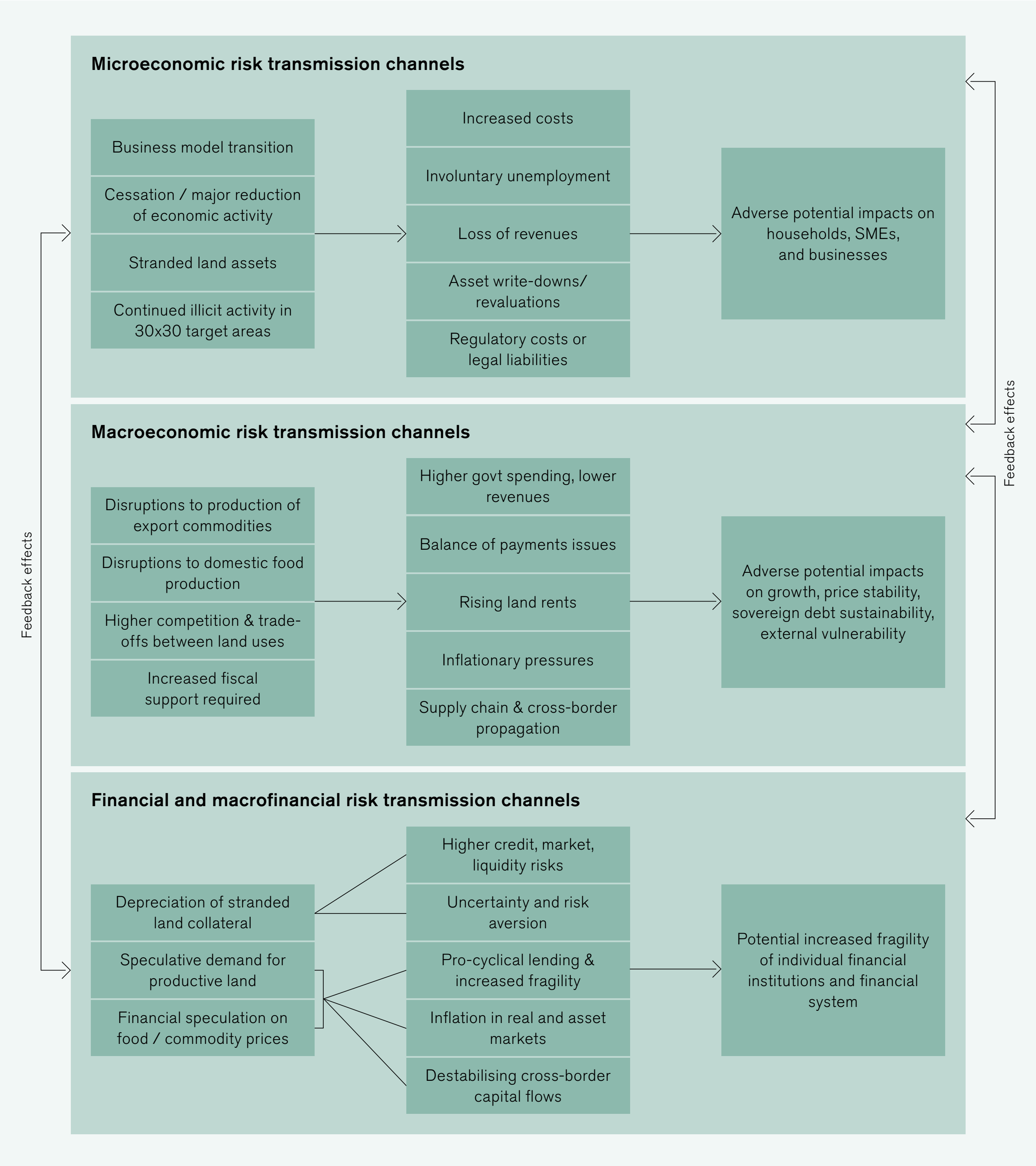
v It is estimated that approximately one third of highly biodiverse land areas are yet to be protected and, whilst at 17% of land area is now under some protection as of 2020, the quality of those protected areas still requires improvement to conserve and restore biodiversity.[22]

for these 'disequilibrium dynamics' means that IAMs may underestimate the transmission channels by which 30x30 target implementation might generate significant macrofinancial risks, or even a 'disorderly' transition.[vi]

Consequently, the main contribution of this report is the presentation of a novel conceptual framework that articulates the risk transmission channels posed by implementing the 30x30 targets and their possible implications for macroeconomic and financial stability (Figure 1). After articulating how the 30x30 targets might pose a potential transition risk 'hazard' via increased competition between land uses, the framework explores three key dimensions of risk transmission channels: (i) microeconomic channels, (ii) macroeconomic channels, and (iii) financial channels. The principal argument put forward is that the unique characteristics of land as an input to production (finite supply, location-specific qualities) and of land within the financial system (as loan collateral, portfolio asset) means land-related transition policy shocks could adversely affect macrofinancial stability in ways that are distinct from climate-related transition shocks. Finally, we use a simple cluster analysis approach to assess the potential for land competition between conservation and economic production in countries, globally. The conclusion discusses implications for policymakers and identifies avenues for future empirical research.

vi The Network for Greening the Financial System – a group of over 100 central bank and financial supervisors setting standards on scenario analysis for environmental risks – define a transition as 'disorderly' where it is characterised by 'late, sudden and/or unanticipated shifts in policy, the economy and financial system'. By contrast, an 'orderly' transition scenario assumes that policies are introduced early and become gradually more stringent, resulting in a smooth pathway to target goals with minimal transition risk.[29]

Figure 1: Potential risk transmission channels of 30x30 target implementation.



Source: Authors

2. Literature review

2.1 Existing studies

Over the past decade, a large body of academic and policy literature has explored the potential 'transition risks' that could result from the transition to a low-carbon economy, focusing in particular on the macrofinancial volatility that might accompany a 'disorderly' transition.[5,30–33] In recent years, policy attention has also turned to understanding the potential transition risks that could result from efforts to reverse nature loss. This research has already conceptualised various transmission channels for nature-related risks, but has not yet sufficiently focused on land use constraints.[34,35] More granular analysis on specific nature transition policies has primarily been explored using integrated assessment models (IAMs). A few recent studies have explored the potential effects of the 30x30 targets or similar land use constraints, in general finding that the implementation of these policies would incur relatively minor economic costs.

Using the GTAP-InVEST model, Johnson et al. (2021) estimate that the opportunity cost of implementing the 30x30 targets, relative to developing land to its most profitable use, is just $115 billion globally by 2030 (0.1% of global GDP), with the change in GDP across different country groups ranging from -1.93% (low income) to 0.0% (upper-middle income).[36] In the MAVA model, Naso et al. (2022) find social welfare losses of reducing the quantity of land allocated to agriculture by 37.5% over 15 years to be around -1.59% in 2025 and -0.88% in 2050, representing around 1% of global GDP.[37] Finally, using the MAGNET model, an analysis by the Dutch central bank finds that characterising 50% of the planet's land as a protected area, weighted towards the most biodiverse richest areas, would result in a 3.7% decrease in global production, a 17% increase in agricultural product prices, but only limited GDP declines globally.[27,vii]

Another recent study by Waldron et al. 2020 undertook a more detailed cost-benefit analysis of expanding protected areas (PAs) to meet 30x30 targets, focusing on the economic impacts to agricultural, forestry, and fisheries sectors at the global level.[38] It found that these sectors would in fact benefit from increased revenues of $64-454 billion by 2050, with the range reflecting different PA approaches taken, whilst the investment cost of implementing PAs was estimated at $103-178 billion. The final impact on global GDP by 2050 was projected to be as much as a $1 trillion *increase* per year, once multipliers capturing downstream effects were accounted for. In this study, increased revenues reflect a dynamic where the scarcity of land pushes up prices paid to producers and stimulates productivity improvements. However, the analysis did not account for the fact that producer costs might also increase (e.g., due to higher land rents/prices, intensification costs, longer distance to markets), nor the broader macroeconomic impacts that could result from higher food prices. A subsequent value-added analysis (producer revenues minus costs) in the same study found that the worst-case scenario would result in net losses of 0.7-1.2% to the agricultural sector, representing just a few tens of billions of dollars globally.

2.2 Limitations of existing studies

In these studies, the surprisingly low economic impacts of what amounts to a large-scale and rapid reorientation in land use dynamics reflects a mechanism within the underlying models where labour or capital allocation shifts to agriculture to compensate for the loss of land availability through increasing agricultural productivity or labour input. However, recent reviews of IAMs for nature and biodiversity-related scenarios have suggested that the economic components of these models

vii Whilst results for other countries are not reported in this study, spatial differences are relevant: agricultural production and GDP is actually estimated to increase in the Netherlands, due to trade substitution effects that favour the Dutch economy.

neglect important feedbacks between the biosphere and economy, and hence may underestimate likely economic impacts of physical or policy shocks.[39,40] Indeed, equilibrium-based[viii] IAMs assume *a priori* that producers and consumers are relatively easily able to adapt to the effects of price shocks through substitution of inputs/goods and trade. If the price of a consumption good (e.g., food) or production input (e.g., land) rises relative to another, that option can be switched for an alternative, meaning that substitution possibilities tend dampen the magnitude of economic impacts, especially at the macroeconomic level.[ix]

However, the ease with which the reduced availability of land for economic production can be compensated for by substitution and productivity improvements is highly contested. At a conceptual level, some economists have argued that aspects of nature – including land as a production input – should be regarded as *complements* rather than substitutes to human forms of capital in production.[43] Most notably, non-renewable resource availability, the finite availability of land, and its finite carrying capacity, are all defining constraints on economic activity.[3] As was well understood by the Classical economists Adam Smith, David Ricardo, and John Stuart Mill, the fixed supply and location-specific qualities of land render it a unique input into production that has limited substitutability with man-made capital.[44] For instance, investing to improve agricultural yields may maintain or even increase food production where there are only marginal losses in land area, but there are clear limits to the ability of technologies to compensate for very large reductions in the availability of land for agriculture.[x] Moreover, agricultural productivity gains may even perversely stimulate further land use change, through environmental 'rebound effects'.[xi]

