Restoring Global Forests: Opportunities & Challenges

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Outline

1. Need for more economic research on forest restoration

2. Financing large-scale restoration

3. Sampler of recent research

Forest Restoration in Low- and Middle-Income Countries

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[2]Henry M. Jackson School of International Studies, University of Washington, Seattle, Washington 98195, USA; email: scurran@uw.edu

[3]The Forest School at the Yale School of the Environment, Yale University, New Haven, Connecticut 06511, USA; email: mark.ashton@yale.edu

My definition of "forest restoration"

- Reestablishment of *tree-dominated ecosystems that supply forest goods and services* (fuelwood, timber, carbon sequestration, biodiversity habitat, watershed conservation, …), *in locations where forests naturally occur*

  - Includes planted forests and introduced species: not limited to forests of naturally regenerated native species

  - Excludes perennial tree crops (oil palm, orchards, …)

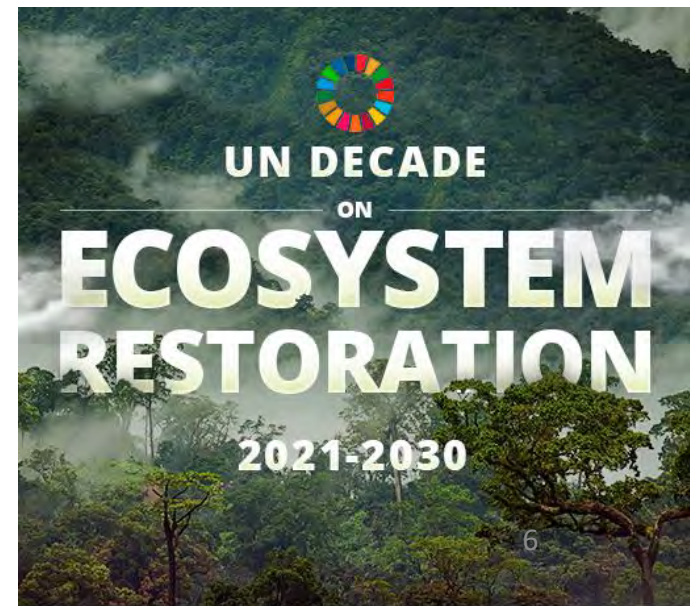# LMICs in Africa, Asia & Pacific, Latin America & Caribbean (2000-present)

Low and middle income
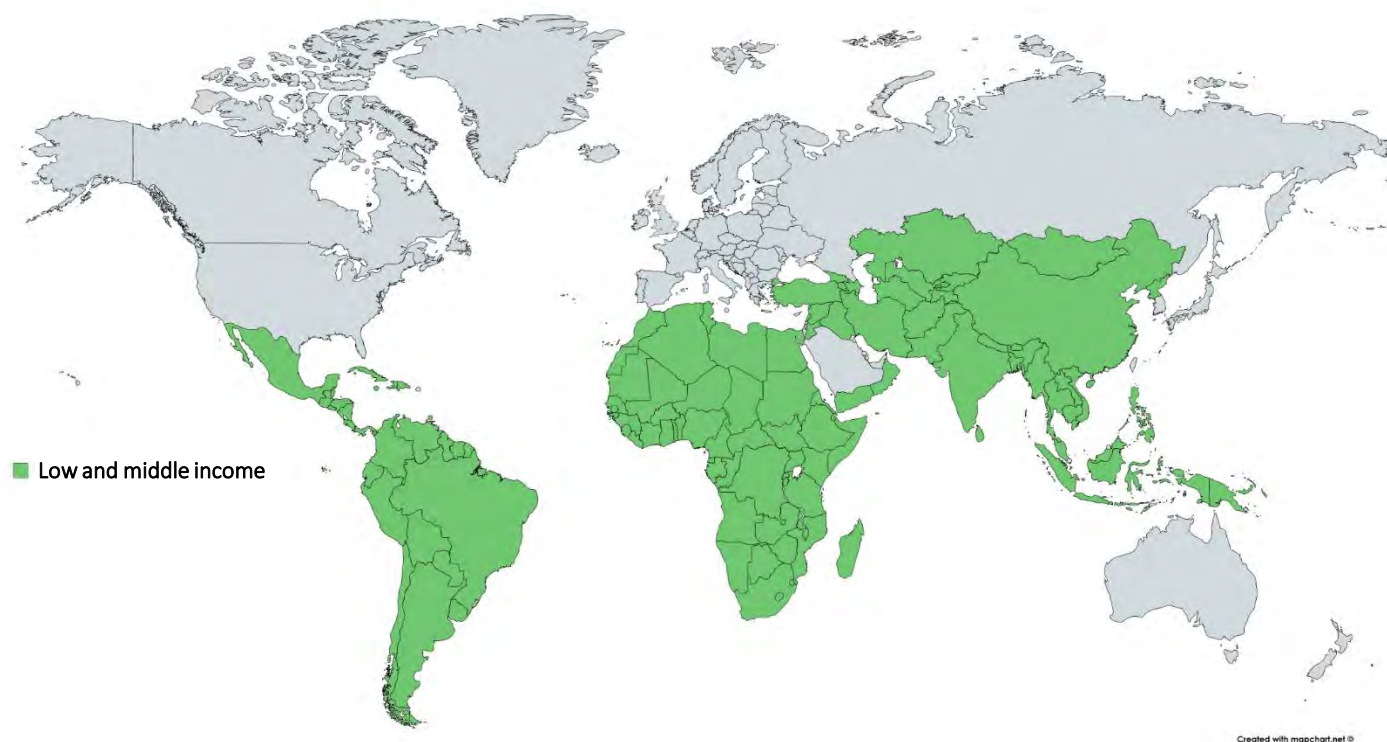
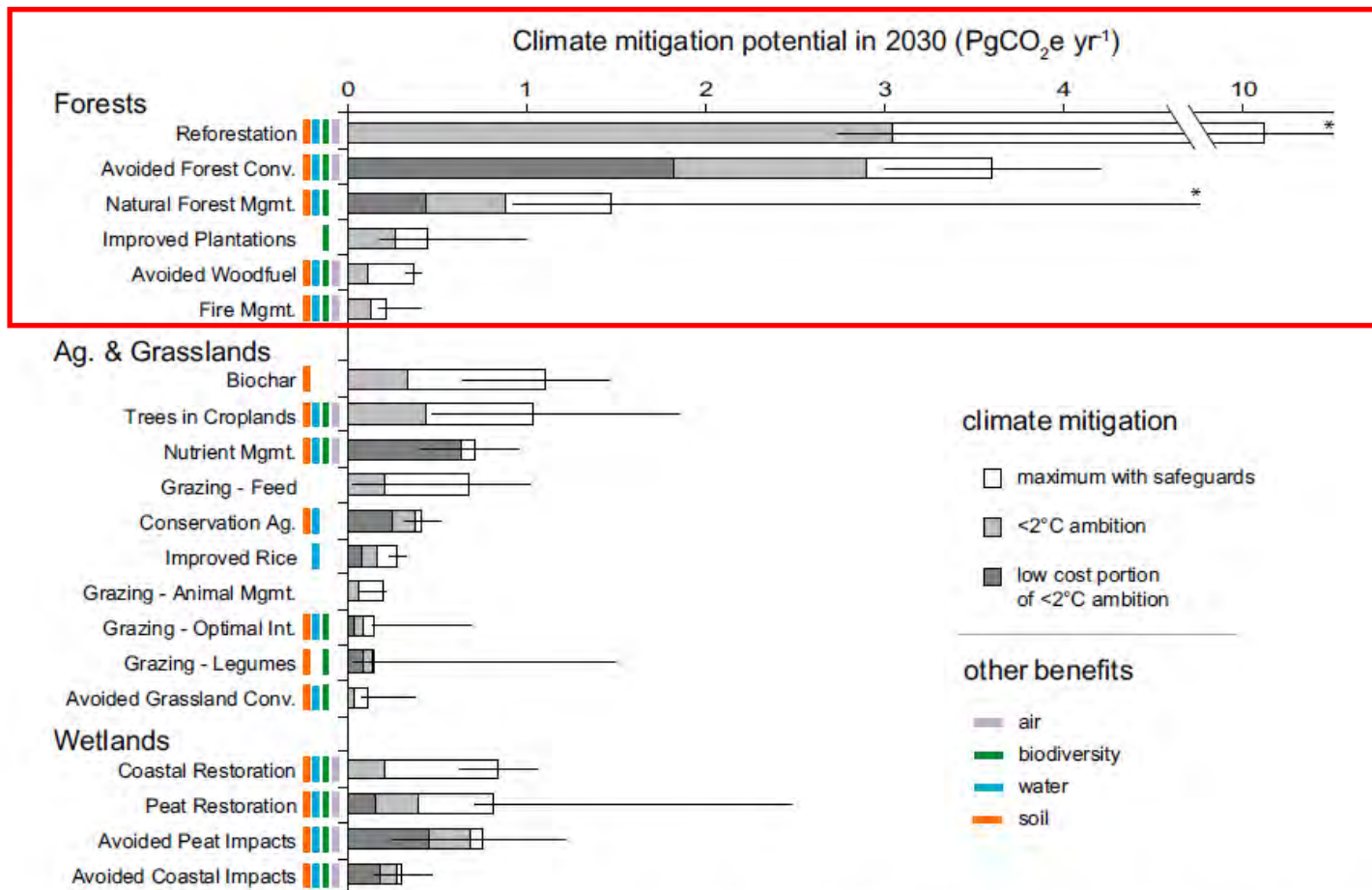# Principal driver of interest: climate mitigation

Fig. 1. Climate mitigation potential of 20 natural pathways. We estimate maximum climate mitigation potential with safeguards for reference year 2030. Light gray portions of bars represent cost-effective mitigation levels assuming a global ambition to hold warming to <2 °C (<100 USD $MgCO_2e^{-1}$ y^{-1}). Dark gray portions of bars indicate low cost (<10 USD $MgCO_2e^{-1}$ y^{-1}) portions of <2 °C levels. Wider error bars indicate empirical estimates of 95% confidence intervals, while narrower error bars indicate estimates derived from expert elicitation. Ecosystem service benefits linked with each pathway are indicated by colored bars for biodiversity, water (filtration and flood control), soil (enrichment), and air (filtration). Asterisks indicate truncated error bars. See *SI Appendix*, Tables S1, S2, S4, and S5 for detailed findings and sources.

Source: Griscom et al. (*PNAS*, 2017)

