A Growth Story for the 21st Century: building sustainable, resilient, and equitable development

Lecture 3: Recasting the global economy and international institutions; collaboration, competition, and the new growth story

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Slides sufficiently detailed to be read independently of lectures. Not all detail will be presented.

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Lionel Robbins Lectures,12th, 13th, 14th March 2024
London School of Economics and Political Science

LSE The London School of Economics and Political Science

Grantham Research Institute on Climate Change and the Environment

Grantham Foundation for the Protection of the Environment

The Queen's Anniversary Prizes For Higher and Further Education 2021

This is the time for economics and the social sciences to chart a course for fundamental and rapid change

- These lectures are about **economic analysis, ideas, policy, and action that can guide a rapid change of course** and the creation of sustainable, resilient, and equitable growth and development.
- Building on the science, they show what is necessary, and on the technology, what is feasible. The scale, speed, and nature of the necessary change imply that the **transition will not be easy. The obstacles lie mostly in economics, politics and society rather than technology.**
- The prize is the **avoidance of a catastrophic future for the generations to follow and the creation of the growth story of the 21st century.** Far more attractive than the dirty, destructive paths of the past.
- Our focus then is on the **economics of change**. But we must also recognise that **economics must itself change towards the economics of rapid structural, systemic, and technological transformation.**
- This is the moment **economics must step up**. But its analysis must be interwoven with politics, finance, law, geography, international relations, history, culture, and crucially, moral philosophy. **With the social sciences and the humanities.** I trust that the great Lionel Robbins would have recognised this clearly and lead the way.
- **This is a moment for the LSE "to know the causes of things", "for the betterment of society"; its motto and its purpose.**

Essence of the lectures

Lecture 1 : A world re-drawn; a world in crisis; a moment in history; the agenda for growth and transformation (12th March)

1. Looking back: growth and development since the second world war.
2. A world redrawn: a series of crises and deepening understanding of the unsustainability of current paths.
3. Climate and biodiversity crises: science and necessity of rapid and fundamental, structural, and systemic change.
4. The ethics, the economics, and the politics of sustainable development and fundamental change.
5. A decisive decade: urgency and scale of action.
6. Implication: the agenda for analysis and action is the building of sustainable, resilient, and equitable growth and development; rapidly and effectively.

Lecture 2 : A new growth story; structural transformation; policies and institutions (13th March)

1. The basics of the new growth story.
2. Climate action, development, and poverty reduction.
3. Investment and innovation.
4. The analytics of the new growth story.
5. Policies and institutions.
6. The role of the state.

Lecture 3 : Recasting the global economy and international institutions: collaboration, competition, and the new growth story (14th March)

1. Vulnerability, history, and opportunity: differences across countries.
2. Technology, geography, trade.
3. International action, responsibilities, and collaboration. Five key areas: trade; technology; land; overshooting; finance.
4. Land, forests, and biodiversity.
5. Overshooting, removal, and geoengineering.
6. Fundamental reform of MDBs and international finance system.

Closing call; optimistic about what we can do as a world; anxious about what we will do; challenge is to turn "can" into "will".

References provided in a separate document.

Lessons from Lectures 1 and 2

The next decade is critical to keep the Paris Agreement targets within reach. Emissions are still rising. Mounting scientific evidence pointing to still earlier and more severe climate effects. **Delay is dangerous; a fundamentally unrealistic strategy.**

A moment of **great risk and great opportunity**. Science is ever more worrying; the consequences of rising above 1.5°C or 2°C looking still more dangerous. Immense risks from failure to keep Paris. **Climate tipping points are ever closer.** Technology has become more promising; clean is cheaper than dirty across much of the economy. Costs of clean still falling rapidly. Rapid innovation in hard-to-abate sectors. **Tipping points on cost/technology** also.

Action on climate and nature is an investment, not a cost, essential for fostering a sustainable, resilient, and inclusive economy over the next three decades. This demands a **major and urgent push on investment**, particularly in EMDEs, to support the required **structural and systemic transformation** towards new, better and sustainable forms of growth.