Indeed, empirical evidence on the substitutability of land in production suggests that the impressive agricultural yield increases achieved over the course of the twentieth century are unlikely to be replicable into the future because many yield gaps have now already been closed, although geographical differences are highly relevant.[46] Moreover, additional agricultural intensification tends to have diminishing returns (notably fertiliser application) as well as resulting in other forms of ecological degradation, such as water scarcity and soil infertility.[47] As a result, future technological innovation may be insufficient (if still necessary) to fully compensate for constraints on the availability of land for economic production. These limitations on feasible productivity improvements are not transparently incorporated into IAMs investigating nature scenarios.[39,40]

Other assumptions underlying IAMs may also underestimate the broader macroeconomic impacts of price shocks caused by land constraints. For instance, many IAMs do not treat household consumption of food goods as essential consumption.[39] Typically, if faced with relatively more expensive food, households are modelled as able to substitute food goods for non-food goods in utility-maximising behavioural equations. Yet this assumption does not account for caloric intake as a biophysical constraint on consumption choices, and hence does not capture the broader macroeconomic impacts of large food price shocks (which intuitively should result in reduced

viii We refer to all IAMs that assume economies always reach a long-run equilibrium (i.e., where supply and demand is balanced in relevant markets and where there is no involuntary unemployment) as 'equilibrium-based' – including partial and general equilibrium models. Recent reviews have identified that the economic modules within IAMs used for nature scenarios so far are typically computable general equilibrium (CGE) models.[41]

ix The assumption that natural capital can be easily substituted with human forms of capital is also referred to as a 'weak sustainability' perspective.[42]

x It has been proposed that recent innovation in 'landless' food production (e.g., via vertical farming systems, hydroponics, aeroponics) could enable the absolute decoupling of food production from land use. However, such technologies are capital- and energy-intensive and have only been proven economically viable at scale for high-value horticultural crops rather than staple commodity crops. Various studies have shown that the decoupling of food production from land use is unlikely to be achievable without demand side measures (e.g., dietary shifts, reductions in food waste).[8,45]

xi For instance, (i) farmers may be more incentivised to convert natural land by the potential for higher earnings per hectare, (ii) productivity gains may feed through to lower prices thus increasing demand for agricultural products, and (iii) agricultural productivity gains may stimulate overall macroeconomic growth and employment, further increasing demand and land conversion pressures (see NGFS, 2023, p.25).[39]

consumption of other non-essential goods).[xii] IAMs also tend to assume smoothly functioning international markets, although network-based empirical work has shown that food resilience and resource scarcity can be undermined by trade dynamics through behaviours such as stockpiling and export bans.[49] Similarly, financial market dynamics (e.g., exchange rate shocks, asset bubbles, and credit crunches) can drastically exacerbate adverse economic shocks, but are not commonly captured within most IAMs.

Overall, the few studies to date that have explored the potential economic effects of implementing policies similar to the 30x30 targets have estimated relatively minor costs or even net benefits at the global scale. Where regional differences are explored, costs are estimated to be higher for low-income countries albeit arguably still muted in the context of recent global recessions.[xiii] In addition to the underlying assumptions discussed above, such results could also be partially explained by the fact that equilibrium-based IAMs are designed to assess the marginal effects of policy changes – i.e., holding all other factors equal – rather than rapid and transformative policy scenarios. Importantly, these models estimate economic impacts at the point of equilibrium, where the economy is assumed to have had time to price in all changes implied by a policy shock and adjust supply and demand in all relevant markets accordingly – in other words, an 'orderly' transition.

However, the various negative economic effects that could occur in the short-term aftermath of a transition policy shock before economies have time to adjust and adapt – i.e., the disequilibrium dynamics – are not captured in these models. This means that existing IAMs are structurally unable to account for all the economic dynamics that could lead to a 'disorderly' transition in land use. Such a blind spot is troubling, given that 'disorderly' transition scenarios are regarded to be the most important from a macroeconomic and financial stability perspective.[27] We therefore identify a need for a conceptual framework to articulate the transmission channels by which the implementation of the 30x30 targets could adversely impact macrofinancial stability in order to inform effective policy action to manage potential social and environmental trade-offs.

xii Ease of substitution is governed by elasticity of substitution parameters. Theoretical work has shown that accounting for a subsistence requirement in the consumption of ecosystem services decreases the ease of substitution between ecosystem services and manufactured inputs.[48] However, a recent review found that applied IAMs typically calibrate substitution elasticities according to historical data, without accounting for how substitution possibilities might change under unprecedented environmental change.[41]

xiii E.g., Johnson et al. (2021) estimate -1.93% shock to output in low-income countries from 30x30 target implementation.[36] GDP growth in low-income countries was -4.6% in 2012 following the fall-out of the global financial crisis (World Bank data).

3. Conceptual framework

Building on existing work on nature-related risks,[34,35] this section explores how 30x30 target implementation might generate transition risks that impact macroeconomic and financial stability. First, we articulate how implementing the 30x30 targets poses a potential source of transition risk, drawing on the existing literature. Then, we articulate the transmission channels that could generate adverse impacts at the microeconomic, macroeconomic, and macrofinancial levels.

3.1 Sources of risks[xiv]

The fact that economic activities in some locations will have to transition, stop, or be relocated in order to meet the conservation priorities of the 30x30 targets represents the principal source of transition risks. Potential competition between ecological and economic land uses stems from the more or less finite quantity of land, as well as clear biophysical limits to its abundance.[xv] A parcel of land can only produce so much food or raw materials, and its productive capacity can be exhausted through overuse, in turn diminishing the ecosystem services it can supply. Whilst land productivity can be enhanced in some cases, processes of restoration are far slower than degradation.[50,51] For sectors such as mining, it is the location-specific qualities of land (i.e., the spatial heterogeneity of where mineral seams are physically located) that limit the substitutability of one land parcel for another. Overall, these characteristics mean that land is a unique input to production, unlike other resources that can be more easily substituted or that can more readily increase in supply.

Agricultural production is the economic activity that most extensively comes into competition with conservation priorities. Of the 107 million square kilometres of habitable terrestrial surface (excluding glaciers and barren land), agriculture occupies the largest footprint at 45%,[xvi] with forest land at 38%, shrubland at 13%, and urban land at 1%.[52] Expansion of agricultural land area slowed dramatically from the 1960s onwards due to advancements in agricultural intensification practices (known as the "Green Revolution") that enabled food production to support a doubling of the global population without doubling the agricultural land footprint.[53] However, adverse forward-looking trends look increasingly likely to disrupt this relative decoupling, bringing food production increasingly into conflict with conservation priorities. Other land uses such as urbanisation and mining have less extensive land footprints but do have substantial direct impacts on proximate ecosystems that also look increasingly likely to conflict with conservation priorities under forward-looking scenarios of economic development.

On the demand side, land needed to provide food, fuel, minerals, and carbon sequestration is projected to increase even with slowing population growth. Various scenario modelling exercises estimate that meeting future food demand will require agricultural area to expand due to slowing improvements in crop yields.[54] Even under 'sustainable intensification' scenarios, where yield gaps are closed whilst eliminating over-use of fertilisers, it is estimated that an additional 570 million hectares of land area will be required for crops and pasture to feed a global population of 9.6 billion by 2050 – an area of land 1.7 times the size of India.[45] Land-based carbon dioxide removal (CDR) is also projected to require significant land area. One study estimated that achieving 2°C targets relying primarily on bioenergy with carbon capture and storage (BECCS) would require 380-700 million hectares of land (1.2 to 2.1 times the area of India).[55] Additionally, urbanization, mining, sand extraction, and the production of plant-derived materials for the bioeconomy are projected to increase

xiv Sources of risks are also referred to as 'hazards' in existing conceptual frameworks on environmental risks.

xv There are of course isolated examples of land 'reclamation', most notably the artificial islands of Dubai, yet the expense, capital/labour intensity, and serious environmental impacts of these projects likely rules them out as a feasible solution for most countries facing land constraints.

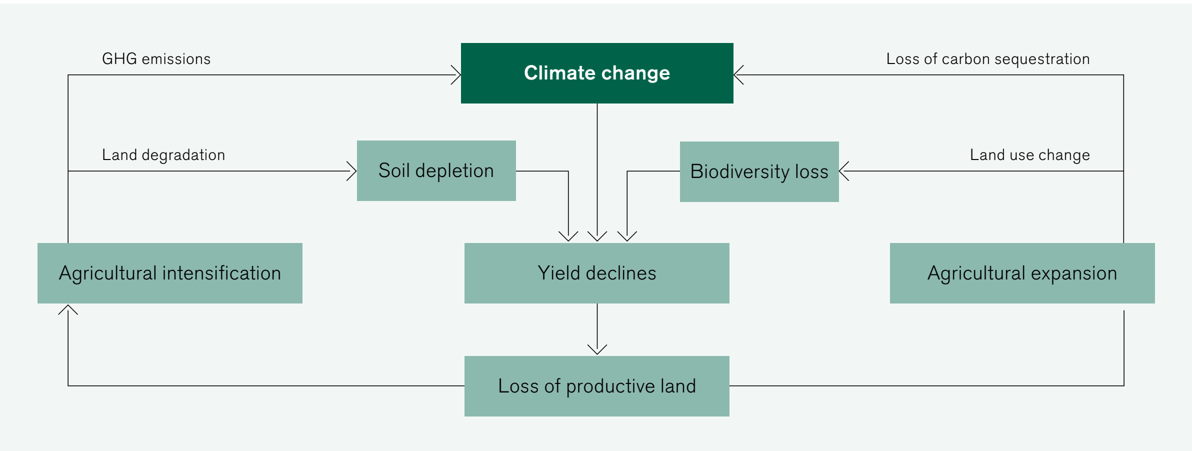
xvi 80% of agriculture's terrestrial land footprint is used to support livestock (grazing, and cropland for feed), whilst 16% is cropland for food, and 4% cropland for non-food crops (e.g., biofuels, fibres).[52]

over the coming decades.[8] Mining for critical metals, in particular, will increasingly conflict with biodiversity conservation as demand grows for mineral inputs for renewable energy production, with recent studies mapping overlaps between areas of mining importance and biodiversity importance.[56–58]