Panel A - Estimated costs and 2050 potentials
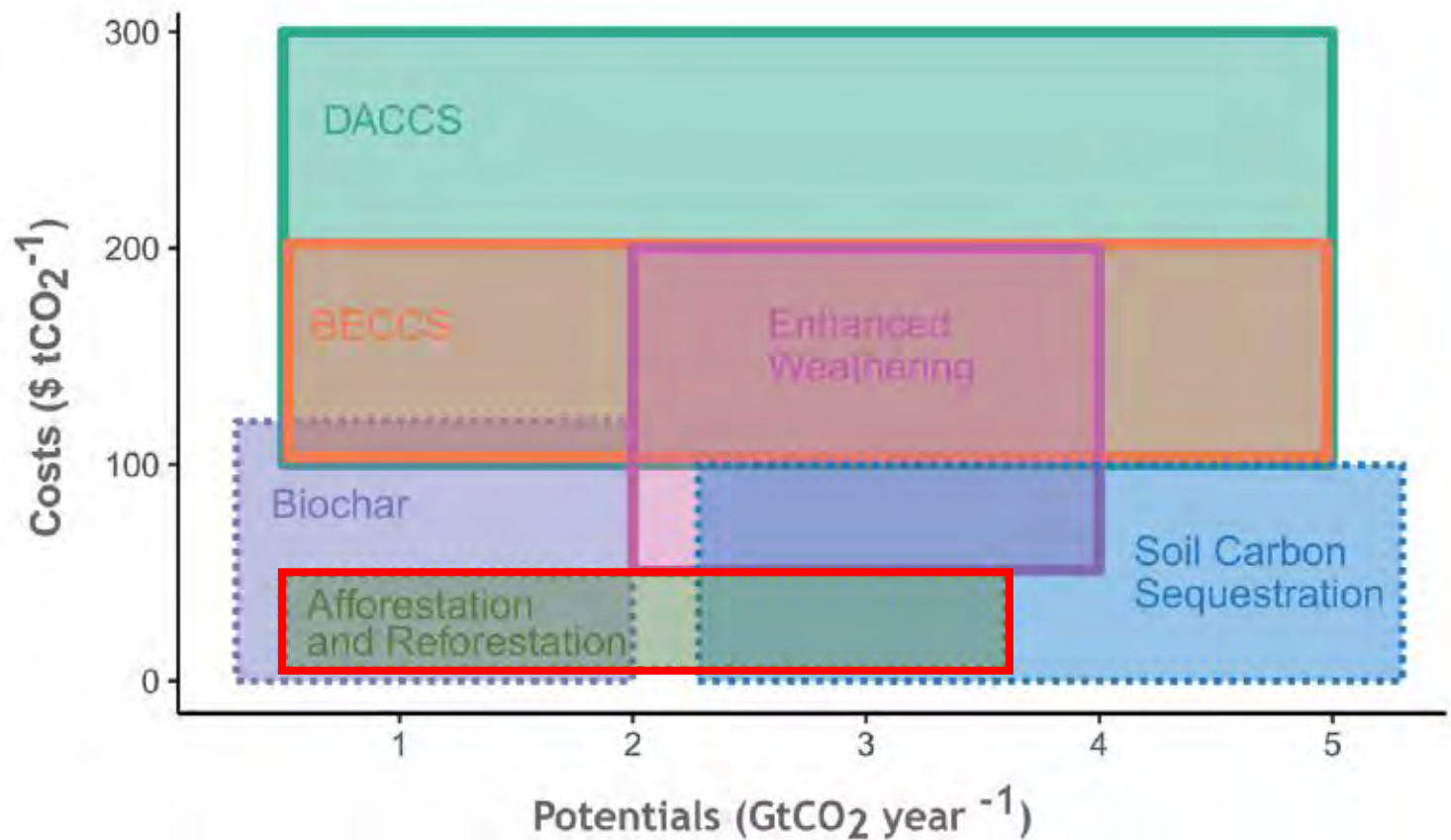
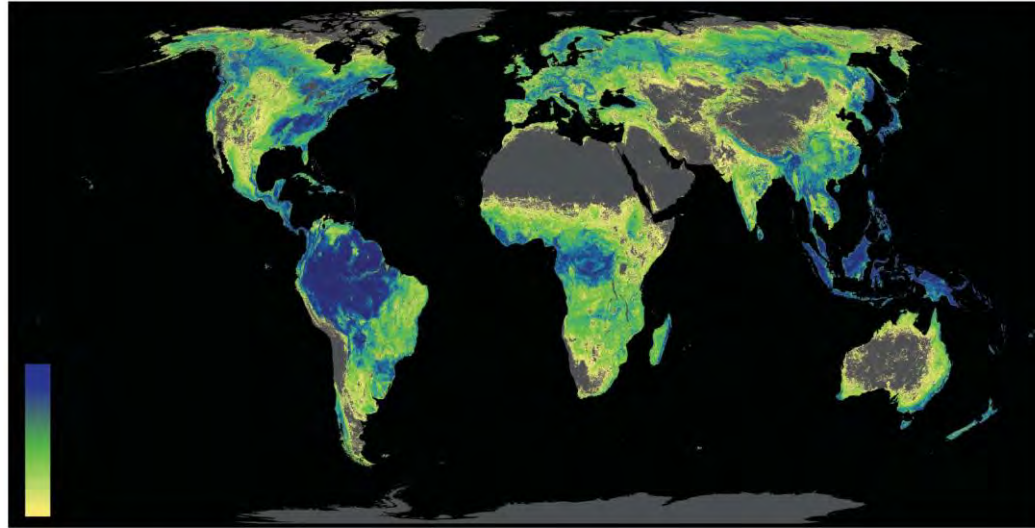Source: IPCC (*Global Warming of 1.5°C,* 2018)

Afforestation   Regenerating forest on sites where the most recent land cover was not a forest (typically, crops or pasture)

Reforestation   Regenerating forest on sites where the most recent land cover was a forest

Great biophysical restoration potential

Where trees can grow: 8.7 Bha

*Where no trees currently exist, outside urban areas and cropland: 1.8 Bha*

Source: Bastin et al. (*Science*, 2019)

Where are the economists?

- Search results for "forest restoration" in:

    – Web of Science   2,981 publications

    – EconLit   118 publications

- Search results for "deforestation" in:

    – EconLit   1,549 publications

Why should economists—especially in the Global South—be interested in forest restoration?

1. Evidence of a "forest transition" in many LMICs

Human population dynamics

Fig. 1. Conceptual framework. See text for explanation. To avoid clutter, potential feedback from land-use transitions (arrows 3, 4) and their effects (arrow 5) to rural outmigration (arrow 1) is not shown.

Land-use change
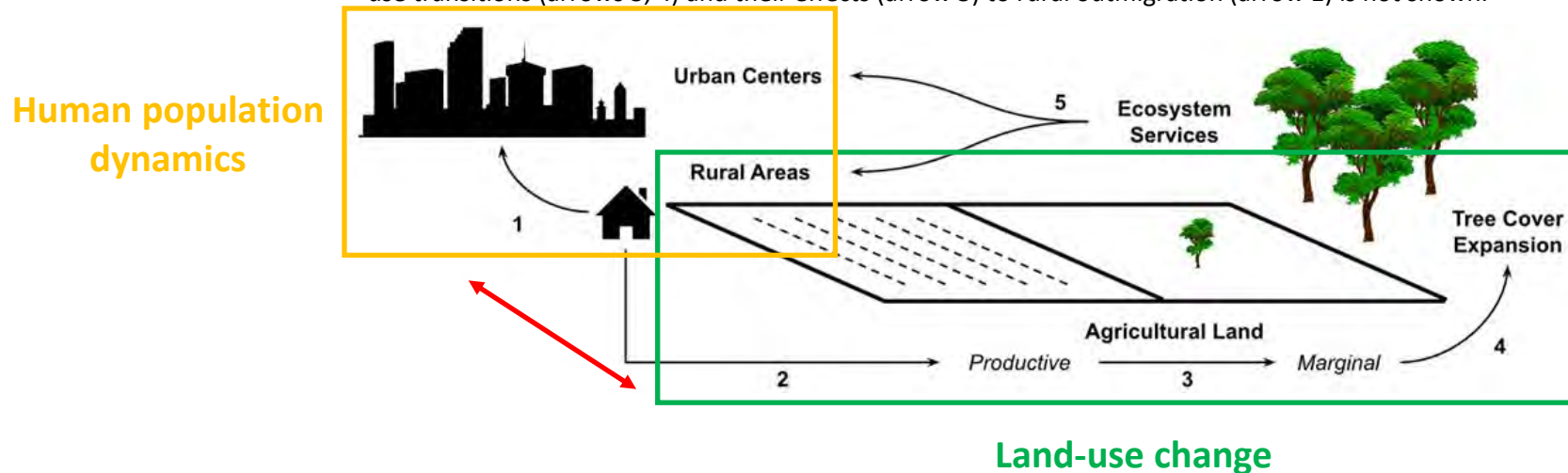
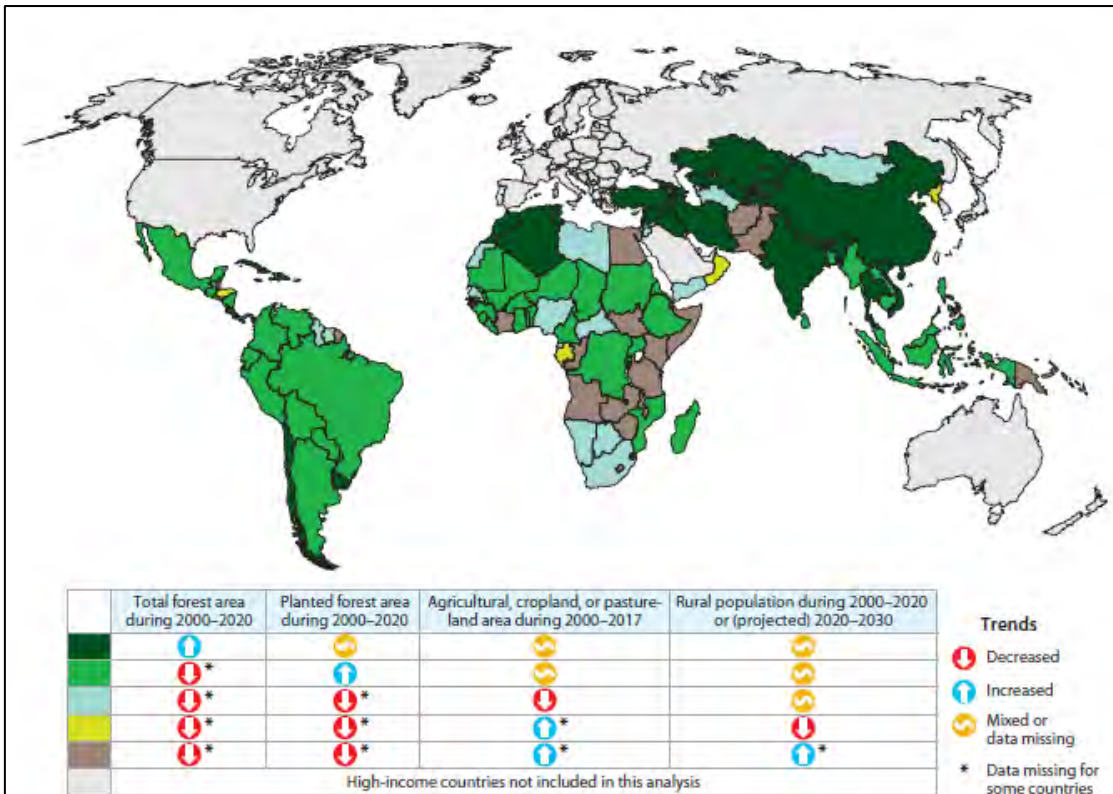Source: Vincent & Curran (SESYNC proposal, 2020)

LMICs?

Figure 2

Evidence of a forest transition in low- and middle-income countries (LMICs) in Africa, Asia and the Pacific, and Latin America and the Caribbean. (*Dark green*) Countries with increased total forest area during 2000–2020. (*Green*) Countries with increased planted forest area during 2000–2020, but not increased total forest area. (*Light blue-green*) Countries with decreased agricultural, cropland, or pastureland area during 2000–2017, but not increased total or planted forest area during 2000–2020. (*Light yellow-green*) Countries with decreased rural population during 2000–2020 or (projected) 2020–2030, but not increased total or planted forest area during 2000–2020 or decreased agricultural, cropland, or pastureland area during 2000–2017. (*Brown*) Remaining LMICs. Data from sources described in text.

Among LMICs:

- **30%:** increasing total forest area
- **85%:** increasing planted forest area
- **40%:** declining agriculture area
- **40%:** declining rural population

Source: Vincent, Curran, and Ashton (*ARER*, 2021)

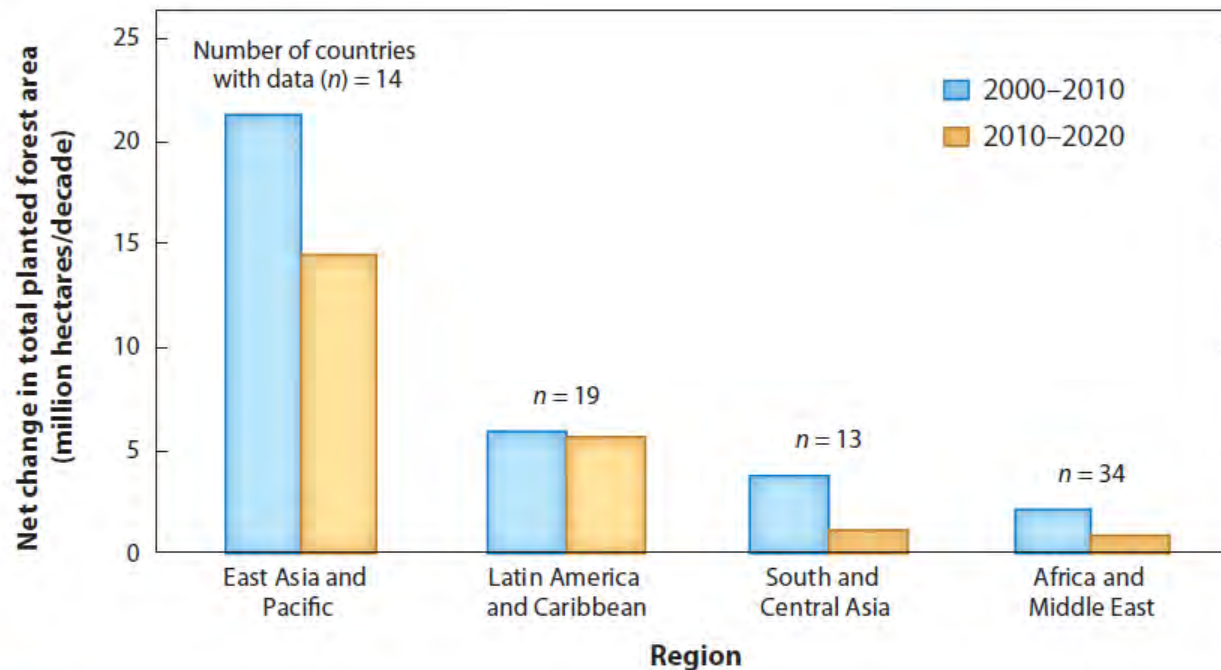# Forest transitions are neither automatic nor fully understood

Figure 1

Net change in total planted forest area in low- and middle-income countries by region and decade, calculated as total area at end of decade minus total area at beginning of decade. Total planted forest area increased in all regions in both decades, but it increased more slowly during the second decade, especially outside of Latin America and the Caribbean. Regional totals include only countries with data on total planted forest area in all three years, 2000, 2010, and 2020. Data from Reference 15.