The new growth story of the 21st century **relies on six key drivers:** innovation; economies of scale; efficiency; systemic changes; health improvements; and the significant investment increases required for a rapid and comprehensive economic transformation. **Current analytical economic frameworks are generally inadequate** for grasping the full scope of climate risks and the requirements and mechanisms for systemic and structural change. These critical elements of the problem and necessary response require a rich and diverse set of analytical approaches and judicious synthesis for guiding the complex transition towards sustainable growth.

Effective climate strategies **contribute to development and poverty reduction**. Inaction creates and exacerbates poverty and hinders overall development progress. Achieving climate and development objectives necessitates substantial investments in clean technology, particularly in EMDEs, with a strategic focus on electrification, efficiency, urban transformation, agriculture, forestry, and leveraging AI for green technology.

Robust policies and institutions are needed to create a stable and encouraging investment climate and tackle a broad range of market failures. We need to **move beyond market fundamentalism** towards state-led initiatives that guide and shape markets and promote the private and investment and structures that can deliver sustainability, resilience and equity. Public participation in defining goals and strategies a key element. **New role for the state.**

Structure

- **Vulnerability, history, and opportunity: differences across countries**
- Technology, geography, trade
- International action, responsibilities, and collaboration: five key areas - trade; technology; land; overshooting; finance
- Land, forests, biodiversity
- Overshooting, removal, geoengineering
- Fundamental reform of MDBs and international finance system
- Closing call

Collaboration and transformation

Effective climate collaboration hinges on recognising diverse emissions histories and country circumstances, guided by the Paris Agreement, which mandates temperature limits, emissions reductions, adaptation, support mechanisms, and regular assessments. Focus on investment and finance as core to action.

The key international foundation is the Paris Agreement (see Lecture 1).

- ✓ **Long-term temperature goal** (Art. 2) – limiting global temperature increase to **well below 2^{0}C; efforts for 1.5^{0}C.**
- ✓ **Global peaking and 'climate neutrality'** (Art. 4).
- ✓ **Mitigation** (Art. 4) - submit and update **NDCs every 5 years.**
- ✓ **Voluntary cooperation**/Market- and non-market-based approaches (Art. 6) - e.g. GHG **emissions trading** across countries.
- ✓ **Adaptation** (Art. 7) - enhancing adaptive capacity, strengthening resilience and reducing vulnerability to climate change.
- ✓ **Loss and damage** (Art. 8).
- ✓ **Finance, technology and capacity-building** (Art. 9, 10 and 11) commitment of developed countries to provide support to developing countries (in 2009 developed countries committed to mobilize **$100 billion a year** in public and private finance by 2020).
- ✓ **Global Stocktake** (Art. 14) – assess collective progress toward achieving the goals of the Agreement every 5 years.

Understanding **differences in history of emissions, current emissions, vulnerabilities, endowments, opportunities, and objectives, plus the emerging new economic geography**, is crucial to understanding potential for and difficulties in collaboration. Much of history set out in Lecture 1 and opportunities in Lecture 2.

The **several dimensions of collaboration** are all important and pose different questions.

Investment and finance at the heart of national and international action.

Developing countries are more vulnerable to climate change impacts

Whilst their contributions to global concentrations and emissions are much lower than developed countries, developing countries face greater vulnerability to climate change impacts due to their higher exposure, lower coping capacities, reliance on climate-dependent sectors, and, in some cases, history of conflict, poverty and weak governance. The most severe effects are on low-income and Least Developed Countries (LDCs): in 2019, 8 of the 10 countries most affected by extreme weather were low or lower middle-income countries, with half of these being LDCs (Germanwatch and Munich Re, 2021).

In the **Horn of Africa, droughts** have already become about 100 times more likely (World Weather Attribution, 2023).