On the 'supply side', however, adverse environmental trends and human pressures threaten to undermine the availability of productive land suitable for cultivation – most notably, the effects of climate change (changing rainfall, temperatures, pests, diseases, wildfires, and water scarcity) and loss of soil fertility and pollinators resulting from unsustainable land management practices.[59,60] In addition, urban expansion – which is projected to increase – tends to displace prime agricultural land, impacting regional agricultural productivity.[61] The sea level rise implied by the tail risk scenario of global average temperatures reaching 4°C could also result in the loss of an area of land equivalent to 13% of today's arable land footprint, in turn displacing significant populations.[62] Importantly, these demand-and supply-side drivers of future land use pressures could interact to create a 'vicious circle' of land degradation and ongoing ecosystem conversion centred around the increasing scarcity of productive land. Here, increasing land footprints and land use intensification cause further declines in land productivity, in turn driving further land use change and intensification to compensate for the loss of crop yields amidst rising demand (see Figure 2).[63]

Overall, the 30x30 targets to protect 30% of terrestrial land area and restore 30% all degraded ecosystems will have to be implemented amid already unfavourable drivers impacting demand for and 'supply' of productive land. Given that ecosystem conservation and restoration ambitions cannot be achieved whilst prioritising large-scale food or bioenergy production on the same land area,[xvii] these dynamics paint a picture of productive land becoming – in aggregate – an increasingly scarce input to production. Importantly, the implementation of the 30x30 targets may result in the increasing scarcity of land available for economic uses, bringing conservation priorities increasingly into conflict with economic activity. These pressures could be especially acute in low-income countries that currently protect a smaller portion of land, have high levels of degraded land, and/or whose short- and medium-term economic development plans are likely to rely far more on land-based economic activities like agriculture, forestry, and mining. In order to better understand the potential for transition risks posed by implementing the 30x30 targets, the following sections explore the transmission channels by which increased competition between land uses could affect economic and financial stability.

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



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

xvii Large-scale agricultural, forestry, or other commercial uses of land – even if managed sustainably – do not count towards meeting Targets 2 and 3 because these activities are covered are by separate targets (notably Target 10). This means that Targets 2 and 3 focus primarily on conservation-focused land uses, with only a very limited set of conditions allowing small-scale, sustainable use.[64]

3.2 Microeconomic risk transmission channels

Recent policy literature has conceptualised transmission channels from sources of transition risk in terms of its micro- and macro-level effects on the economy.[26,27,35] At the micro-level, misalignment with actions aimed at protecting or reducing negative impacts on nature could affect businesses and households through higher or more volatile prices, disruption of processes, relocation of economic activities, or stranded assets.[26,27,35] This section articulates the additional, specific risk transmission channels that could arise from 30x30 target implementation. As explored in the previous section, commodity production – notably agriculture, forestry, and mining – is likely to feel the most severe economic effects of increased competition between land uses. In those locations where production is likely to conflict with conservation and restoration priorities (most notably, at the 'commodity frontier' close to highly biodiverse remaining ecosystems), land use constraints may present potentially large disruptions to the profitability and competitiveness of individual firms.

For smallholder farmers – defined as farms under two hectares – that are often household/family-owned businesses and that produce 30-34% of global food on 24% of agricultural land area,[65] agricultural activities located in areas of conservation or restoration importance are likely to require transitioning to more nature-friendly modes of food production. Depending on the financial support or compensation available for such a transition, this may impose significant cashflow difficulties upon households and small farming business, as well as a loss of way of life and sense of economic security.[xviii] Other types of smallholder activity located in biodiversity hotspots, such as artisanal mining, conflict substantially with conservation goals and withdrawal from these activities will require careful management of the trade-offs with local economic opportunities and the growing need for critical minerals for the energy transition.[66] For larger agricultural or other land-intensive businesses, including multinationals and farmland investment firms operating via own-and-lease schemes, land use constraints may have significant cashflow and balance sheet effects in the form of stranded assets, where holdings of land assets, mining or timber concessions, or infrastructure located in conservation priority areas will become restricted for economic uses.[xix]

Whilst there is a prominent blind spot in research into stranded agricultural and forestry land assets,[67] recent policy developments to tackle deforestation-linked commodities, most notably the European Union Deforestation Regulation (EUDR), implies future increases in stranded land assets within the timber, agriculture, livestock, and mining sectors in particular. Case study evidence suggests increasing instances of land stranding in the palm oil sector in South East Asia and West and Central Africa.[68] In Indonesia, for example, 29% of the country's oil palm concessions – an area of 6.1 million hectares, distributed across the whole oil palm sector – cannot be developed without contravening the No Deforestation, No Peatland, No Exploitation (NDPE) policies imposed by almost all major oil palm buyers and traders.[69] Companies holding stranded land assets may be forced into costly asset write-downs or sales below implied value. Large landbanks facing stranding in turn may result in equity revaluations for entire regional economic sectors, as well as reducing value of land-based loan collateral and hence access to financing.[xx] On the flipside, continuing to develop stranded land assets also poses commercial risks for firms, as it risks suspension by major buyers, material loss of revenues, and potential legal liabilities – especially

xviii Especially as nature-friendly production strategies may result in lower yields and revenues. Note that the 'sustainable use' provision of Target 3 does imply a limited tolerance for low-impact subsistence-level farming and harvesting from natural ecosystems.

xix Whilst beyond the scope of this report, it is worth noting that stranded land assets may also result from physical hazards – e.g., loss of soil fertility from unsustainable farming practices can leave agricultural land severely degraded to the point of no longer supporting reliable food production.

xx Anecdotal evidence suggests that some of these effects have been in play within Indonesia's major oil palm growers, although 'leakage markets' (selling to non-NDPE compliant buyers) and shifting deforestation-related activities to biofuels production have also emerged as alternative development uses for stranded land assets, hence continuing to contribute to deforestation.[70]

as major markets impose regulations to ensure deforestation-free supply chains (such as the EUDR). For example, agricultural multinationals Cargill and JBS have faced increased litigation in recent years for sourcing commodities from deforestation zones.[71,72]

Market-based mechanisms have been proposed as one solution that could compensate for the micro-level risk potential of stranded land assets, reducing the adverse economic effects felt by individual actors.[xxi] Also increasingly referred to as 'nature markets', instruments such as payments for ecosystem services, biodiversity offsets, and biodiversity credits broadly seek to advance novel income streams to land holders for conserving ecosystems that they would otherwise transform for economic purposes.[73] However, despite various iterations of different types of nature markets being trialled over the past two decades, few studies demonstrate empirical evidence of conservation effectiveness,[74,75] and some have identified significant challenges to their implementation and potential for scalability.[76–78] In particular, many land-based offset programmes have been shown to suffer from weak or no additionality – or in other words, the land assets underlying such instruments were not at risk of conversion in the first place (i.e., they weren't stranded) and so have not delivered any measurable 'gains' in conservation outcomes.[79–81] Whilst nature markets may yet play a critical role in enabling rapid shifts required in land uses, it is far from clear if they are able to *fully* compensate for the microeconomic risk transmission channels posed by taking conservation-priority land out of economic use.

3.3 Macroeconomic risk transmission channels

At the macroeconomic level, reduced commodity production due to land use constraints could also have broader regional and macroeconomic impacts, for example impacting other sectors, price stability, fiscal balances, and cross-border dynamics. Suspension of economic concessions could have knock-on effects on downstream industries involved in the supply chains of commodity sectors (e.g., refining, processing, and manufacturing industries). Various studies have shown that accounting for these indirect dependencies in value chains substantially increases the magnitude of environmental shocks.[26,82,83] Local and regional employment opportunities could also initially be adversely affected, although the creation of protected areas also has the potential to generate conservation or restoration based employment opportunities.[84]

For export-oriented economies, disruptions or reductions in the production of primary commodities for export may have significant implications in the short term for fiscal revenues and foreign exchange earnings. A number of studies have found a strong association between dependence upon primary commodity exports and increased external vulnerability.[85,86] In some (particularly lower income) countries, primary commodity exports are crucial to securing the balance of trade, current account positions, and access to dollar liquidity to service external liabilities – and significant loss of export revenues may have the potential to trigger balance of payments or sovereign debt crises.[87] These risk transmission channels are likely to be particularly severe for those commodity export-dependent countries located in highly biodiverse areas.[24,xxii]

Macroeconomic risk transmission channels may be exacerbated by land rent dynamics. When a typical capital stock is stranded (e.g., coal-power plant), its value falls with lower demand for its use and investment can be reallocated to other forms of capital (e.g., renewable power generation) that can increase in supply to accommodate increased demand. By contrast, the fixed supply of land means that land use restrictions coupled with increased competition for land could push up land prices and rents for productive land found outside of conservation zones. This could in turn increase costs for economic activities relying on land and/or land-intensive commodities as inputs

xxi These mechanisms also have implications for financial risk, which we discuss in Section 3.3.

xxii Primary commodity export dependence also represents an important structural drivers of ongoing land use change, as well as potential obstacles to the effective implementation of the 30x30 targets (see Dempsey et al., 2024).