Source: Vincent, Curran, and Ashton (*ARER*, 2021)

2. Better data and methods than 20 years ago

Taking stock of agroforestry adoption studies

Subhrendu K. Pattanayak[1], D. Evan Mercer[2,*], Erin Sills[3] and Jui-Chen Yang[1]

[1]*Research Triangle Institute, Research Triangle Park, NC, US;* [2]*Southern Research Station, USDA Forest Service, P.O. Box 12254, Research Triangle Park, NC 27709, US;* [3]*College of Natural Resources, North Carolina State University, Raleigh, NC, US; *Author for correspondence (e-mail: emercer@fs.fed.us)*

3. Restoration is costly …

UNEP/FAO Factsheet
June 2020

UN environment programme

Food and Agriculture Organization of the United Nations

We need to get the funding lined up. It will take US$1 trillion to restore 350 million hectares.

… at a time when government budgets are stressed …

United Nations | Department of Economic and Social Affairs
Economic Analysis

World Economic Situation And Prospects: October 2020 Briefing, No. 142

1 October 2020

Figure 1
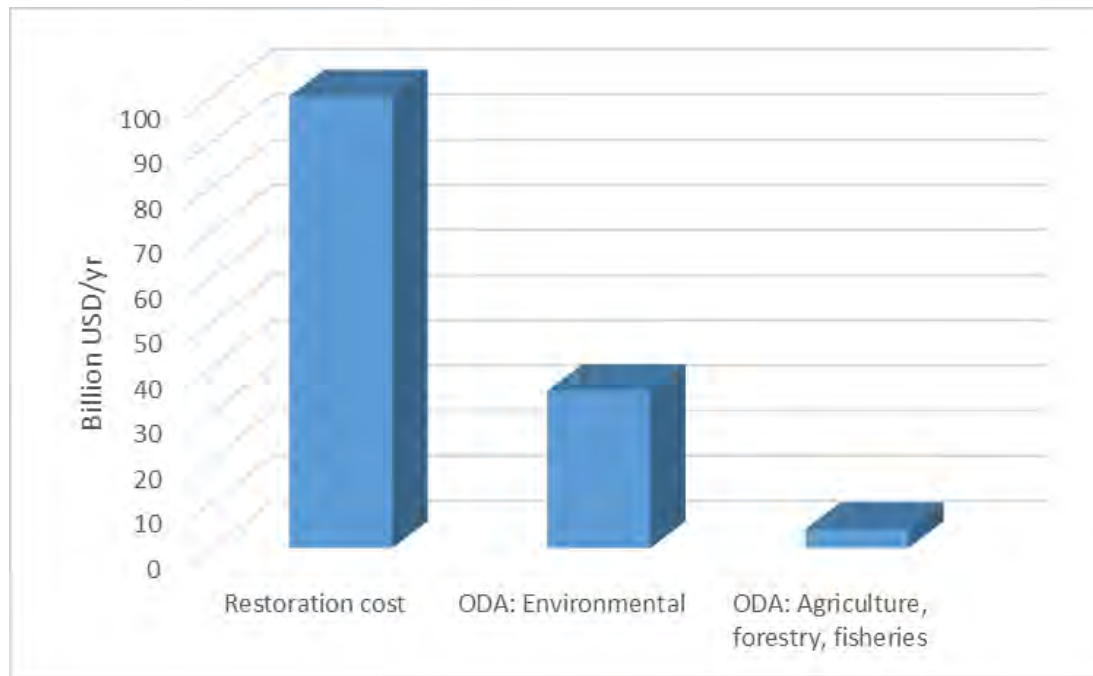**Fiscal balances of developing countries, 2004–2020**
Percentage of GDP

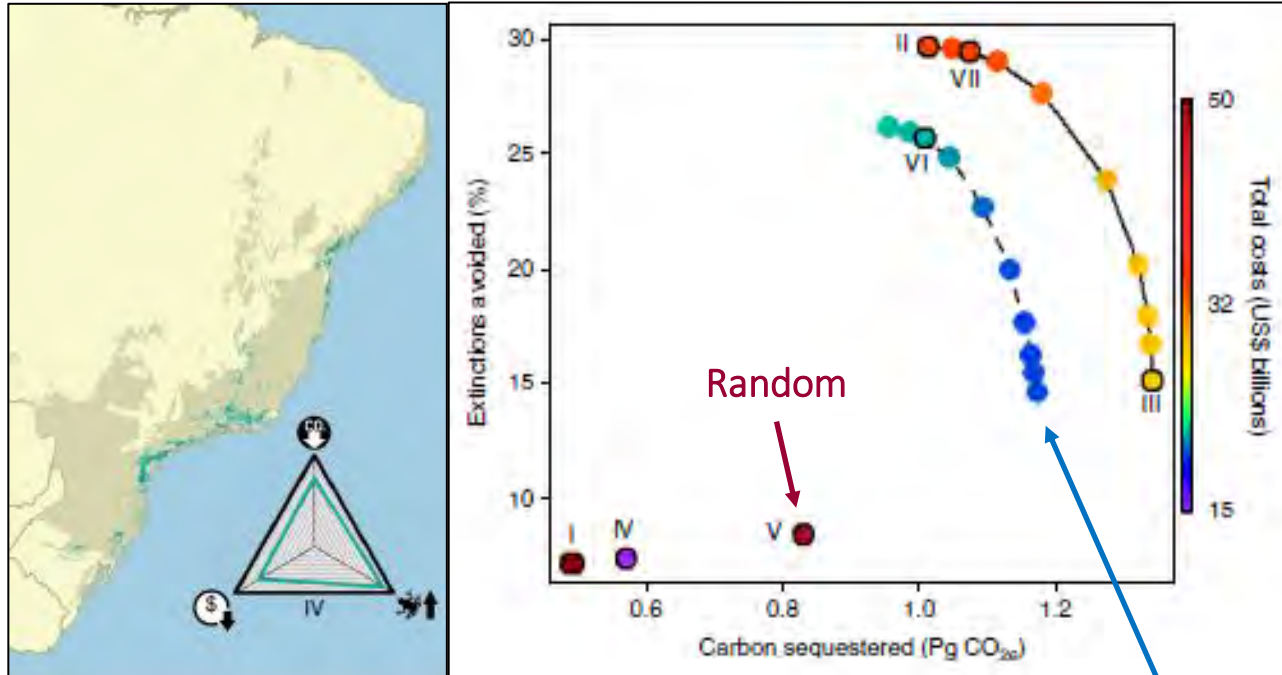Source: UN DESA based on IMF World Economic Outlook data (April 2020).
Note: The fiscal balance is defined as general government net lending or borrowing. 2020 values are estimated.

… and little ODA flows to forestry

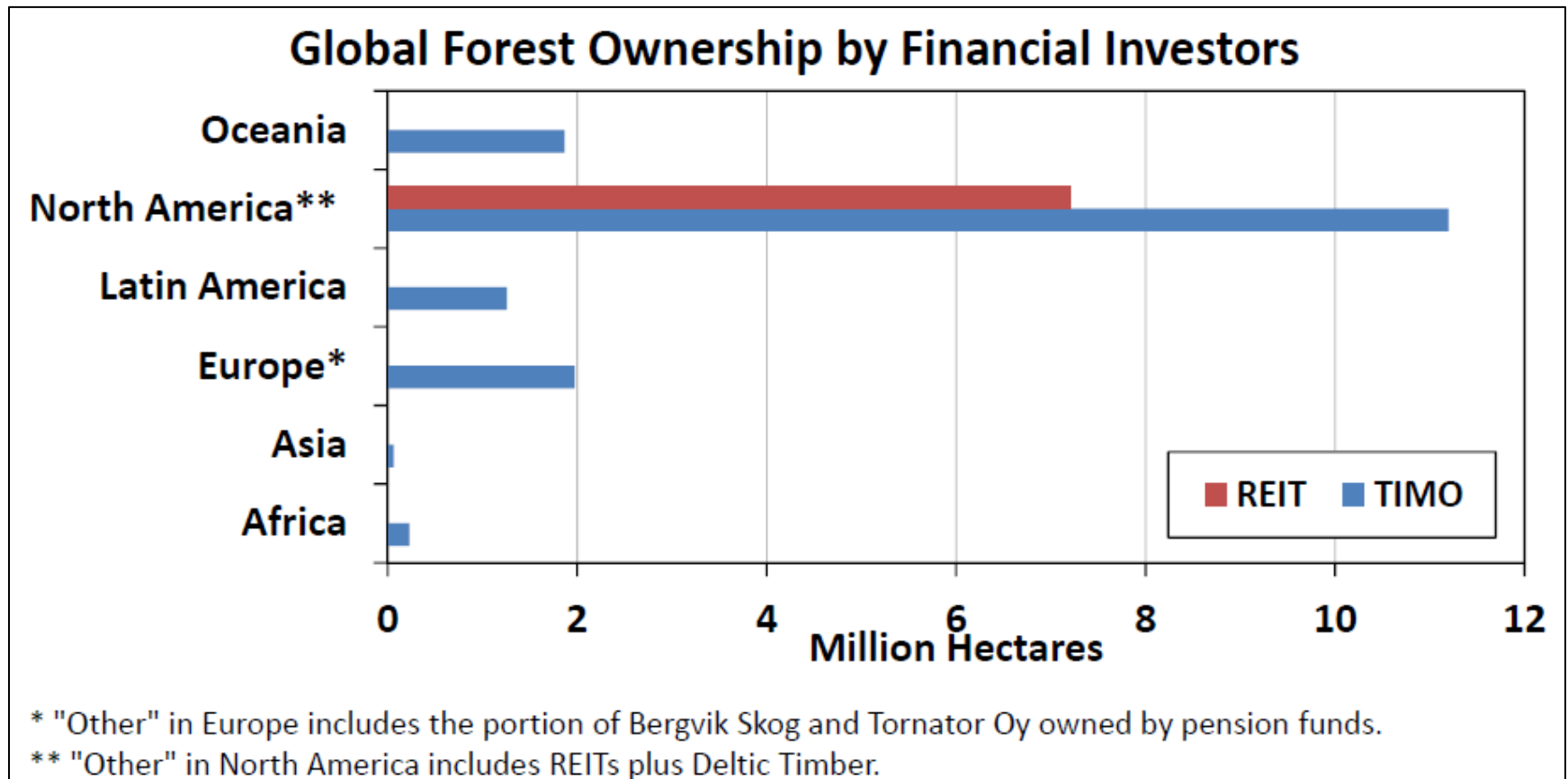(UNEP/FAO, *Factsheet*, 2020; OECD, *Aid Focused on Environment*, 2019)