A healthy person may not be able to survive outdoors for more than 6 hours at a wet-bulb temperature of 35 °C. Under GHG emissions BAU scenarios, that threshold will be reached several times in the North China Plain region between 2070 and 2100 (MIT, 2018).

The proportion of **tropical cyclones that are intense** is expected to increase globally, especially in **Southeast and East Asia**. In these 2 regions, cyclones, floods and typhoons triggered internal displacement of 9.6 million people in 2019, almost 30% of total global displacements (Shaw et al., 2022).

AMPLIFICATION OF PRE-EXISTING STRESSES

Asian and African urban areas are high-risk locations due to projected climate, extreme events, unstructured urbanisation and rapid land use change. Pre-existing stresses related to poverty, informality, exclusion and governance are likely to be amplified (Pörtner et al., 2022).

IMPACTS ON DEVELOPMENT

Africa's GDP per capita for 1991–2010 was on average 13.6% lower than if climate change had not occurred – due to agriculture, tourism, manufacturing and infrastructure losses (Trisos et al., 2022).

HIMALAYAN REGION

Melting of snow, ice, glaciers, likely to produce unmanageable torrents and floods in rainy season (which will likely be more intense) and very weak river flows in dry seasons. Devastating effects on lives, livelihoods, infrastructure, agriculture…

SOCIAL TIPPING POINTS

Even with current moderate climate change, vulnerable groups will experience additional erosion of livelihood security that can interact with humanitarian crises, violence and armed conflict, leading to social tipping points (Pörtner et al., 2022).

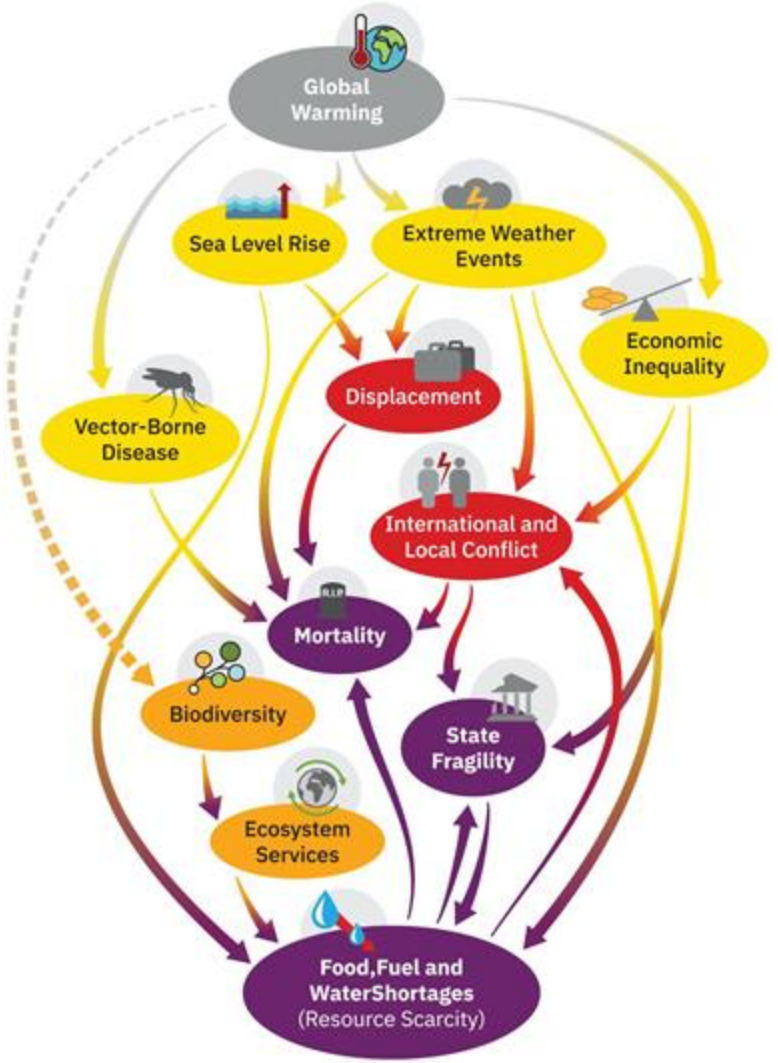
ALL COUNTRIES ARE AT RISK

In **Europe**, the amount of people at high risk of mortality will triple at 3°C compared to 1.5°C warming - especially in central and southern Europe, and urban areas (Pörtner, 2022).