– notably key food commodities. The dynamics driving and resulting from land rents are complex and influenced by country-specific institutions, but rising land-related rents are likely to increase inequality and drag on consumer demand, as well as generate additional inflationary pressures.[88]

Very land-constrained countries, for instance, may face tricky trade-offs allocating remaining land between domestic food production and export commodity production. Reduced land availability for agriculture coupled with increased frequency of climate shocks and declining ecosystem services would be expected to lead to structurally higher inflation via higher food prices.[89,90] Food shortages or higher food prices in turn represent a transmission channel where cross-border dynamics might amplify shocks more widely. Whilst rising prices might benefit the terms of trade for agricultural exporters, food importers face serious fiscal risks from higher import bills, the need to provide food subsidies, and mitigate against increased poverty. Rising food prices can also adversely impact the balance of payments, via declining foreign exchange reserves to pay higher import bills and undermine the ability to pay foreign-denominated liabilities. These fiscal stress dynamics have been empirically documented particularly in low-income food-importing countries.[91,92]

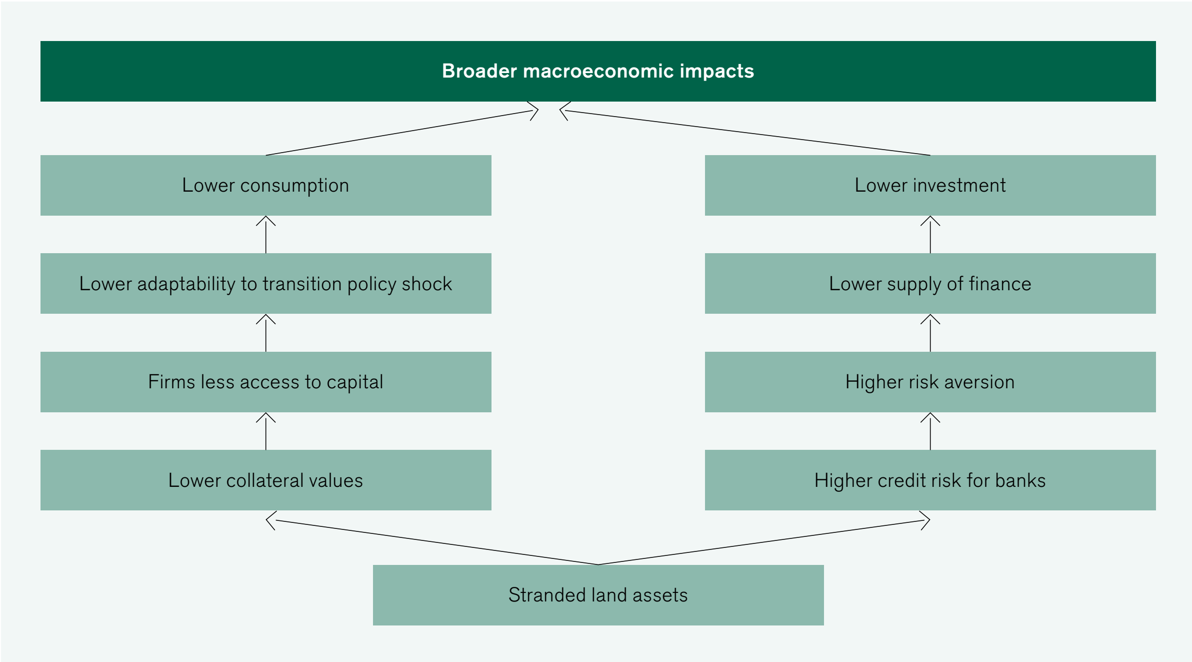
To counteract inflationary pressures from agricultural prices, ensuring future domestic food security may require transformative measures, such as export bans and reshaping domestic agriculture away from commodity crops in favour of meeting domestic food needs. Substantial capital investment may also be warranted to deploy yield-enhancing technologies on productive land, requiring supportive financial conditions – particularly in countries where the proportion of smallholder farms supplying domestic food is significant. The extent to which international trade can alleviate food price or supply shocks is dependent on complex interacting factors. In particular, network effects and non-optimising behaviours (e.g., domestic hoarding) could result in further cascading shocks across regions, but global supply chain implications from food system shocks are generally not well understood.[93]

3.4 - Financial and macrofinancial risk transmission channels

Finally, we articulate the financial risk transmission channels, both for individual institutions and for the financial system as a whole. In much the same way as has been conceptualised for climate-related transition risks, financial risks from nature-related transition policies can materialise if financial institution activity (its lending, investing, or insurance activities) become misaligned with the aims of the 30x30 targets. At the micro level, adverse impacts on individual firms could also feed through to financial balance sheets via increased credit, liquidity, and underwriting risk. Macroeconomic risk transmission channels can affect overall perceptions of market risk, through increased uncertainty and risk aversion, thus worsening financing conditions and potentially exacerbating the economic effects of the transition shock.[94]

In addition, unlike with most climate risks, the unique role fulfilled by land in the financial system could result in additional feedback effects.[44] Land does not only have a productive use value, related to revenues generated from activities such as agriculture and mining, but it also holds a speculative use value. For example, land is regularly treated as a financial asset whose value depends on expected future returns. Moreover, land is scarce in supply and can act as a store of value, as well as a liquidity value because it can be used as collateral to access finance. Indeed, empirical analysis has shown that land values tend to appreciate relative to other assets and to economic growth over the long run.[95] These characteristics render land an appealing safe asset for investment portfolios, as well as an ideal form of 'reliable' collateral for the financial system. Various studies have shown that farmland collateral is an important factor in explaining access to and cost of credit in rural communities, particularly in developing countries.[96–99] Taken together, these alternative sources of demand for land assets pose additional risks for financial balance sheets.

Figure 3. Macrofinancial effects of stranded land assets via the bank collateral channel



Source: authors

On the one hand, the depreciating value of *stranded* land assets represents a potentially significant source of credit risk through depreciating collateral values. As depicted in Figure 3, lower collateral values of land may not only worsen the credit profile of bank balance sheets, but also exacerbate transition shocks in the real economy, by increasing financial sector risk aversion and worsening financing conditions at a time when firms and households may need more capital to support the relocation or reorientation of economic activities. Causal evidence linking both lower collateral values and damaged bank balance sheets to adverse effects in the broader real economy has been well-documented in the context of residential land assets, and housing crises.[100–102] However, the potential magnitude of financial risks posed by stranded agricultural land or mining concessions is not well-established: not only is the extent of stranded land and related value-at-risk rarely included in company analysis, but evidence from the Indonesian oil palm sector suggest that corporate disclosures of undeveloped land concessions is low and inconsistent.[103] As such, the potential magnitude of macro-level impacts from the bank collateral channel remain largely unknown, revealing an important area to target corporate disclosures and future empirical research.

On the other hand, the value of remaining *productive* land outside of conservation zones may increase in countries where it becomes scarcer, encouraging speculative financial activity and asset bubble dynamics. Unlike conventional commodities (where increasing prices depress demand and then supply), lending against land tends to generate its own demand for more borrowing.[104] Rising land prices can have the effect of increasing demand for mortgage credit in turn further fuelling land prices, whilst the rise in collateral values has also been shown to be a factor in business investment decisions,[105] further stimulating the demand and supply of credit. Importantly, the self-reinforcing feedback loop that results from the interactions of fixed supply of land and the relatively more elastic supply of credit is a source of pro-cyclicity: economic or policy shocks can result in the implosion of the cycle, and drastically worsen broader macroeconomic conditions.[104]

The treatment of agricultural land as a portfolio asset by financial actors has been well-documented empirically, as has the speculative rush for agricultural land in lower-income countries in the early 2000s, as part of a 'global land rush'.[106–110] Most notably, studies exploring the 47 million hectares of large-scale land acquisitions (LSLAs) for agricultural purposes that took place between 2000 and 2014,[xxiii] mainly in low- and middle-income economies, have found that 76% of land purchases were by non-domestic investors, with financial institutions prominently featured.[111–113] Moreover, LSLAs are associated with subsequent deforestation as foreign investors target areas of high forest cover for its high transformation potential,[112] evidence which tends to support the capital gains (i.e., speculative) appeal of land assets in financial portfolios.[114] These assets also could potentially be subject to transition risks from 30x30 target implementation.

More recently, burgeoning regulatory and voluntary markets for carbon and biodiversity offsets have resuscitated concerns that land grabbing dynamics may accelerate under the guise of 'green grabbing', as new financial instruments facilitate additional sources of demand into rural land markets.[9] In Scotland, for instance, rural land values increased by 87% between 2020 and 2021 with demand largely driven by investor demand for land assets for offsetting and afforestation.[115] The sub-Saharan country of Liberia also recently conceded 10% of its land area to an Emirati company for carbon offsetting purposes.[116] Offsetting instruments may be particularly susceptible to speculative effects as many programmes now aim to build liquid secondary markets aimed at scalability and attracting mainstream financial actors into carbon or conservation financing. Yet securing the returns, standardisation, and scalability required to attract large-scale investment funds has thus far proven challenging with nature-related asset classes,[117] leading some to propose that it is speculation on rising values of the underlying land assets that is attracting investors to offsets, rather than returns from monetising the provision of ecosystem services.[118]

At the macro-level, it could be argued that rising land values for remaining productive land may 'balance out' the risks posed by stranded land assets. Whilst this might be true within a financial portfolio, the effects of speculative demand are well-established to be negative for real economy dynamics over the medium to long run. For instance, studies of residential land show a causal link between greater speculative demand during 'boom' times and more pronounced negative impacts on employment, wages, and per capital income during economic busts.[119] There is a prominent research gap on the effects of rural land speculation but several macrofinancial transmission channels might become relevant in some jurisdictions.