Need to use scarce available funds cost-effectively

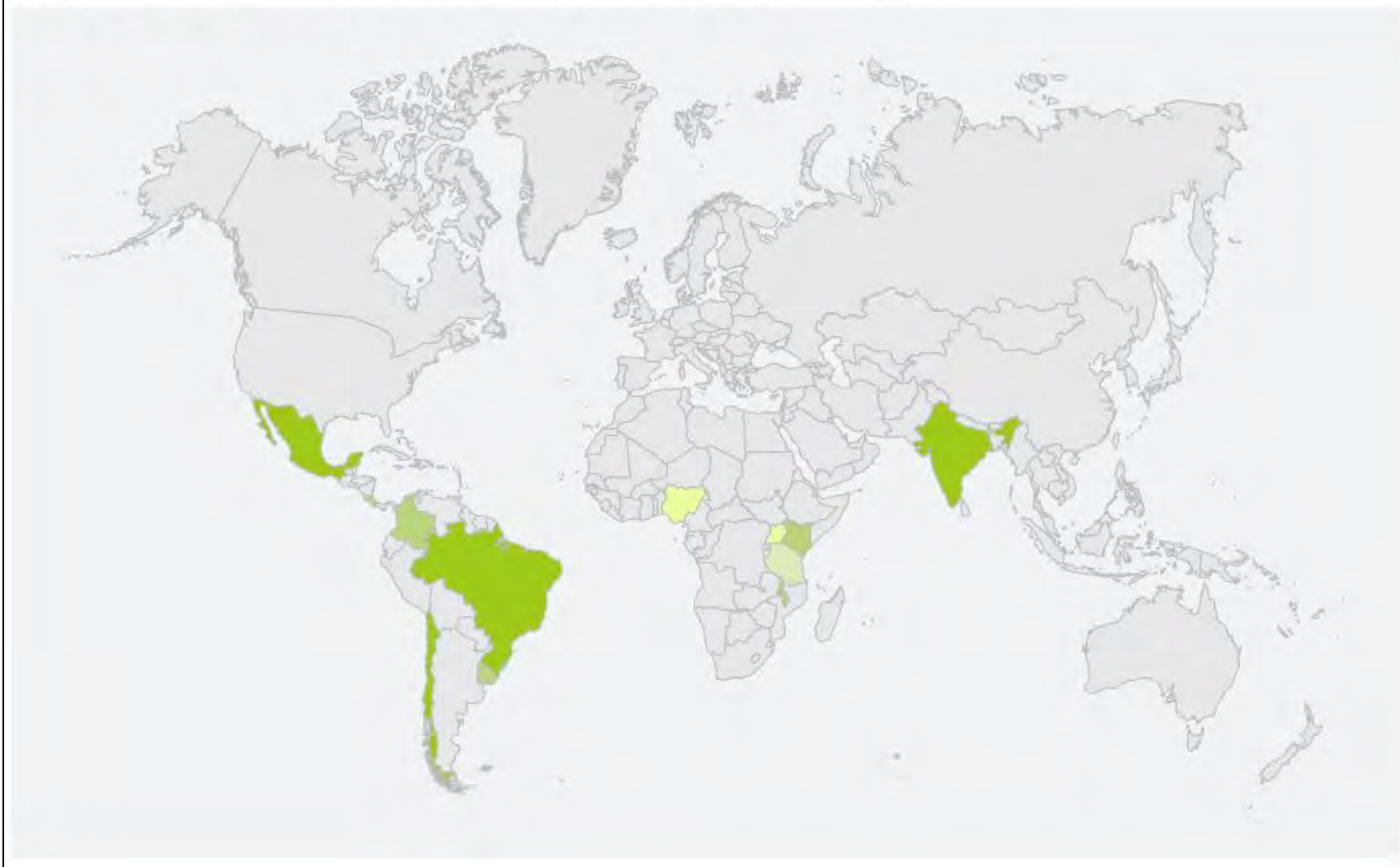Source: Strassburg et al. (*Nature Ecology and Evolution*, 2019)

Efficient frontier

Need to evaluate potential sources of new financing

Global Forest Ownership by Financial Investors

Categories: Oceania, North America**, Latin America, Europe*, Asia, Africa

Legend: REIT, TIMO

X-axis: Million Hectares (0, 2, 4, 6, 8, 10, 12)

* "Other" in Europe includes the portion of Bergvik Skog and Tornator Oy owned by pension funds.
** "Other" in North America includes REITs plus Deltic Timber.

Source: Flynn, *Institutional Investment in Forestry* (RISI, 2016)

FIGURE 4 - Map of Select Countries Scored According to Attractiveness [44]

Source: Binkley et al., *Pension-Fund Investment in Forestry* (World Bank, 2020)

4. People!

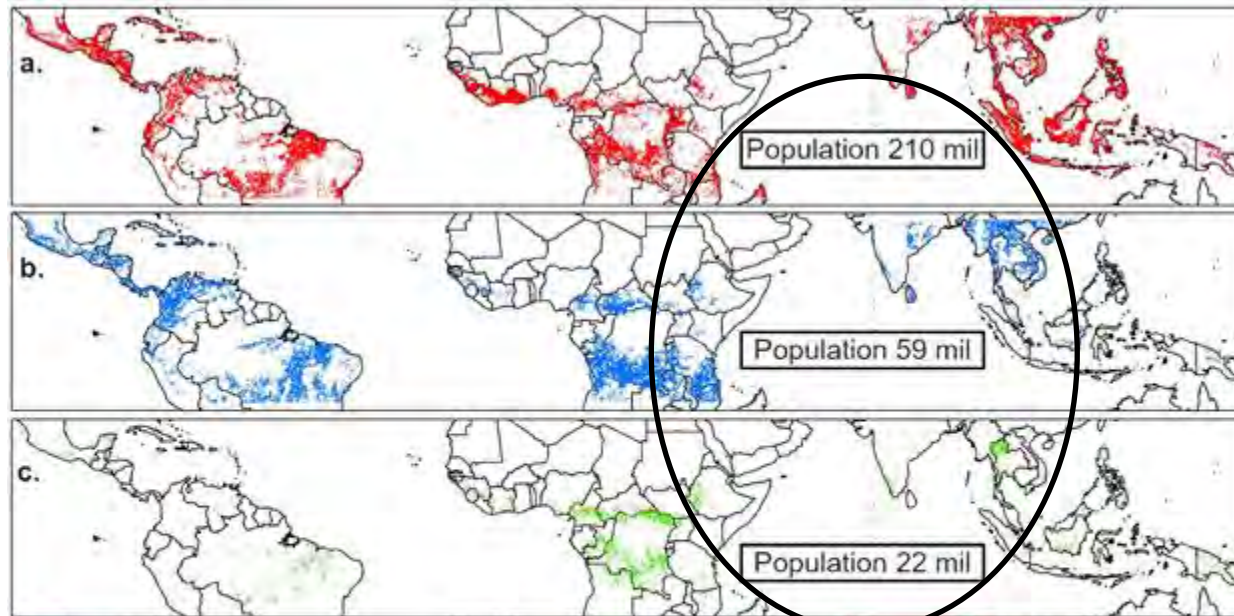Source: https://www.channelnewsasia.com/asia/india-tree-planting-forest-sustainability-environment-1993936

Low-cost tree cover restoration sites in the tropics ($\leq \$20 \, tCO_2^{-1}$)

Cropland
(284 Mha)

Pastureland
(204 Mha)

Degraded forest
(58 Mha)

Source: Shyamsundar et al. ("Scaling smallholder tree cover restoration in the tropics," in prep.)

Where can funding come from to create large-scale financial incentives for landholders to restore forests?

Nationally funded payments for ecosystem services (PES)?

Sloping Lands Conversion Programme, People's Republic of China

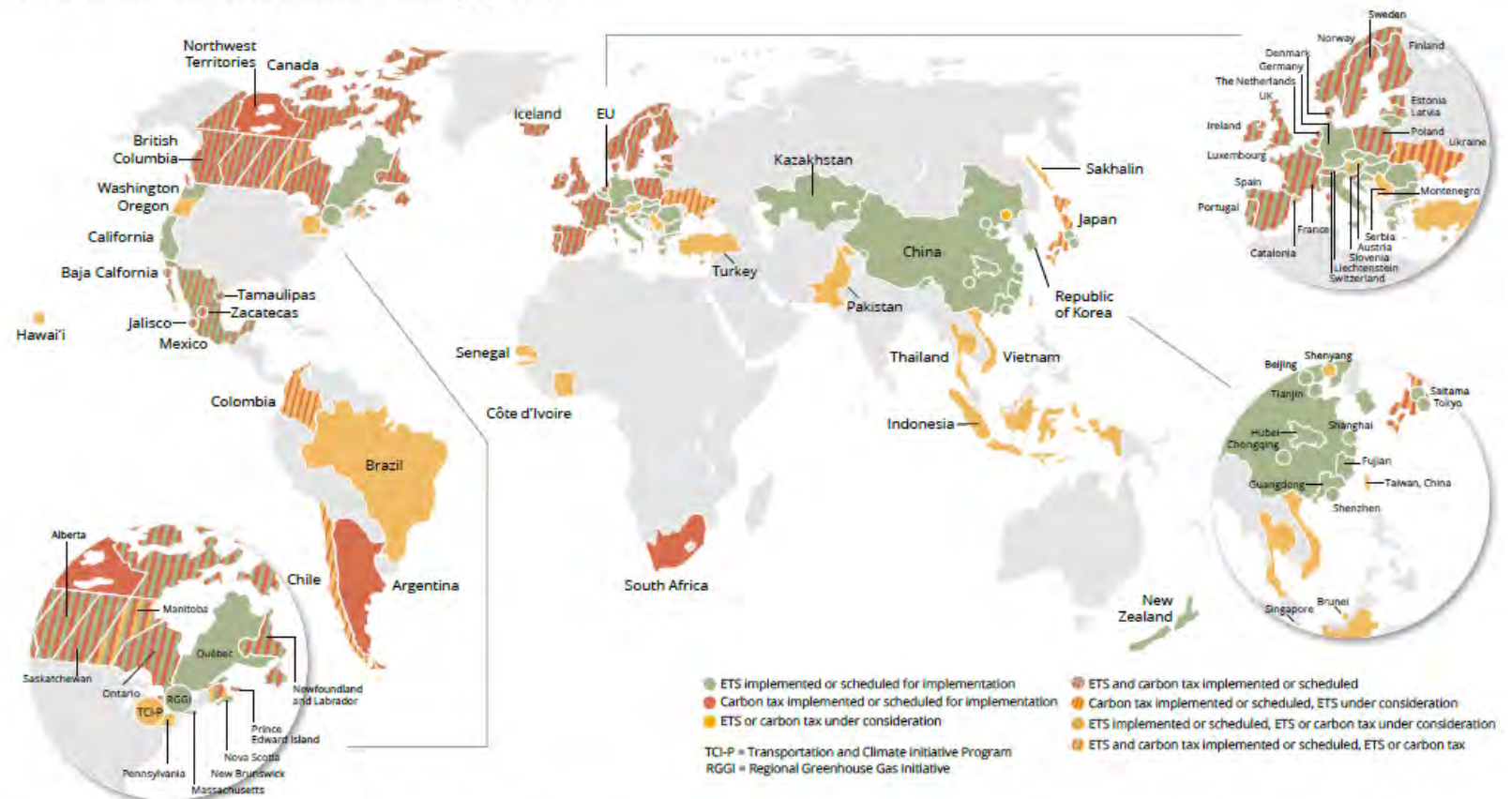Source: Jin et al. (*Sloping Land Conversion Programme, People's Republic of China*, 2017)

1999 – 2015: US$69 billion, 32 million smallholder farming households, 15 Mha restored forest

Carbon payments?
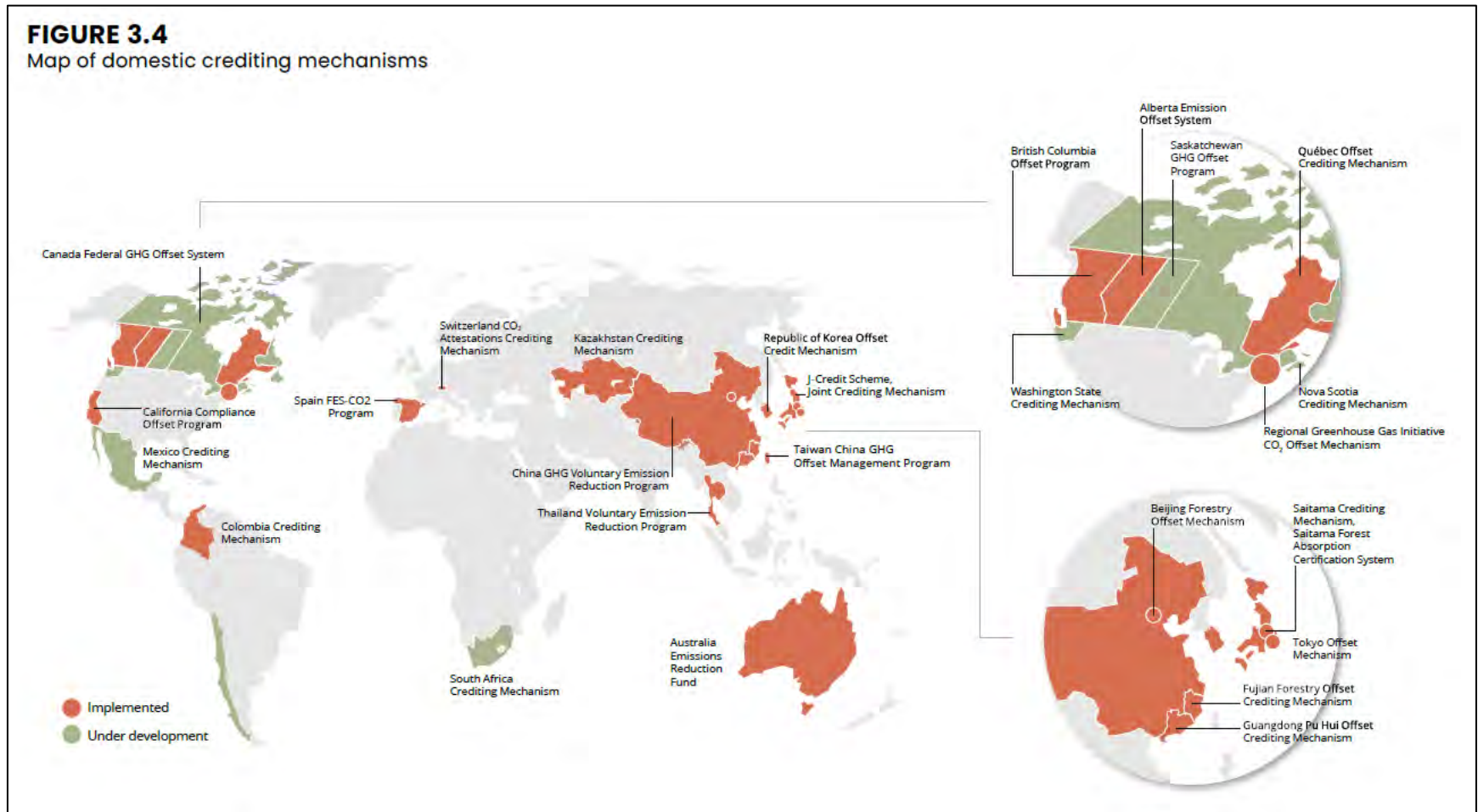# Spotty government commitment …

FIGURE 2.1
Map of carbon taxes and emissions trading systems

Source: World Bank, *State and Trends of Carbon Pricing 2021*

... with few government programs allowing carbon offsets ...