The world's fragile states are even more affected by climate impacts

Climate change affects fragile states particularly intensely; higher temperatures, more frequent disasters, droughts and desertification, substantial economic losses...

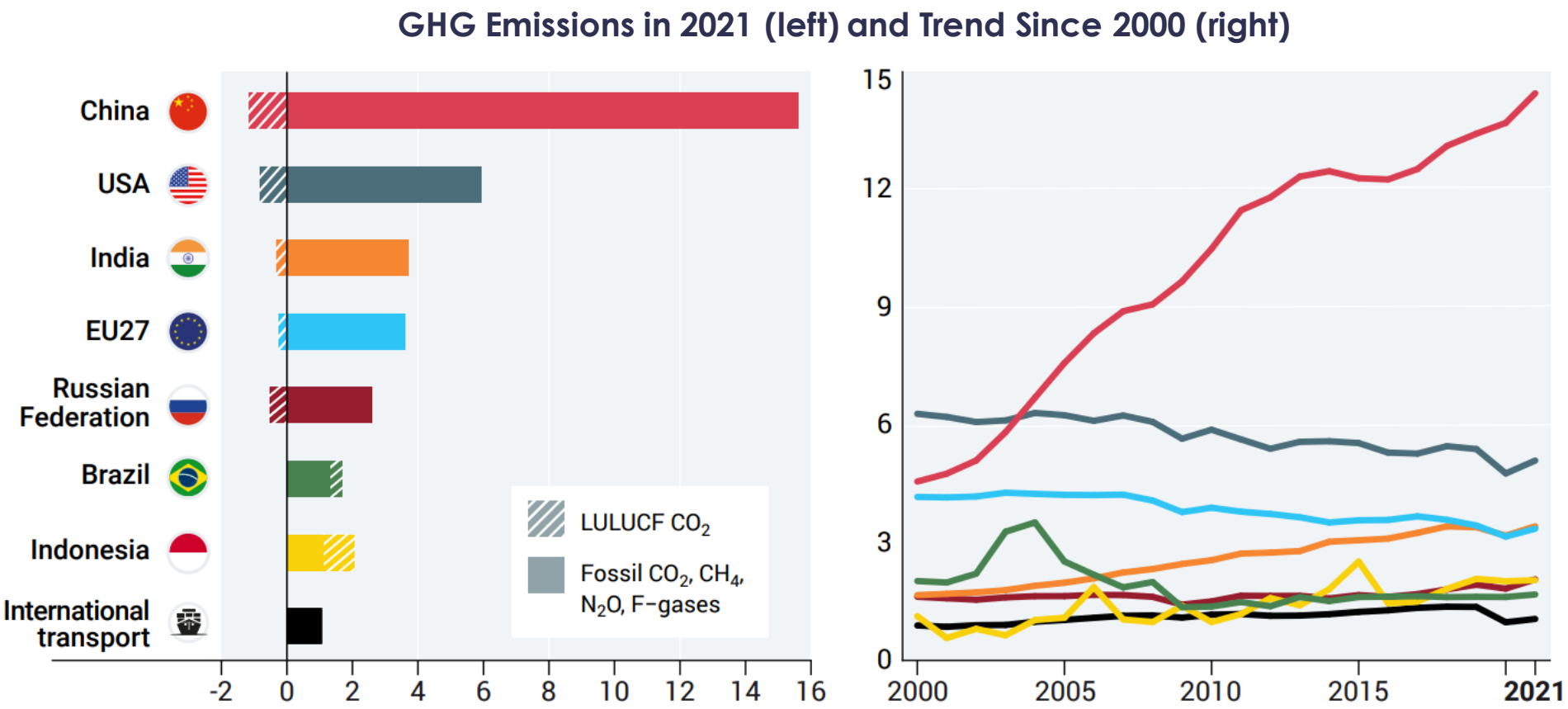
- Disasters in fragile states **displace more than twice the share of the population** than in other countries (IMF, 2023).
- **Temperatures in fragile states are already higher** than in other countries because of their geographical location (IMF, 2023).
- By 2040, fragile states could face 61 days a year of temperatures above 35 degrees Celsius on average - **four times more than other countries** (IMF, 2023).
- **Climate change has eliminated one fifth of the wealth of the Vulnerable Twenty** (V20) economies over the last two decades - V20 would have been 20% wealthier today had it not been for climate change (V20, 2022).