First, higher agricultural land prices may become a potential source of pro-cyclicity within some jurisdictions, as higher asset values encourage further debt-financed speculative demand and increase the overall fragility of the financial system. In developing countries, this could materialise as another 'global land rush' by investors seeking agricultural land as portfolio assets, exacerbating rising land values.[8] Second, higher agricultural or commodity prices may encourage financial speculation, exacerbating inflationary pressures and potentially food insecurity. Financial derivatives, for instance, are well-documented to have contributed to the rapid price increases in staple food commodities that dramatically worsened food poverty in 2008.[120] Third, financial speculation can also result in destabilising effects in commodity-exporting countries, via boom/bust dynamics. Whilst commodity price booms stimulate capital inflows, downturns in commodity cycles can trigger capital outflows that induce exchange rate depreciations, increasing the burden of debt for domestic firms/governments, and weakening growth.[87] Indeed, historical evidence has demonstrated a strong correlation between the boom and bust of commodity prices, capital in/outflows, and sovereign defaults.[86,121] Future research should further explore these dynamics and their possible feedback effects on the micro- and macroeconomic risk transmission channels discussed above.

xxiii The studies used data from the Land Matrix – a dataset of 82,000 land deals across 15 countries, focussed mainly in Latin America and Sub-Saharan Africa.

3.5 The significance of disequilibrium dynamics in understanding 30x30 target transition risk

Many of the risk transmission channels identified in this Conceptual Framework are 'disequilibrium dynamics' – i.e., they can be expected to occur in the short-term aftermath of a transition policy shock, before economies have time to adjust and adapt.[xxiv] As discussed in Section 2, existing IAMs exploring nature transition scenarios assume that the economy is in equilibrium, meaning they estimate economic effects of a policy shock after supply and demand is assumed to have been balanced in all markets via price adjustments. These models also impose strong normative assumptions on rational behaviours of homogenous economic agents in responses to policy changes.[123] However, the risk transmission channels articulated in this Section reveal that there are many short-term economic dislocations, non-rational behaviours, and heterogeneities that might delay or complicate the achievement of an optimal equilibrium pathway.

These disequilibrium dynamics are highly relevant to understanding the potential transition risks that could arise from increased competition between land uses. Most notably, disruptions to the supply of food and key commodities are unlikely to be smoothly absorbed by market mechanisms, because non-rational behaviours such as hoarding, speculative demand, and risk aversion are likely to undermine price adjustment mechanisms.[xxv] Additionally, the analysis in this Section has also highlighted that the differentiated economic and financial position of low-income economies within the global economy is also highly relevant to understanding potential risk transmission channels because higher debt burdens and dollar liquidity needs result in increased vulnerability to capital outflows and reduced fiscal capacity.

Overall, this Conceptual Framework reveals a number of blind spots not captured within current nature IAMs. These transmission channels and their potential disequilibrium effects are summarised in Table 1. Arguably, no single modelling framework can be relied upon to account for all possible dynamics of a rapid transition in land uses to achieve the 30x30 targets. This reality highlights a need for additional approaches to macrofinancial risk assessment to inform policymakers on relevant risk exposures faced by their jurisdictions. For example, a recent report by the C3A Nature Transition Hub suggests the need to explore alternative scenario and modelling frameworks to conduct nature-related risk assessments.[xxvi]

The above Conceptual Framework provides a useful starting point for empirically assessing transition risks through multiple different transmission channels. The following section will now elucidate a simplified method for analysing risk exposure arising through one of the macroeconomic channels: the potential for land competition between conservation and economic production within a given country.

xxiv Some disequilibrium dynamics may even persist over the medium- to long-term, resulting in complex systems behaviour.[122]

xxv Briefly, in CGE models, prices adjust to quantities, and agents adjust their behaviour to prices. Thus, food shortages would lead to higher prices, and consumers substituting food for other items in their consumption baskets. In other words, hunger is not satisfactorily accounted for in an equilibrium framework. Similarly, higher prices of material commodities would stimulate technological adaptation. Whilst this is a reasonable assumption in the medium run, it does not account for the inflationary pressures, supply disruptions, and shifting trade dynamics that result from near-term supply shocks in key commodities, which may have broader adverse macroeconomic effects.

xxvi In particular, the report discusses how policymakers require a method for connecting national macroeconomic outcomes to both local (e.g., changes in land use) and global dynamics (e.g., changes in global policy) through multiple different channels. Furthermore, they highlight the need for moving beyond equilibrium-based models to better understand non-linear changes in macroeconomic variables (including via feedback loops), intersectoral dependencies, and limited possibilities for substitution between factors of production (e.g., between land, capital and labour).

Table 1. Summary of 30x30 target implementation risk transmission channels

TRANSMISSION CHANNEL	POTENTIAL 'DISEQUILIBRIUM' EFFECTS
Microeconomic	
Transition to nature-friendly modes of production	Increased costs and capital expenditure requirements, lower short-term yields. Higher risk aversion resulting from cashflow difficulties. A 'smooth' transition may not be possible without financial support.
Cessation of economic activity	Loss of economic security/way of life, impacting consumption and investment/savings behaviours. Involuntary unemployment and regional displacement.
Stranded land assets	Asset write-downs, forced sales below market value, equity revaluations. Increased cost of financing.
Continued economic development in areas of conservation importance	Suspension by major buyers, loss of revenues (e.g., if can only sell below market value), legal liabilities, increased regulatory costs.
Macroeconomic	
Supply chain propagation	Adverse impacts on economic health of upstream and downstream activities connected to affected economic sectors, with broader effects on employment and regional economic stability (including cross-border effects).
Disruptions to production of primary commodity exports	Adverse impacts on trade balance, current account position, dollar liquidity, sovereign debt sustainability. Inflationary pressures, increased fiscal expenditures to support affected sectors.
Higher land rents	Increased input costs, inflationary pressures, reduced consumer demand, depressed business investment, longer term effects on inequality.
Food shortages / higher food prices	Adverse effects on poverty, health, inequality, economic security, risk aversion, influencing consumption/savings/investment behaviours. Higher fiscal expenditures from increased food subsidies, support to population, adverse impacts on trade balance and foreign exchange reserves.
Financial	
Depreciation of stranded land collateral	Higher credit risk for banks, particularly regional banks with high exposures to affected sectors. Higher risk aversion, lower supply of finance for investment. Firms less access to / higher cost of capital, lower adaptability to transition policy shock. Source of transition risk on balance sheets of investors.
Speculative demand for remaining productive land	Exacerbation of dynamics caused by rising land rents, potential source of pro-cyclicity and systemic fragility if induces debt-financed speculation.
Financial speculation on food/ commodity prices	Exacerbation of inflationary pressures and food insecurity. Capital in/outflows strongly correlated to commodity cycles can further destabilise macroeconomic risk transmission channels.

Source: authors

4. Empirical cluster analysis of country risk exposure to competition between land uses

The conceptual framework has identified the potential mechanisms by which the 30x30 targets could impact economic and financial stability. However, in considering which economies and regions are likely to be most affected by increased competition for land uses, geographical variation is highly relevant. For instance, over 80% of the land areas in Ecuador, Costa Rica, and Suriname are of conservation importance, compared to only 32.3% in Europe, suggesting substantial geographical imbalances in the size of additional conservation priority areas between global north and south.[124] Similarly, competition between land for economic and conservation uses will not play out in all countries: 1.72% of land identified for conservation in developed countries is projected to be at risk of habitat conversion by 2050 in a worst-case scenario, compared to more than 12% in developing countries.[124]

To understand the countries where the implementation of 30x30 targets may become a source of potential transition risk, we conducted a Principal Component Analysis (PCA) of recent cross-sectional datasets of land areas of conservation importance and selected economic indicators. PCA is a technique used to reduce the dimensionality of large datasets whilst preserving as much of the statistical information within the original dataset as possible. Formally, the technique finds new variables (Principal Components – PCs) that are linear combinations of those in the underlying data, that maximize variance, and that are uncorrelated with each other.[122] The reduced dimensionality enabled by the PCs increases the interpretability of large datasets whilst importantly preserving the relationships that might exist between variables. For our purposes, the PCA enables descriptive analysis of patterns across countries, and helps to identify key country groups that share common features.

First, we identified key indicators based on three commonly used dimensions of potential risk: hazard, exposure, and vulnerability.[125] Our chosen 'hazard' indicators denote the magnitude of the potential transition policy shock – i.e., the extent of land in each country identified as important for conservation, including existing protected areas as well as Key Biodiversity Areas (KBAs), Ecologically Intact Areas (EIAs) and 'New Priority' conservation areas, based on species conservation priorities.[xxvii] This cross-sectional data was taken from spatial analysis undertaken by Allen et al. (2022).[124]

Exposure metrics capture the extent to which required conservation areas might come into competition with economically important productive uses. Here, we focus primarily on the agricultural sector and include the extent of agricultural land area in a country, the share of population employed in agriculture, and the area of conservation-priority intact land projected to be at risk of habitat conversion by 2030 and 2050 in each country, under a 'middle of the road' SSP2 scenario for future economic and population growth. Finally, the vulnerability dimension aims to capture the extent to which a country can adapt to the economic effects of land use constraints. Whilst many factors can influence adaptability, we focus in this initial analysis on food system resilience and include a measure of food insecurity status. Across these 9 variables, we obtained a coverage of 150 countries.[xxviii] All variables were normalized. Table 2 reports the first three principal components (PCs) which together explain 62% of the variance in the underlying dataset of multiple indicators.

xxvii We use proportion of relevant land area in each country for all the spatial metrics in order to avoid the distorting effect of country size, and because our research question is more interested in the significance of land areas within each country (to understand economic risks) rather than overall size of conservation areas (which is more of ecological relevance).

xxviii Most of the countries not included have a very small land area and hence weren't well captured by the spatial datasets. Some larger countries are also not included due to insufficient data, these include Greenland, New Caledonia, Puerto Rico, Sudan, South Sudan, and Taiwan. We further excluded the Comoros Islands from the analysis as an outlier due an error in one of the underlying datasets. The 150 countries in our sample are listed in the Annex.