FIGURE 3.4
Map of domestic crediting mechanisms

Source: World Bank, *State and Trends of Carbon Pricing 2021*

... slow growth (until recently) in voluntary programs ...

Figure 2. Market Size by Traded Volumes of Voluntary Carbon Offsets, pre-2005 to 31 August 2021
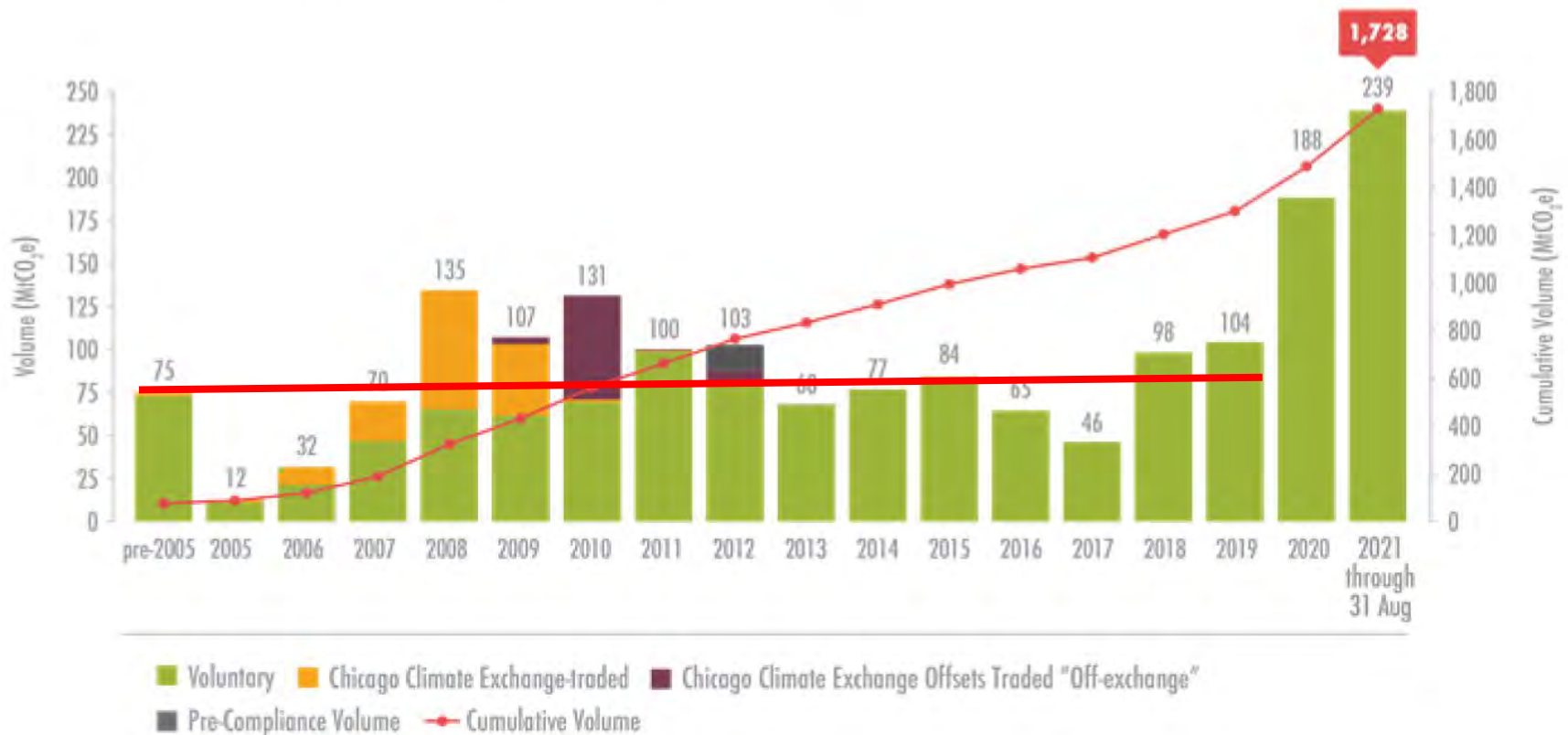
Source: Ecosystem Marketplace, *State of the Voluntary Carbon Markets 2021*

... and low carbon prices

FIGURE 3.3
Volumes transacted and prices per sector (2019)

A majority of carbon prices still remain far below the USD 40–80/tCO₂e range needed in 2020 to meet the 2°C temperature goal of the Paris Agreement[24] — only 3.76% of global emissions are covered by a carbon price at and above this range (see figure 2.4). Even higher prices will be needed over the next decade to reach the 1.5°C target.[25]
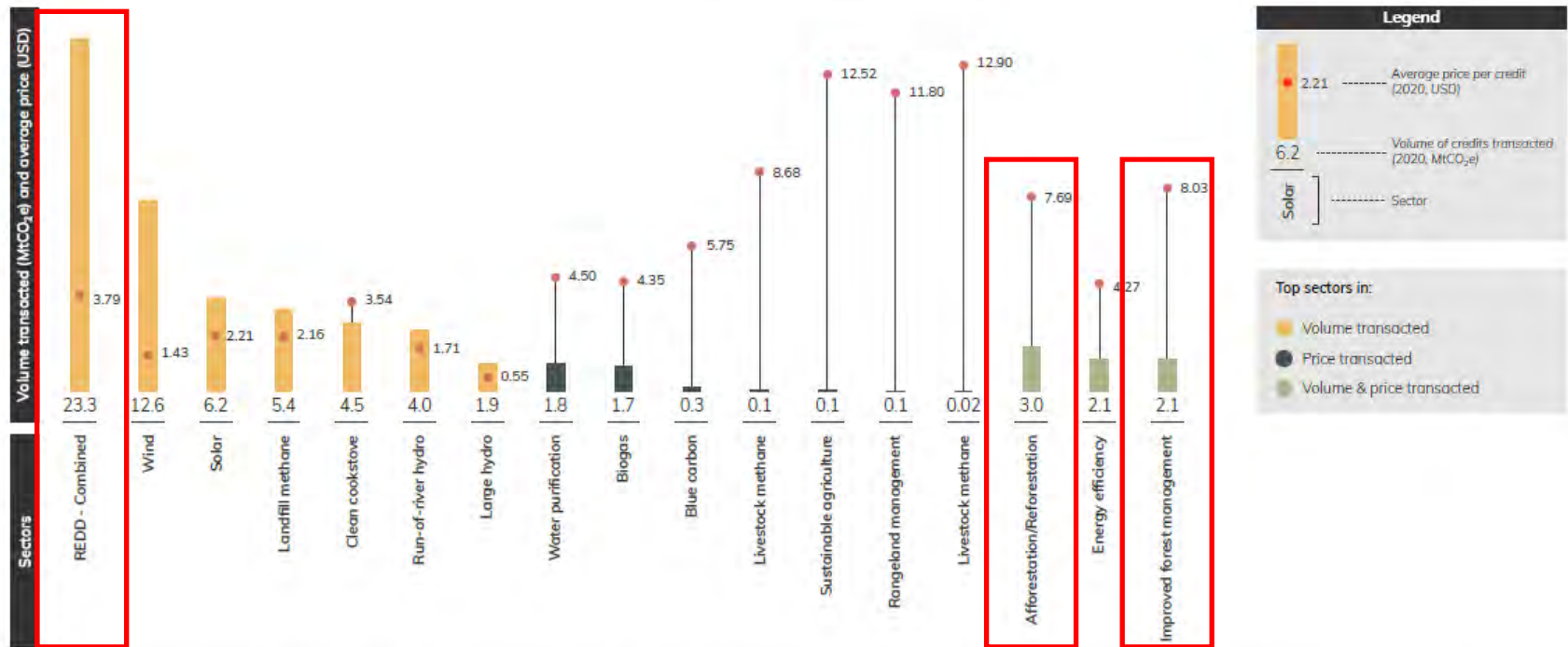
Note: The graphic does not present a comprehensive view of all sectors, only those in terms of highest overall volume transacted and price (or a combination of both) from 2019 are shown. Data is sourced from Ecosystem Marketplace and reflects the sector categories they use in their reporting.

Source: World Bank, *State and Trends of Carbon Pricing 2021*

Figure 4: Transacted Voluntary Carbon Market Sizes by Largest Project Types 2019 - August 2021
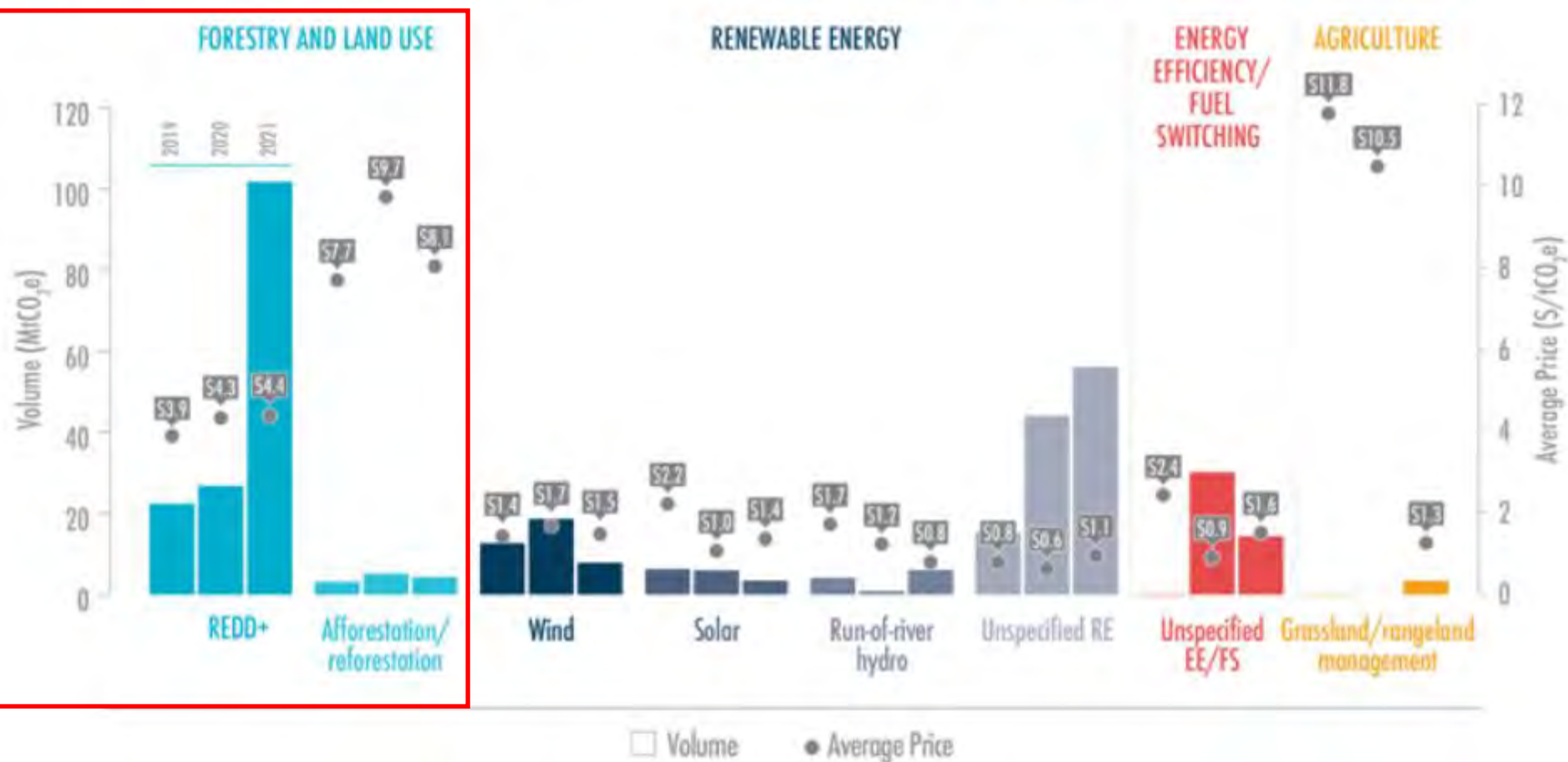
Source: Ecosystem Marketplace, *State of the Voluntary Carbon Markets 2021*

Wood markets?