Source: Kemp et al. (2022)

The history and geography of emissions (I)

The USA, EU, and UK are responsible for around 1/3 of total cumulative emissions (1850-2021) (UNEP, 2023a). China's remarkable economic expansion – with an average annual growth rate of nearly 10% since 1978 (World Bank, 2023f) - propelled it past the USA in aggregate annual emissions in the early 2000s.

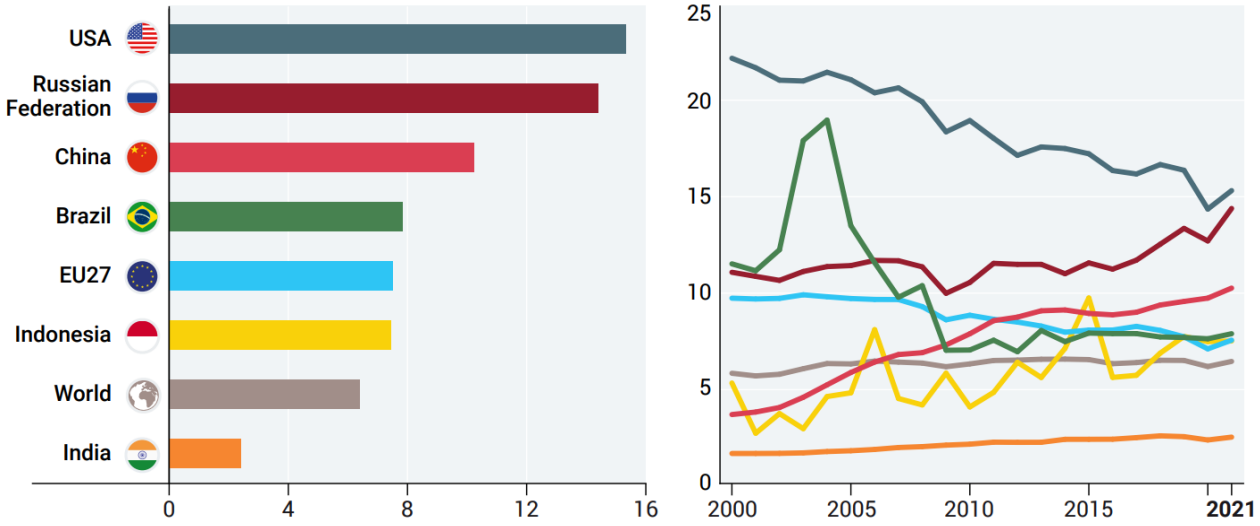


Source: UNEP (2023a)

The history and geography of emissions (II)