Table 2: Correlation factors for principal components, description and source of underlying data

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 Mkm²) (Yr. 2020)	0.22	-0.06	-0.39	Allan et al. 2022
KBA	Key Biodiversity Areas (% of country land area) (11.6 Mkm²) (Yr. 2020)	0.43	0.28	-0.18	Allan et al. 2022
EIA	Ecologically Intact Areas, (% of country land area) (35.1 Mkm²) (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 Mkm²) (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 Mkm²) (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

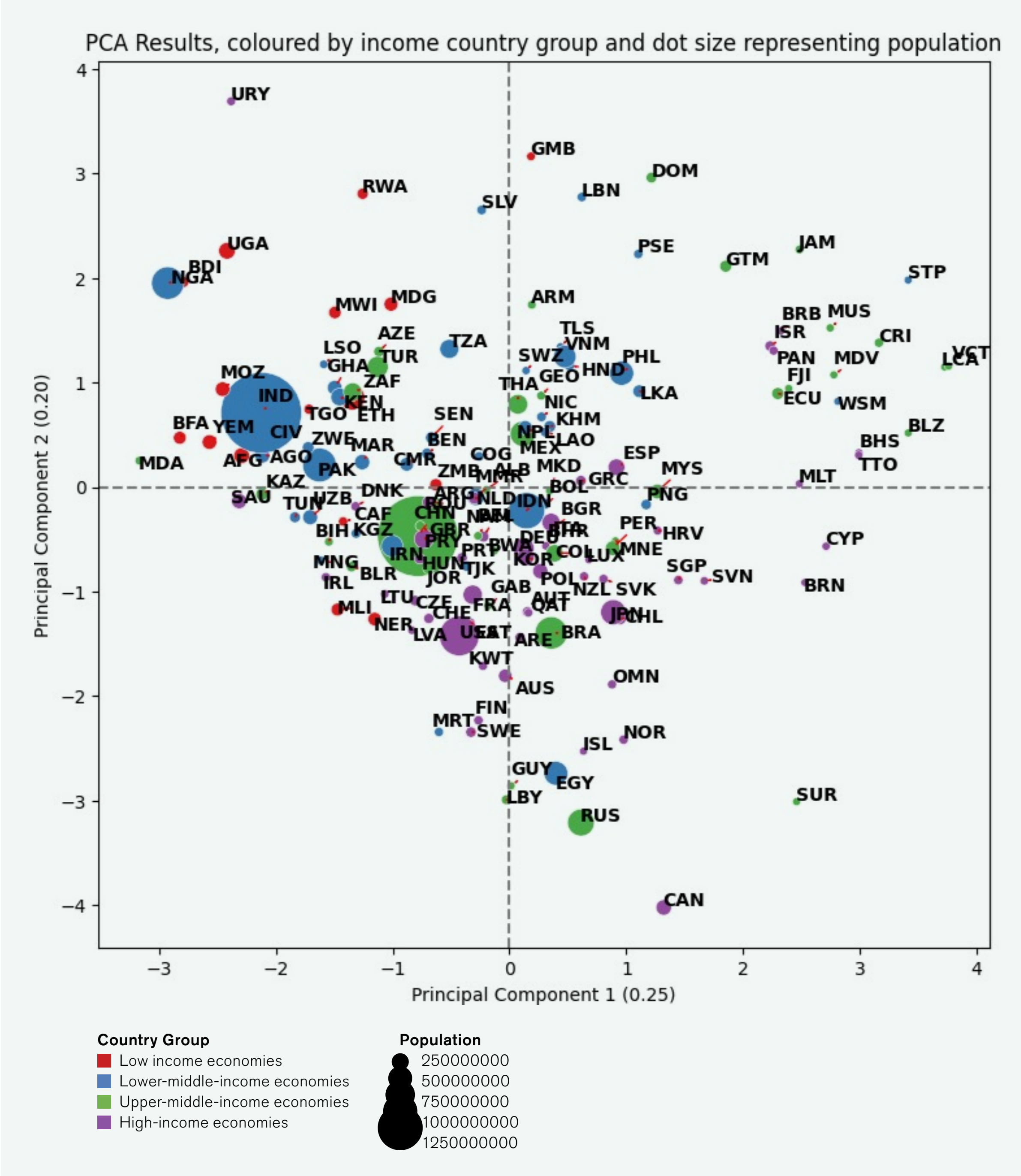
Source: authors

Each PC is associated with a small number of the underlying variables. PC1 is most associated with the total proportion of land area identified as important for conservation and the proportion of Key Biodiversity Areas within this country, whilst it is negatively associated with extent of agricultural land. We can therefore thematically understand this PC as explaining the 'Conservation Importance' of a country. PC2 is most associated with the proportions of new additional land area identified as priorities for conservation, intact land at risk of habitat loss by 2030, and agricultural land extent, whilst being negatively associated with ecologically intact areas. We therefore label PC2 as describing exposure to potential land competition. Finally, PC3 is most associated with food insecurity, employment share in agriculture, and proportion of ecologically intact areas. A higher score on this cluster might indicate a lower adaptability of the economy to withstand food system impacts of land competition, especially because of additional pressures within the conservation science community to preserve the world's remaining EIAs.[126] We hence label this PC as 'Economic Adaptability', acknowledging it is only a partial measure that requires more cautious interpretation. Loading charts that plot the correlations of each variable within each can be found in the Annex.

The results of the PCA are presented in the country scatter plots below. Importantly, the scores of a particular country are relative to all the other countries in the sample. Hence, a higher score on PC1 is to be interpreted as a particular country being more associated with having lands of conservation importance, relative to other countries; whilst a score of 0 indicates that a country holds an average value relative to other countries. Figure 6 plots country scores for PC1 versus PC2 and reveals clear patterns of hazard and exposure. Most notably, there is a clear cluster of countries in the top right quadrant of the plot, which represents countries with higher proportions of conservation-priority land and where more land competition pressures are present. These countries include island states (e.g., Jamaica, Sao Tome and Principe, Maldives), Central and South American countries (e.g., Guatemala, Costa Rica, Ecuador, Belize), and some Mediterranean countries (notably Israel, Lebanon, and Palestine).

Most high-income countries show average or slightly below average conservation importance and land competition pressures (bottom right quadrant). Yet there is also a small cluster of countries of conservation importance but with less land competition pressures (bottom right quadrant) – notably larger countries (Canada, Russia) and those with small populations (Norway, Suriname). Finally, the top left quadrant reveals a dispersed cluster of countries where land competition pressures are above average, but land is deemed less of conservation importance. It is notable that these countries are almost all low and low-middle income economies, with strong representation of the sub-Saharan African states. However, we caution interpretation of 'less conservation importance' here as the underlying dataset may reproduce common internal biases within conservation science that weight ecological importance more towards tropical biomes than other types of ecosystems (e.g., savannahs) due to the higher density of species and biodiversity in the tropics, and consequently skew scientific focus.[127]

Figure 6: Country scatter plot, Conservation Importance (PC1) vs Land Competition (PC2)