Source: https://www.indiamart.com/proddetail/teak-plantation-21452284612.html

World is not running out of wood!
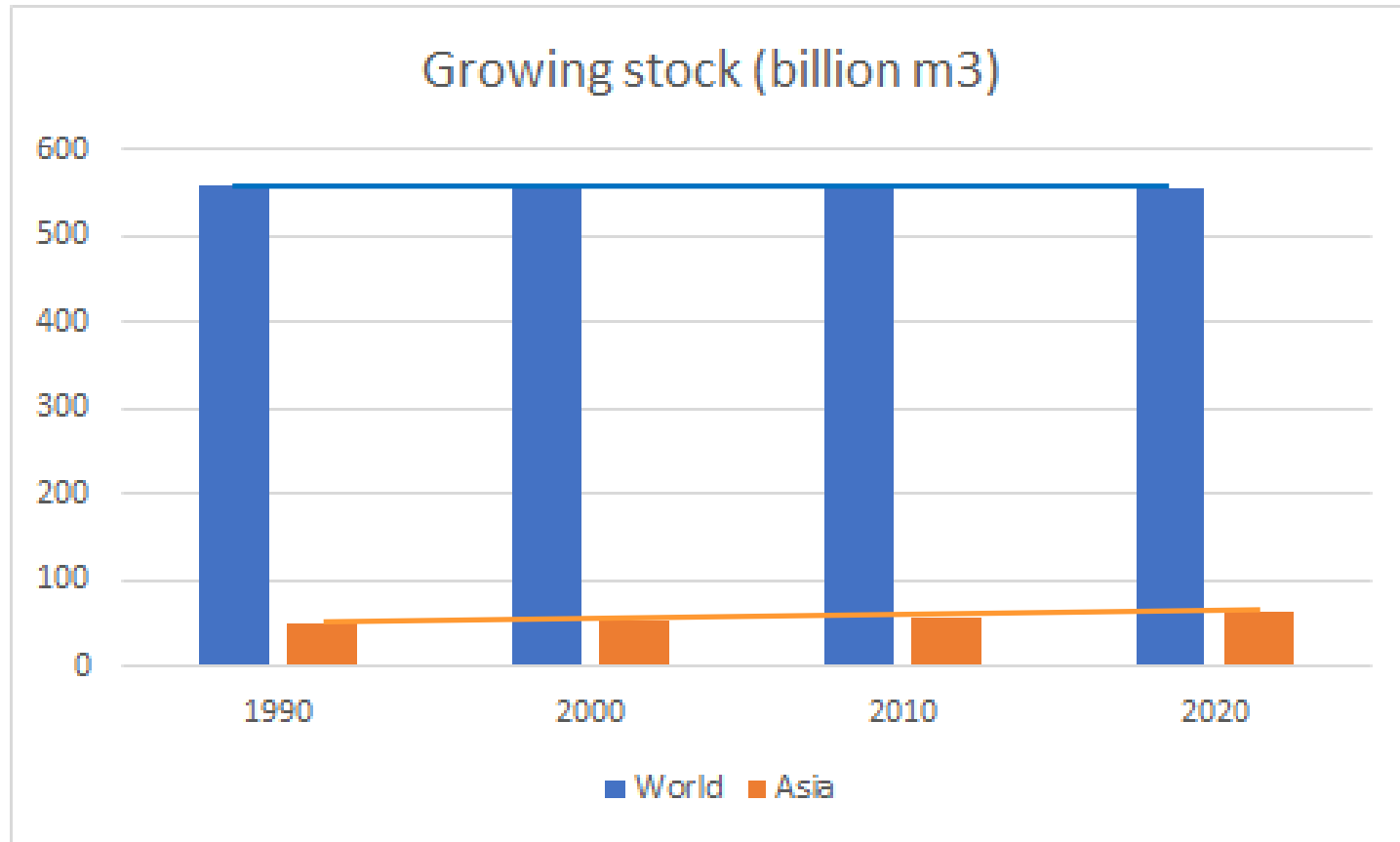
Source: FAO, *Global Forest Resources Assessment 2020*

Stumpage prices rose for much of the 20th Century …

Figure 1. Historical trends in real Southern pine stumpage prices ($1967/mbf Scribner). For 1910–1934, the prices in this figure are from sales of second-growth timber on private lands; for 1935–1985, from sales on national forests. Data through 1970 are from US Bureau of the Census (1975); data following 1970 are from Ulrich (1985). The average rates of increase shown in the figure were calculated by regression for the periods before and after World War II. Note that the vertical scale is logarithmic, so that a curve depicting a constant percentage increase plots as a straight line.

39

Source: Binkley & Vincent (*Southern Journal of Applied Forestry,* 1988)

… but have shown no trend for last 30-40 years

Figure 2. Southwide Pine Sawtimber Prices (**Real** 2010$)
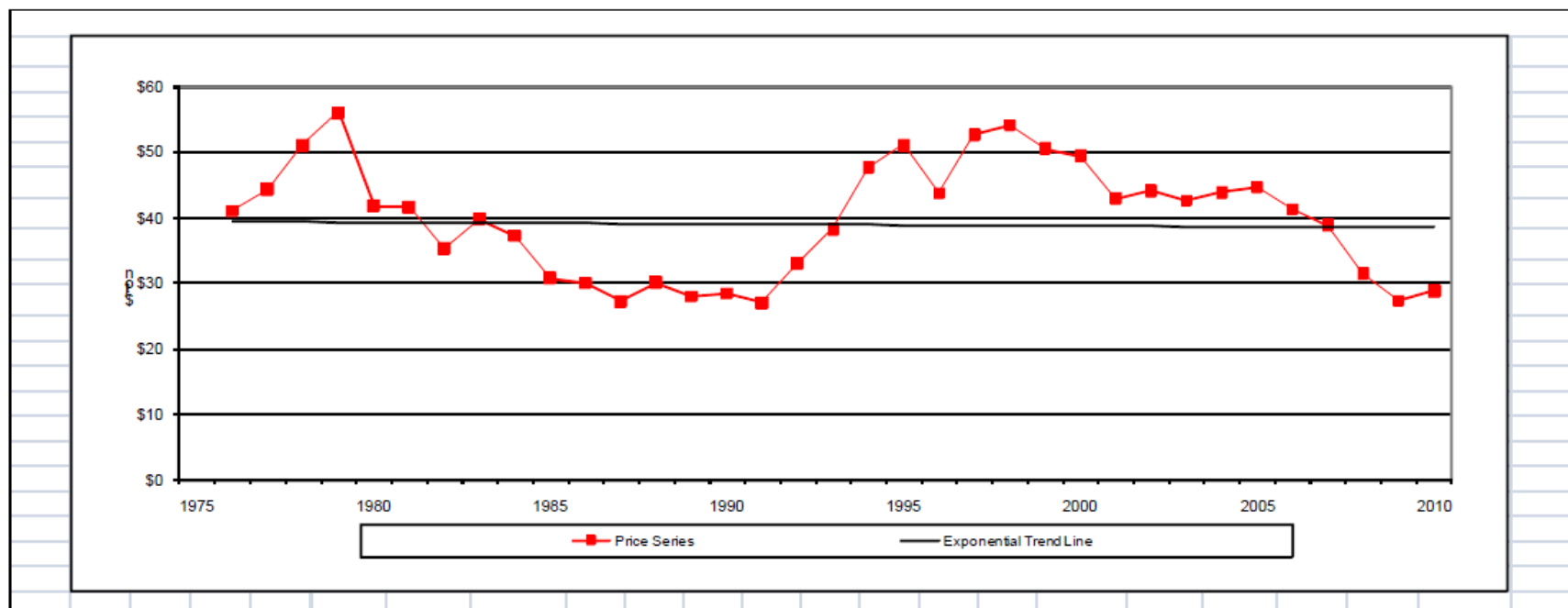
Source: Forest Research Group, *Forest Research Notes* 6(3), 2010

Of course, local scarcity can exist

Net imports (roundwood equiv.)
- >= 1 million m3/yr
- < 1 million m3/yr

Created with mapchart.net ©

Source: FAOSTAT-Forestry

Business as usual in global forest sector: global forest area stabilizes but does not increase

Table S2. Baseline key GTM estimates, 2010–2100.

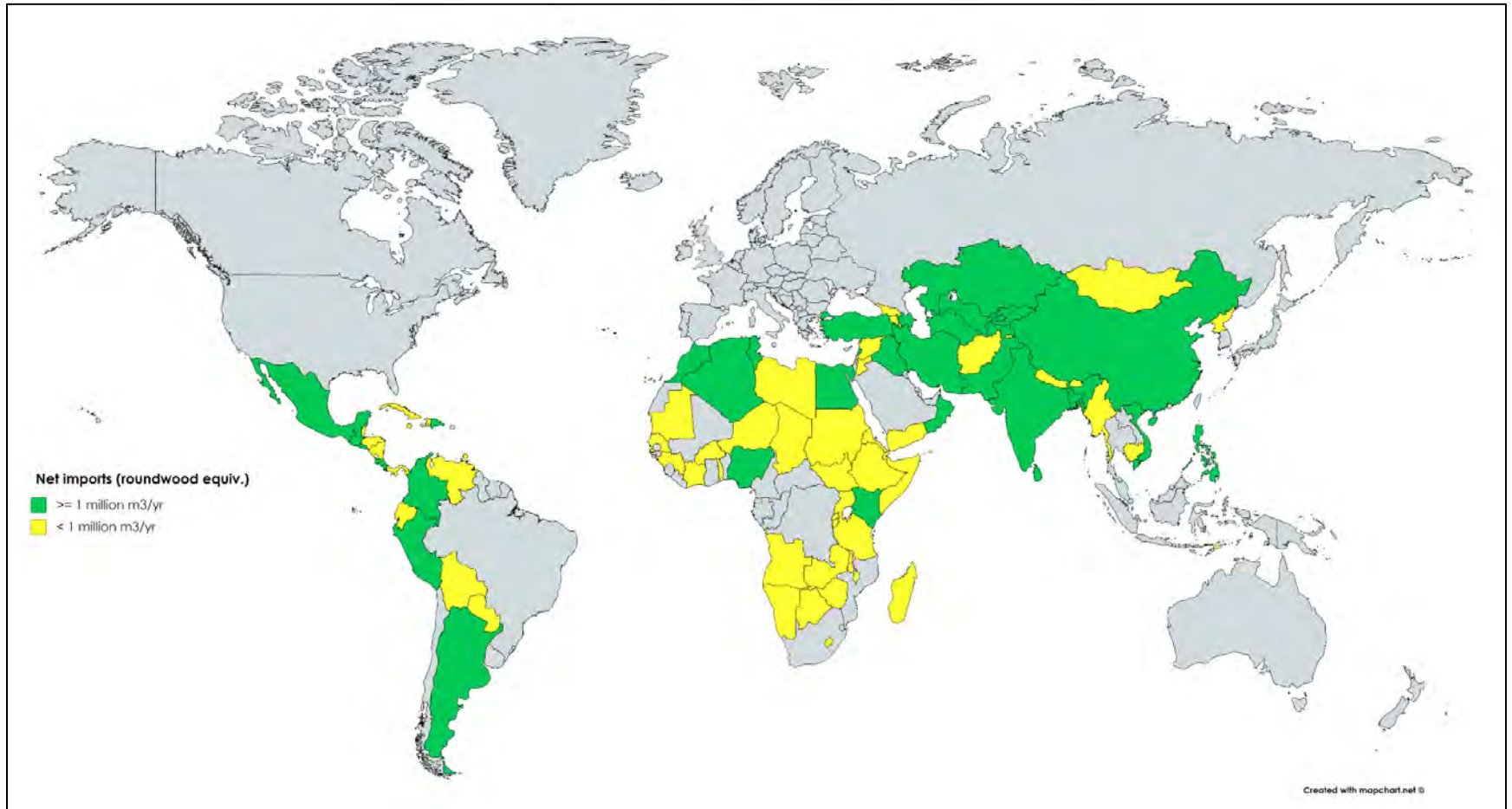| Year	Woody Bio-energy (Mm3)	Forest C Stock (GtCO2e)	Total Forest Area (Mha)	Plantation Area (Mha)	Natural Inaccessible/ Unmanaged Forest Area (Mha)
2010	0	3,336	3,466	72	2,289
2020	0	3,351	3,350	70	2,193
2030	0	3,351	3,333	68	2,107
2040	0	3,347	3,348	80	2,023
2050	0	3,343	3,356	82	1,938
2060	0	3,336	3,393	84	1,850
2070	0	3,334	3,426	89	1,761
2080	0	3,344	3,469	94	1,671
2090	0	3,361	3,516	97	1,580
2100	0	3,376	3,548	103	1,489