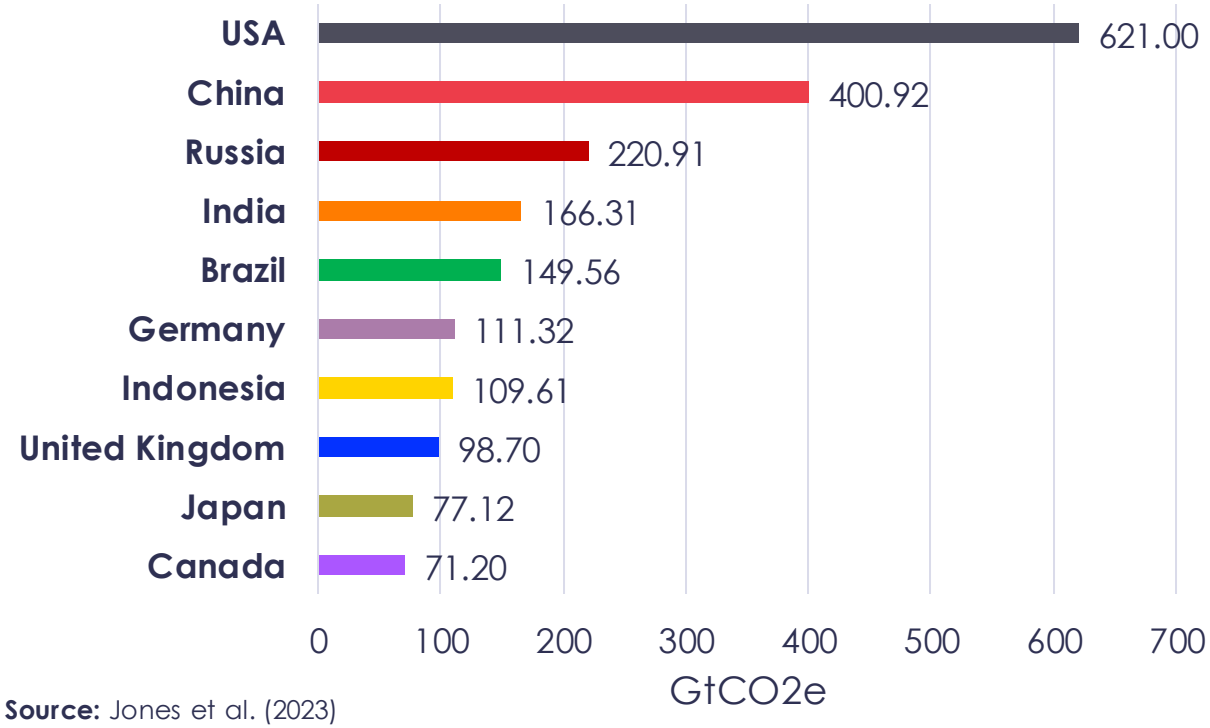
Per capita emissions are very different across countries. In 2021, the United States and the Russian Federation emitted over double the global average, while India's emissions were less than half. Historically, since 1850, a few countries, notably the United States and China, have contributed the majority of GHG emissions, with the G20 nations responsible for about three-quarters of CO2 emissions since 1850. While China surpassed the USA in aggregate annual emissions in the early 2000s, its cumulative and per-capita emissions are still lower than the USA.

GHG emissions per capita in 2021 for key countries (left) and trends since 2000 (right)



Source: UNEP (2023)