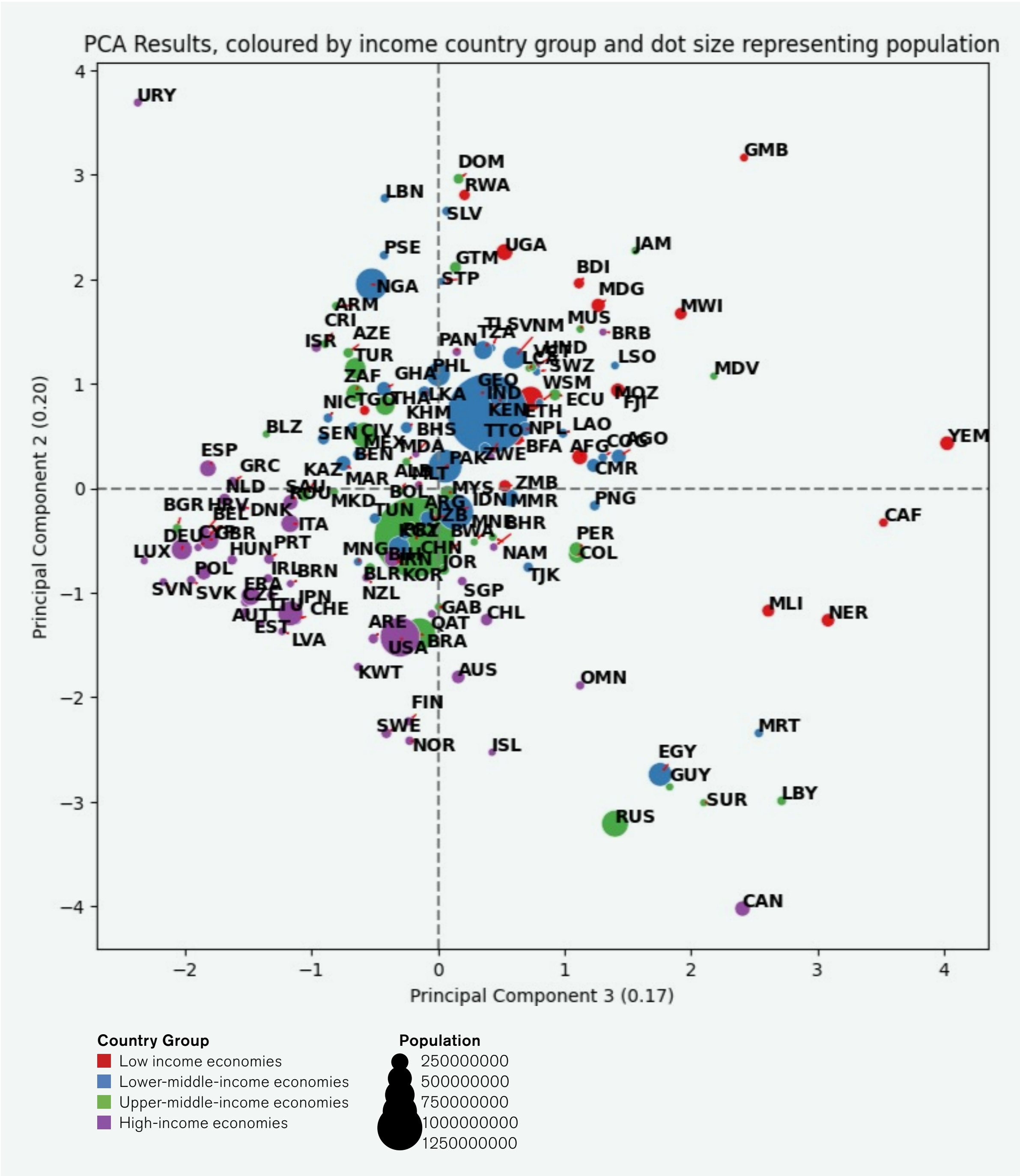
Source: authors

Land competition pressures and degree of economic adaptability between countries largely reflect per capita income levels.[xxix] In Figure 7, the PCA indicates lower land competition pressures and higher economic adaptability for almost all high-income countries (bottom left quadrant). Meanwhile, lower-middle and low-income economies almost exclusively occupy the top right quadrant, indicating that higher land competition pressures coexist with a lower adaptability of the economy to rapid changes in land uses. Most notably, the Gambia, Yemen, Jamaica, Malawi, the Maldives, Burundi

xxix Canada and Russia also score higher on PC3, reflecting the large proportions of their land area that are ecologically intact areas – which also correlated strongly with the component, meaning that caution is needed in interpreting PC3 as a measure of economic vulnerability.

and Madagascar have high proportions of their labour force working in agriculture, and a higher instances of severe food insecurity – suggesting that disruptions to domestic food production, local employment opportunities, and consequent adverse fiscal effects might present significant economic risk transmission channels in areas of conservation importance. Of course, PC3 captures only a partial picture of economic adaptability. As articulated in Section 3, reliance on export commodity production, constrained fiscal space, and higher external vulnerability can also significantly constrain the ability of an economy to adapt to a rapid shift in land uses in an orderly fashion, but these factors are not incorporated in this analysis.

Figure 7: Country scatter plot, Economic Adaptability (PC3) vs Land Competition (PC2)



Source: authors

Some additional limitations of our analysis are worthy of note. Our focus on the agricultural sector as a pressure contributing to land competition does not account for the potential mitigating role of technological progress. Lower income countries that deploy a greater proportion of their land area and labour force towards food production often also have larger yield gaps and hence could benefit from greater intensification of their agriculture to produce more food on less land. We omitted this variable due to the lack of broad global coverage of such data (in particular low data coverage for small island countries). Whilst closing yield gaps could act as a 'safety cushion' for some countries experiencing land use competition, it is also worth noting that monoculture-focused agricultural intensification practices often have adverse impacts on local biodiversity, and that the potential for yield gap closure to maintain food production is highly uncertain in the context of the physical effects of climate change and ongoing soil degradation.[45]

Another notable limitation of this PCA is that it does not consider interconnections between countries that might act as factors either mitigating or amplifying risk transmission channels, such as trade effects or cross-border financial dynamics. The very nature of PCA as a method necessarily requires some subjective reductionism of the complex underlying dynamics at play, which encompass diverse institutional and geopolitical processes, as well as geographical and economic differences. For these reasons, the use of PCA in this section should be regarded as a first step to deeper analysis. However overall, our high-level cluster analysis has identified country groups according to 3 dimensions of potential transition risk (hazard, exposure, vulnerability). Our main finding provides support to the arguments presented in Section 3, confirming that the risk transmission channels posed by the implementation of the 30x30 targets are likely to be disproportionately skewed towards low- and middle-income countries.

5. Conclusion

This paper has presented a novel conceptual framework articulating the channels by which a transition to implement the 30x30 targets may affect economic and financial stability. A key finding of this framework is that the importance of productive land to primary commodity production, as well as the specific role land plays within the financial system, means that land-related transition policy shocks impose additional and distinct risk transmission channels compared to climate-related policy shocks. Our high-level cluster analysis suggests that the risk transmission channels posed by the implementation of the 30x30 targets are likely to be disproportionately skewed towards low- and middle-income countries. These countries generally have a higher proportion of lands of conservation importance, a higher exposure to land competition pressures, and a lower adaptability of the economy to pressures on the food system. Our findings contribute to the growing literature on the biophysical constraints of future development trajectories,[2,10,55,128] by focusing on the specificities of land constraints in the context of the Global Biodiversity Framework Targets.

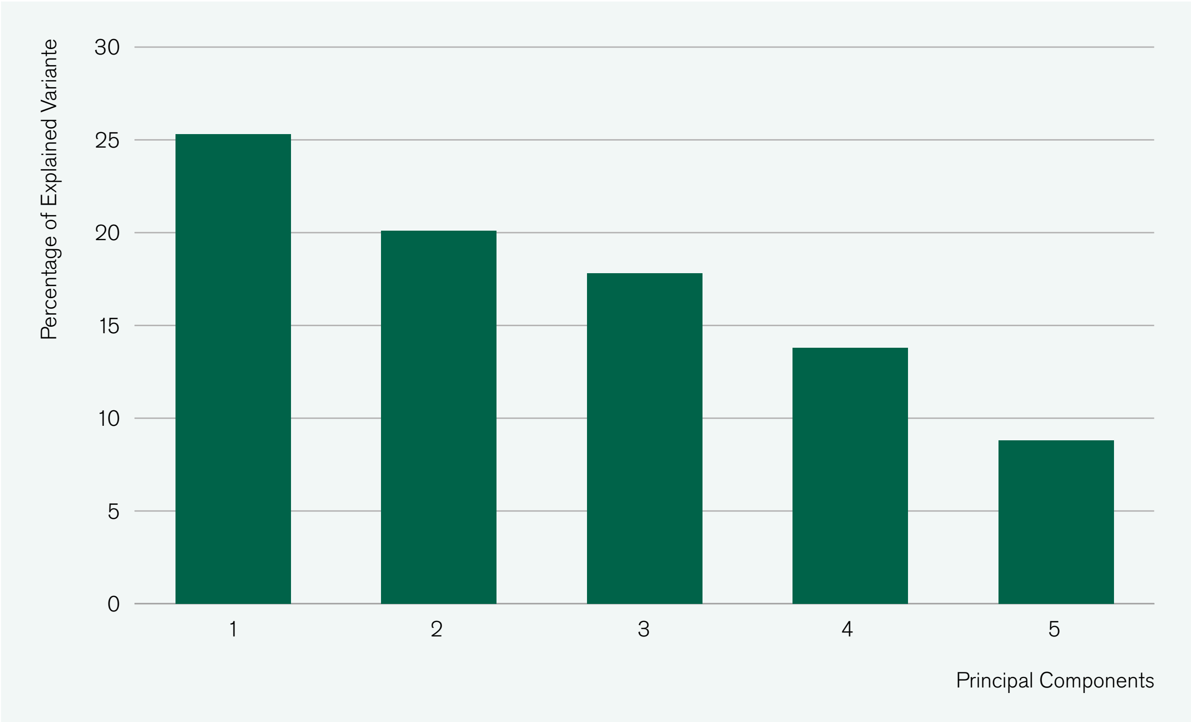
Our findings also have several implications for policymakers. First, the 30x30 targets may require tricky trade-offs between economic development on the one hand, and ecosystem protection and restoration on the other hand – particularly for low- and middle-income economies where increased competition between land uses is likely to be most acute. Second, and relatedly, the adverse macrofinancial consequences of these trade-offs warrants the increased involvement of Ministries of Finance to manage the potential social and economic consequences of land-related policy strategies and ensure the effective implementation of the 30x30 targets. Finally, by indicating the unequal distribution of all three components of macroeconomic risk (hazard, exposure, and vulnerability) related to 30x30 target implementation, this report also contributes to understanding the interplay of ecological and economic inequities that exist between countries of the Global North and Global South. This further supports the case for distributional measures to reverse climate change and biodiversity loss, and to ensure all countries can meaningfully cope with and adapt to adverse environmental effects that are already locked in.[129,130]

The cluster analysis in this report demonstrates just one approach for investigating where lands of conservation importance may intersect with countries exposed and vulnerable to increased land competition pressures, enabling the identification of key country groups at a global scale using existing datasets. This approach could be further expanded in future work by considering a broader set of variables to include, for example, measures of the vulnerability of the productive land area within a country to climate or other negative environmental impacts. Evidently, our analysis is also limited by its top-down approach, relying on the quality and coverage of underlying indicators, and hence neglecting to account for spatially explicit ecological detail or locally specific institutional factors. Future work should also be complemented by country, region, or biome-specific analysis to explore the various local social, economic, and political factors influencing potential for the emergence of land scarcity.

Finally, many research gaps remain on this topic, particularly with regards to exploring potential economic and financial implications of 30x30 target implementation. As discussed in Section 2, the few studies that have investigated this question in forward-looking scenarios focus on economic outcomes at long-run equilibrium, rather than the disequilibrium dynamics that can occur in the short-run aftermath of a policy shock. Future research could seek to explore such scenarios also in non-equilibrium–based IAMs, using approaches such as environmentally-extended input-output modelling and ecological stock-flow consistent modelling to explore the potential macrofinancial effects of a 'disorderly' transition to achieve the 30x30 goals.