Source: Favero et al. (*Science Advances*, 2020)

42

Stronger market incentive for forest restoration requires greater demand for wood products
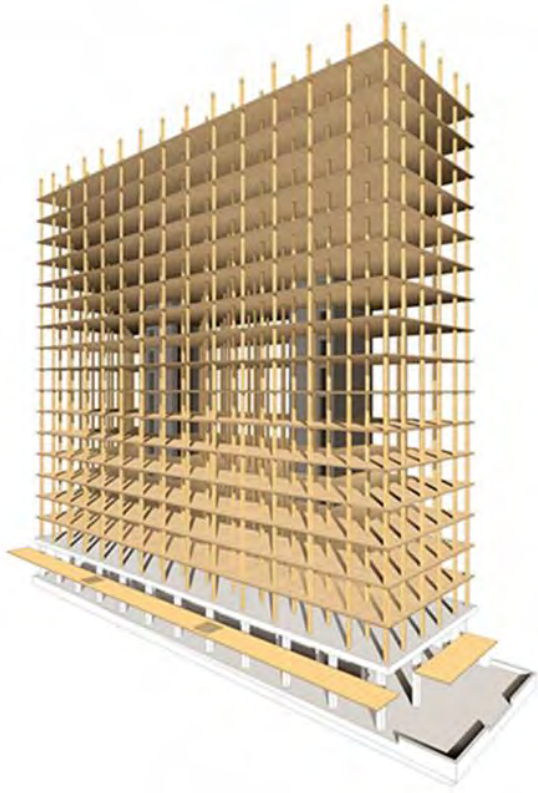
Arla to introduce wood-based bioplastic paperboard cartons. Credit: Arla

Limiting warming to 1.5°C,
with 10% of global energy supply coming from woody biomass

RCP 1.9

0%   100%

Fig. 2. Mean change in total regional harvests relative to the baseline, 2010–2100.
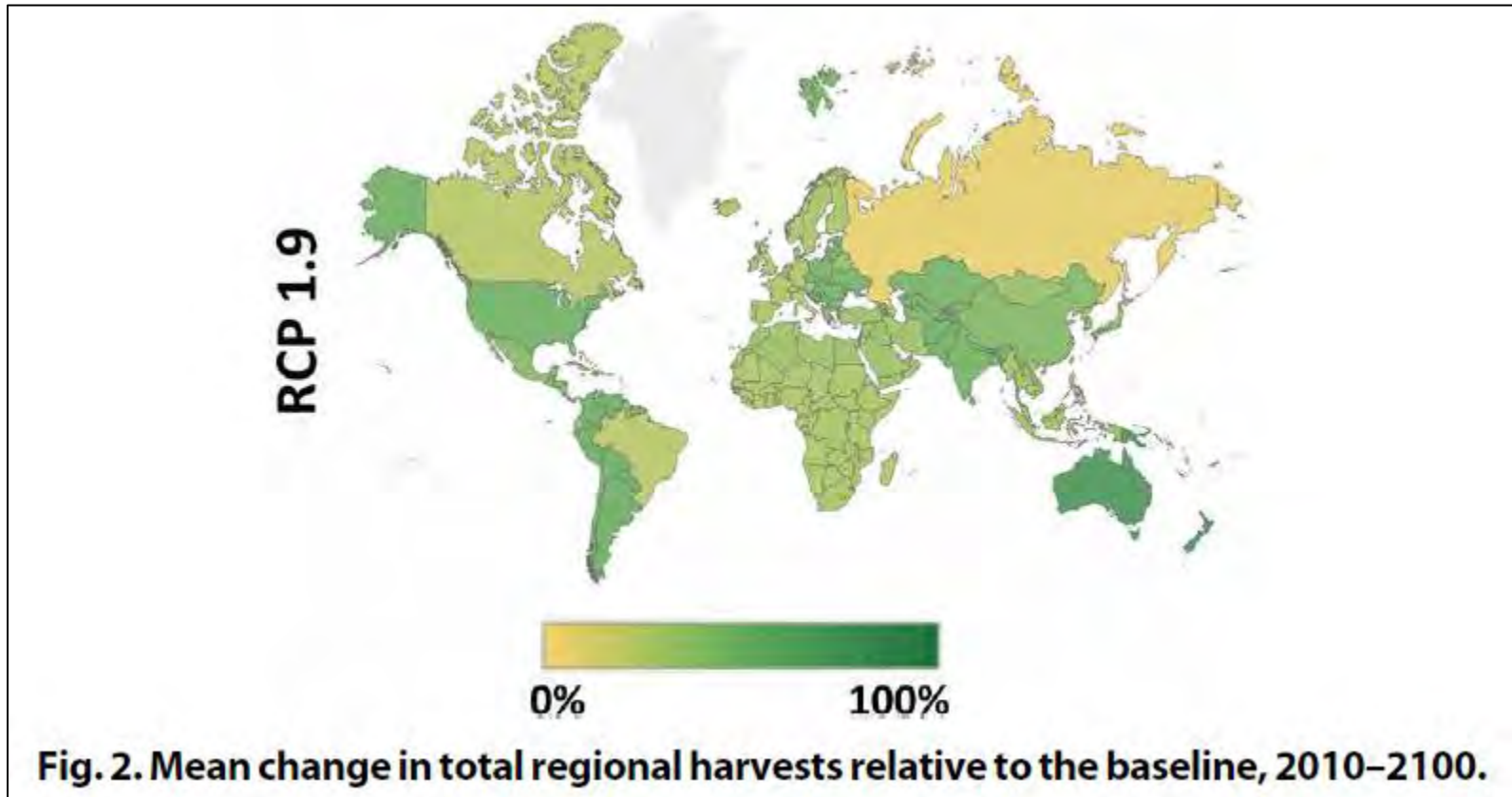
Source: Favero et al. (*Science Advances*, 2020)

> 1 Bha of additional forestland in 2100
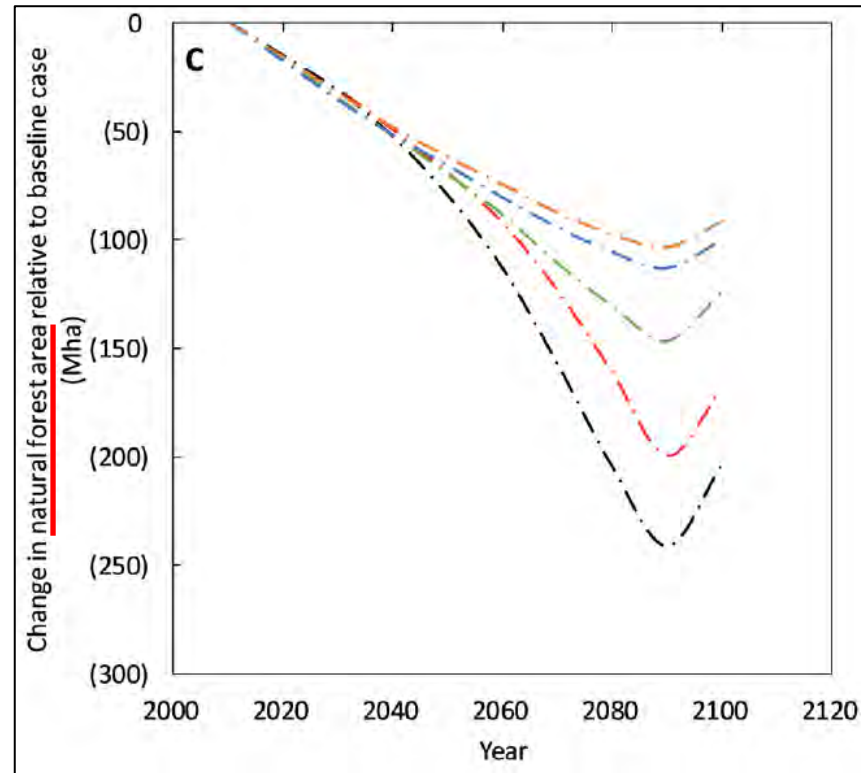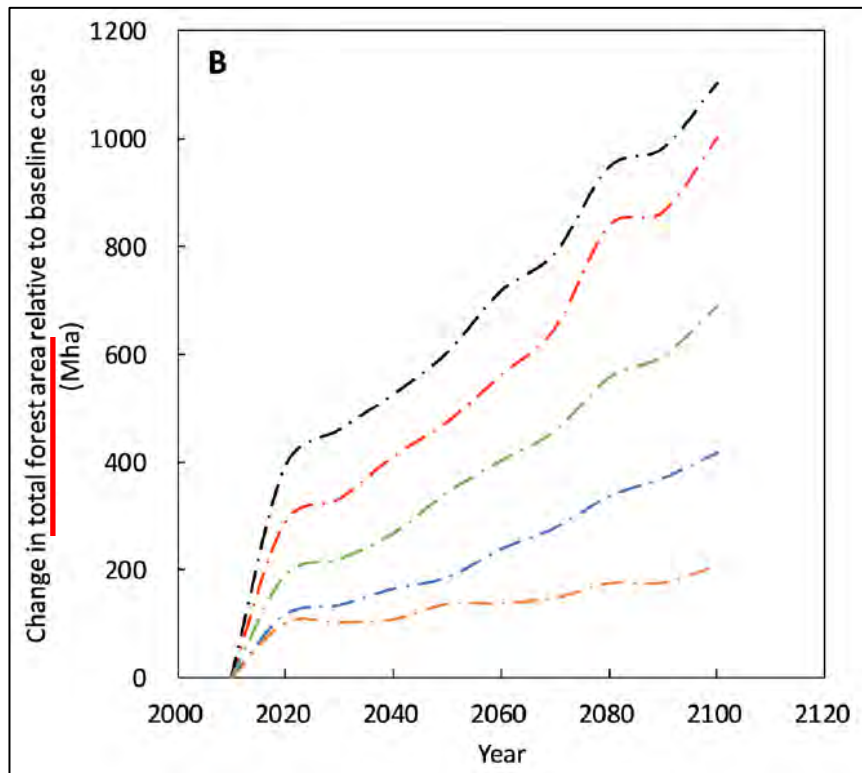
Source: Favero et al. (*Science Advances*, 2020)

Black line: difference, limiting warming to 1.5°C with 10% of global energy supply coming from woody biomass *minus* limiting warming to 1.5°C with 0% of global energy supply coming from woody biomass

See also: Daigneault et al., "How the future of the global forest sink depends on timber demand, forest management, and carbon prices" (*CENREP Working Paper*, 2021)

45

Policy interventions beyond forest sector needed

	Restoration potential (km²)	Quantified NDC	Governance index	Tenure security index	Score for enabling business of agriculture	Minutes to market from reforestable areas
Brazil	843,253		-0.18	74	75	149
Congo, Dem. Rep.	809,997	✓	-1.61	NA	30	175
Indonesia	423,308		-0.17	63	NA	148
Angola	305,239	✓	-0.87	NA	27	236
Colombia	221,888		-0.14	65	82	219
Tanzania	216,290		-0.56	64	57	158
Mexico	200,519		-0.37	79	69	75
Central African Republic	147,531	✓	-1.58	NA	NA	230
Côte d'Ivoire	130,496		-0.50	59	46	59
Myanmar	124,620		-0.95	75	31	196
Venezuela, RB	116,186		-1.78	72	NA	258
Thailand	115,404	✓	-0.20	72	59	63
Cameroon	107,934		-1.12	55	22	132
Mozambique	106,571		-0.77	57	51	154
China	105,041	✓	-0.36	75	70	108
Philippines	104,861		-0.31	51	68	89
India	94,434	✓	-0.11	64	62	64
Malaysia	85,336		0.43	54	52	99
Vietnam	85,206	✓	-0.33	82	61	65
Zambia	82,834		-0.45	70	64	128

Source: Shyamsundar et al. ("Scaling smallholder tree cover restoration in the tropics," in prep.)

Economic research needs

1. *Retrospective analysis*: evaluate impacts of current or past projects/programs/policies directly or indirectly related to forest restoration

2. *Prospective analysis*: discrete choice experiments (DCEs), field experiments, pilot auctions, and randomized controlled trials (RCTs) to test features of potential forest restoration projects/programs/ policies

Liu et al. (*Land Use Policy,* 2017)

Table 4
Empirical results: Impact of NRCFT and MRMs on forestlands.

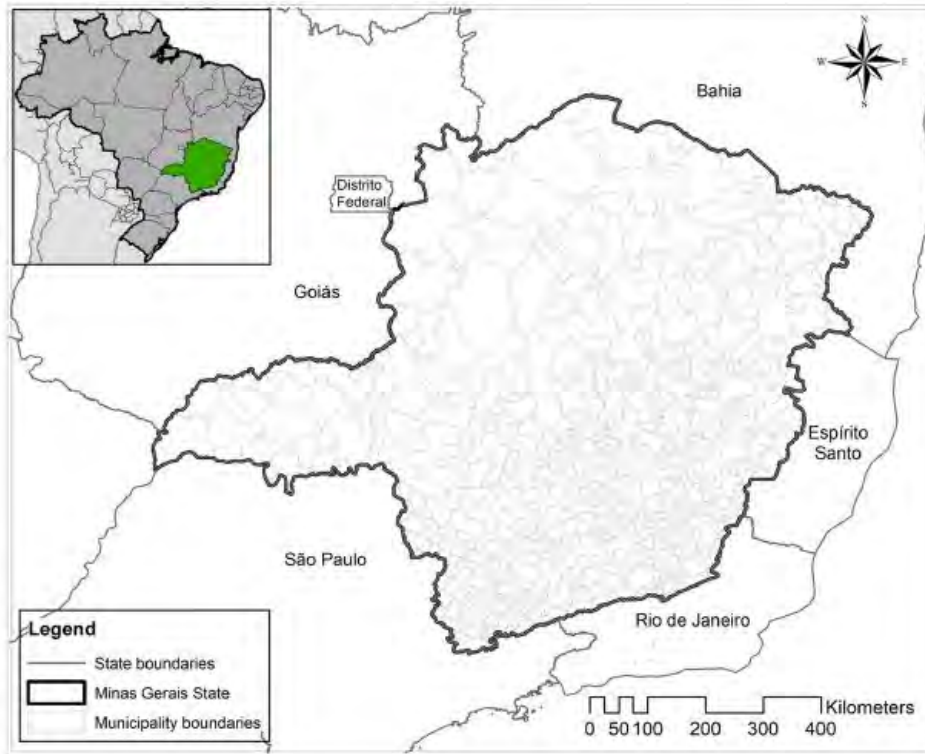| Variables		Forestland (mu)			Family forestland (mu)		Household responsibility forestland (mu)	
Village average timber price index (2003 = 1)	p_1	0.35***(0.09)	0.35(0.21)		0.11(0.09)		0.32(0.19)	
Village average agricultural product price index (2003 = 1)	p_2	0.46***(0.18)	0.46(0.43)		0.76**(0.30)		0.13(0.41)	
Village average off-farm wage index (2003 = 1)	p_3	0.21***(0.06)	0.21(0.19)		−0.06(0.10)		0.35*(0.19)	
Village average labor cost index directed towards agricultural activities (2003 = 1)	p_4	−0.48***(0.09)	−0.48(0.42)		−0.54**(0.21)		−0.12(0.35)	
Village average labor cost index directed towards forestry activities (2003 = 1)	p_5	−0.14**(0.06)	−0.14(0.20)		−0.05(0.05)		−0.13(0.18)	
Village average agricultural subsidy (yuan/mu)	x_6	0.03***(0.01)	0.03**(0.01)		0.01(0.01)		0.01(0.01)	
Village leader/chief of a village or sub-village (yes = 1; otherwise = 0)	x_7	−0.19(0.12)	−0.19(0.17)		−0.07(0.09)		−0.12(0.23)	
Education of household head (junior middle school or above = 1; otherwise = 0)	x_8	−0.13(0.10)	−0.13(0.17)		−0.09(0.07)		−0.21(0.16)	
Road condition (if hard road surface = 1; otherwise = 0)	x_9	−0.98***(0.16)	−0.98(0.96)		0.15(0.35)		−1.53(0.94)	
Labor size (persons)	x_{10}	−0.05**(0.02)	−0.05(0.03)		−0.02(0.01)		−0.02(0.04)	
Annual household total income (yuan)	x_{11}	0.24***(0.02)	0.24***(0.03)		0.12***(0.03)		0.16***(0.04)	
Household signed legal contract for forestland (yes = 1; otherwise = 0)	z_1	1.23***(0.07)	1.23***(0.33)	1.64***(0.34)	0.22*(0.12)	0.41**(0.16)	1.44***(0.43)	1.71***(0.44)
Easiness to obtain AAC (yes = 1; otherwise = 0)	z_2	0.43***(0.08)	0.43(0.35)	0.52(0.45)	0.18(0.19)	0.26(0.24)	0.56(0.41)	0.55(0.47)
Household has forest insurance (yes = 1; otherwise = 0)	z_3	0.06(0.10)	0.06(0.37)	0.31(0.46)	0.00(0.21)	0.08(0.24)	0.27(0.43)	0.46(0.50)
Household received afforestation or reafforestation subsidy (yes = 1; otherwise = 0)	z_4	1.01***(0.07)	1.01***(0.23)	1.05***(0.21)	0.29*(0.12)	0.32*(0.12)	1.06***(0.25)	1.06***(0.22)
Household used forestland as collateral for a loan (yes = 1; otherwise = 0)	z_5	0.09(0.42)	0.09(0.35)	0.07(0.25)	0.12(0.22)	0.10(0.22)	0.12(0.49)	0.15(0.31)
Forest tax and fee rate (%)	z_6	−2.38*(1.37)	−2.38*(1.17)	−2.33*1.24)	1.30(3.84)	1.27(3.83)	−5.81**(2.63)	−5.76**(2.55)
Inception		−2.51***(0.19)	−2.51**(0.98)	−1.40***(0.30)	−6.89***(0.49)	−5.89***(0.15)	−3.40***(0.90)	−2.93***(0.39)
Overall-R^2		0.12	0.12	0.12	0.10	0.09	0.08	0.09
Within-R^2		0.19	0.19	0.14	0.16	0.12	0.16	0.13

Fixed effects model on impacts of tenure reform on forest area in China

Converting community forestland to *de facto* private forestland increased forest cover

Afonso & Miller (*Forest Policy and Economics,* 2021)

Fixed effects model on socioeconomic impacts of commercial wood plantations in Brazil

Increase in plantation area is associated with a reduction in poverty in local communities

Permadi et al. (*Land Use Policy,* 2017)

Table 3
An example of the choice sets presented to the respondents with the following question: *"Imagine you have 1-ha of private land and a forestry agency (government/company/NGO) offers contract options to grow genetically-improved acacia trees on that land. Which one of the following contract options do you prefer the most?".*

Discrete choice experiment on hypothetical smallholder pulpwood outgrower scheme in Indonesia

Scheme more likely to succeed if it offered three types of contracts with different primary objectives:
(i) wood production
(ii) livelihood development
(iii) conservation

Huntington & Shenoy (*Journal of Development Economics*, 2021)

a) Nearly Half of Households Think a Loss of Land is Likely

b) Large Farmers and Farmers with Contested Rights Are More Fearful

Note: The survey asks households how likely it is (on a 1 to 6 scale) that in the next 3 years each plot will be encroached by any of several private actors, and how likely it is that the chief or village head will reallocate their land. **Panel a:** We plot the fraction of households that "fear a loss of land," meaning they think it likely, very likely, or happening right now on one or more of their plots. We plot the responses by the source of risk. We also plot the fraction who fear a loss from any of the sources. **Panel b:** We plot the fraction who fear a loss from any source conditional on whether it has recently had land reallocated or had a land dispute, and whether it is a "large" landholder (in the top decile of the distribution).

Fig. 1. Perceptions of tenure insecurity.

Randomized controlled trial (RCT) on tree planting in Zambia

Strengthening customary use rights by mapping farmers' parcels increased perceived land security, but it did not affect tree planting; however, technical assistance did increase tree planting

Jindal et al. (*Land Use Policy*, 2013)
Andeltova et al. (*Ecosystem Services*, 2019)

Fig. 2. Predictive margins of the bids for the treatment-gender interaction calculated from predictions of the OLS regression in Table 1: column 3. 95% confidence intervals.
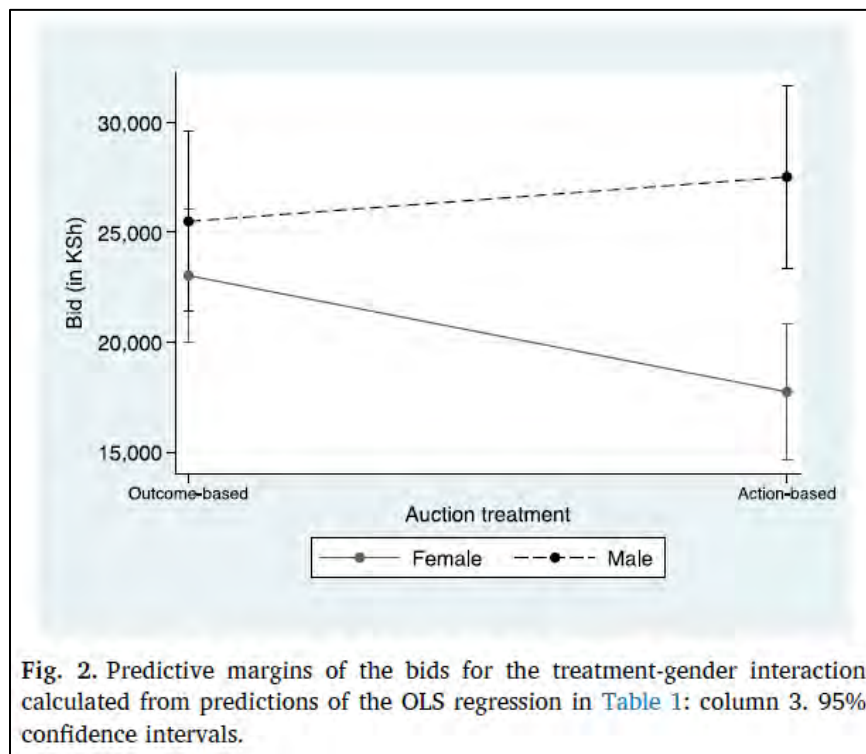
Distributional impacts of tree-planting PES (via pilot auctions) in Tanzania and Kenya, respectively

Auction outcomes tended <u>not</u> to be pro-poor—better-off households were more likely to win them (Tanzania)—but did tend to be pro-female—women were more likely to win them (Kenya)

Oliva et al. (*Review of Economics and Statistics*, 2020)

Note: The survey asks households how likely it is (on a 1 to 6 scale) that in the next 3 years each plot will be encroached by any of several private actors, and how likely it is that the chief or village head will reallocate their land. **Panel a:** We plot the fraction of households that "fear a loss of land," meaning they think it likely, very likely, or happening right now on one or more of their plots. We plot the responses by the source of risk. We also plot the fraction who fear a loss from any of the sources. **Panel b:** We plot the fraction who fear a loss from any source conditional on whether it has recently had land reallocated or had a land dispute, and whether it is a "large" landholder (in the top decile of the distribution).

Fig. 1. Perceptions of tenure insecurity.

Randomized controlled trial (RCT) on two-stage PES for tree planting and tree survival in Zambia

Forest restoration via PES entails a budgetary tradeoff: implementing agency can boost landholder participation by allocating more of its budget to subsidize seedling purchases, but boosting tree survival requires allocating more of the budget toward payments linked to survival

Economics of forest restoration: studies underway

- SANDEE
  - 6 studies underway: Bangladesh, China, India, Nepal, Pakistan
  - 4 studies proposed to IDRC: Bangladesh, Bhutan, Nepal, Pakistan

- Environment for Development Initiative (EfD): study underway in Uganda

- FAO: study underway in Uganda

- US Socio-Environmental Synthesis Center (SESYNC): studies underway in Brazil, China, Guatemala, and Malawi, plus global analysis

Thank you!