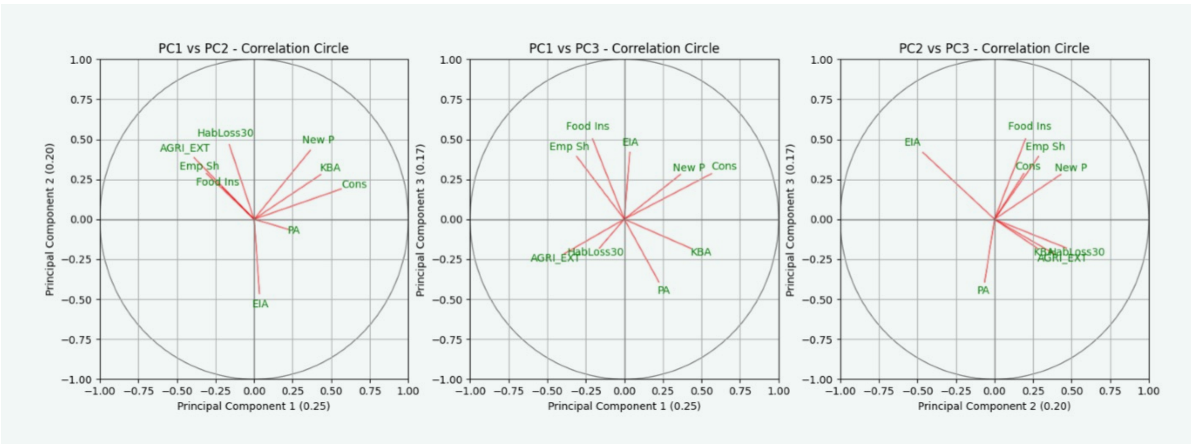
Annex

Figure A1. Explained variance of Principal Components



Source: authors

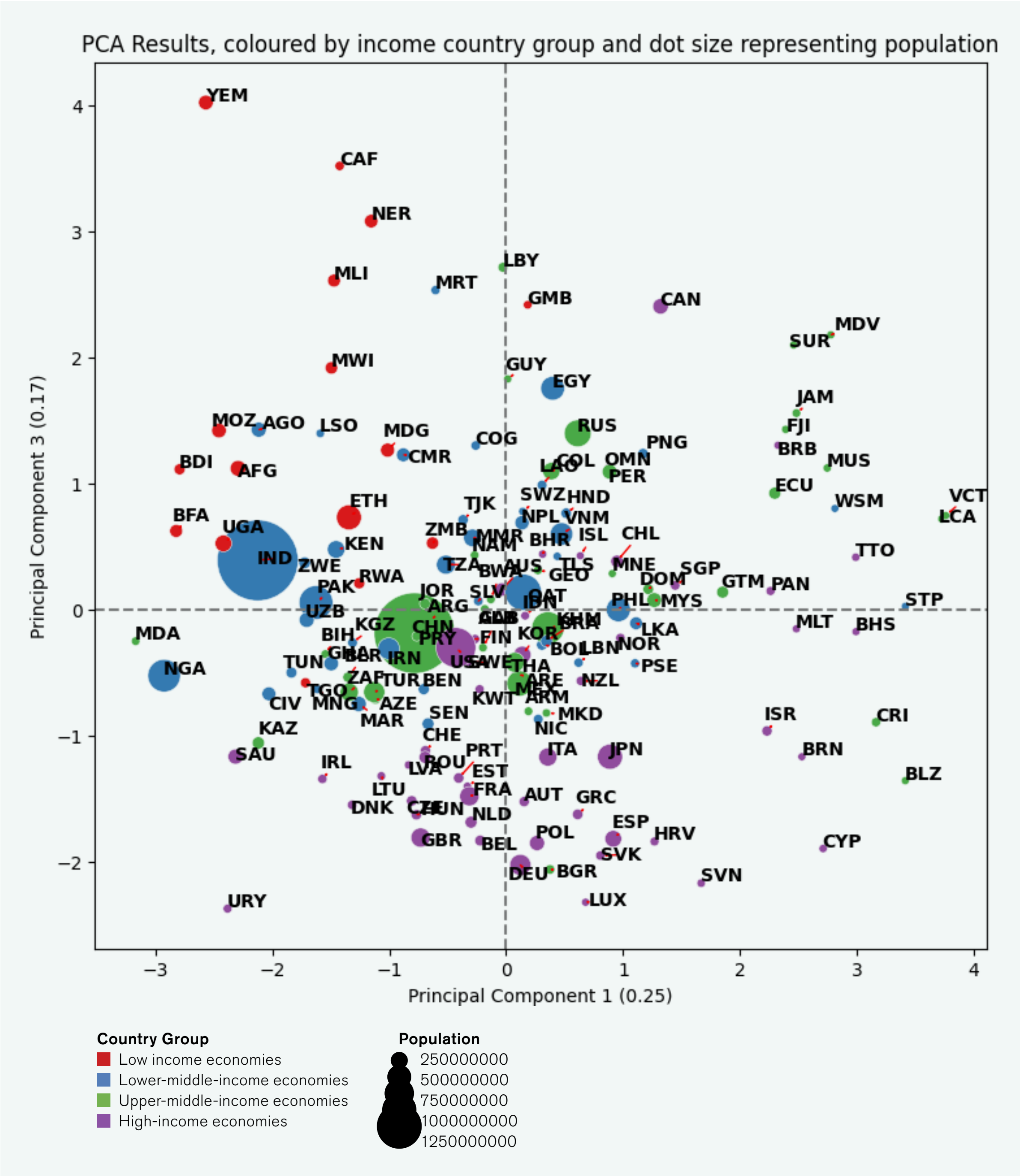
Figure A2 : Loading charts for the variables in each PC



Source: authors

Variables grouped close together at a small angle are more positively correlated to each other, variable lines at angles of towards 180° are more negatively correlated, and those at 90° to each other are uncorrelated. For example, in the left-hand chart, extent of EIA is negatively correlated with projections of habitat loss, suggesting that the smaller the extent of ecologically intact area, the more likely it is to be at risk of conversion. Similarly, in all three charts, PAs are uncorrelated with New P which makes intuitive sense, as existing protected areas will differ to new additional areas of conservation priority.

Figure A3. Country scatter plot, Conservation importance (PC1) vs Economic Adaptability (PC3)



Source: authors

Table A1. Country list and codes

COUNTRY CODE (ISO 3)	COUNTRY NAME
AFG	Afghanistan
AGO	Angola
ALB	Albania
ARE	United Arab Emirates
ARG	Argentina
ARM	Armenia
AUS	Australia
AUT	Austria
AZE	Azerbaijan
BDI	Burundi
BEL	Belgium
BEN	Benin
BFA	Burkina Faso
BGR	Bulgaria
BHR	Bahrain
BHS	Bahamas
BIH	Bosnia and Herzegovina
BLR	Belarus
BLZ	Belize
BOL	Bolivia, Plurinational State of
BRA	Brazil
BRB	Barbados
BRN	Brunei Darussalam
BWA	Botswana
CAF	Central African Republic
CAN	Canada
CHE	Switzerland
CHL	Chile
CHN	China
CIV	Côte d'Ivoire
CMR	Cameroon
COG	Congo
COL	Colombia
COM	Comoros
CRI	Costa Rica
CYP	Cyprus
CZE	Czechia
DEU	Germany
DNK	Denmark
DOM	Dominican Republic
ECU	Ecuador
EGY	Egypt
ESP	Spain
EST	Estonia
ETH	Ethiopia
FIN	Finland
FJI	Fiji
FRA	France
GAB	Gabon
GBR	United Kingdom
GEO	Georgia
GHA	Ghana
GMB	Gambia
GRC	Greece
GTM	Guatemala
GUY	Guyana
HND	Honduras
HRV	Croatia
HUN	Hungary
IDN	Indonesia
IRL	Ireland
IRN	Iran, Islamic Republic of
ISL	Iceland
ISR	Israel
ITA	Italy
JAM	Jamaica
JOR	Jordan
JPN	Japan
KAZ	Kazakhstan
KEN	Kenya
KGZ	Kyrgyzstan
KHM	Cambodia
KOR	Korea, Republic of
KWT	Kuwait

LAO	Lao People's Democratic Republic
LBN	Lebanon
LBY	Libya
LCA	Saint Lucia
LKA	Sri Lanka
LSO	Lesotho
LTU	Lithuania
LUX	Luxembourg
LVA	Latvia
MAR	Morocco
MDA	Moldova, Republic of
MDG	Madagascar
MDV	Maldives
MEX	Mexico
MKD	North Macedonia
MLI	Mali
MLT	Malta
MMR	Myanmar
MNE	Montenegro
MNG	Mongolia
MOZ	Mozambique
MRT	Mauritania
MUS	Mauritius
MWI	Malawi
MYS	Malaysia
NAM	Namibia
NER	Niger
NGA	Nigeria
NIC	Nicaragua
NLD	Netherlands
NOR	Norway
NPL	Nepal
NZL	New Zealand
OMN	Oman
PAK	Pakistan
PAN	Panama
PER	Peru
PHL	Philippines

PNG	Papua New Guinea
POL	Poland
PRT	Portugal
PRY	Paraguay
PSE	Palestine, State of
QAT	Qatar
ROU	Romania
RUS	Russian Federation
RWA	Rwanda
SAU	Saudi Arabia
SEN	Senegal
SGP	Singapore
SLV	El Salvador
STP	Sao Tome and Principe
SUR	Suriname
SVK	Slovakia
SVN	Slovenia
SWE	Sweden
SWZ	Eswatini
TGO	Togo
THA	Thailand
TJK	Tajikistan
TLS	Timor-Leste
TTO	Trinidad and Tobago
TUN	Tunisia
TUR	Türkiye
TZA	Tanzania, United Republic of
UGA	Uganda
URY	Uruguay
USA	United States
UZB	Uzbekistan
VCT	Saint Vincent and the Grenadines
VNM	Viet Nam
WSM	Samoa
YEM	Yemen
ZAF	South Africa
ZMB	Zambia
ZWE	Zimbabwe

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