Countries with the largest cumulative GHG emissions 1850 - 2021

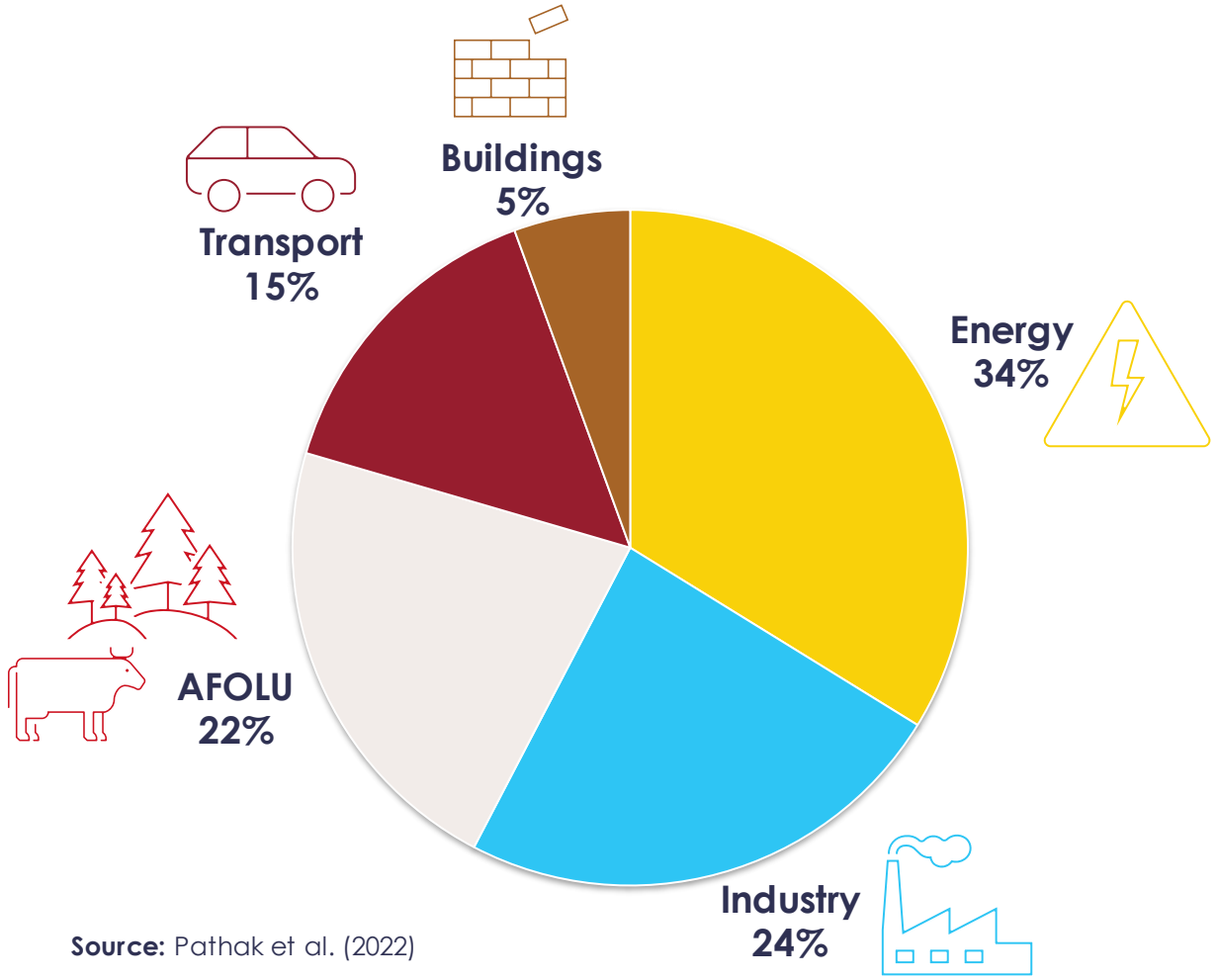


Source: Jones et al. (2023)

Sectoral sources of emissions

GHG have risen across all sectors and subsectors, most rapidly in transport and industry. The energy sector is the largest source of GHG emissions, driven by electricity and heat generation.

Global GHG emissions by sector (2019)



Source: Pathak et al. (2022)

Across much of the developing world, infrastructure remains weak

Building infrastructure is essential to economic growth and poverty reduction. The challenge in advanced economies is decarbonising the current infrastructure and transitioning to a low-carbon economy; in EMDEs it is to build the new infrastructure and economy in a way that is net-zero aligned. This decade is decisive: infrastructure decisions and investments made in this decade will have powerful consequences for the decades that follow. By acting now developing countries can avoid the lock-in of outdated and dirty capital and infrastructure.

- One billion people live more than two kilometers from an all-season road.
- Nearly 3 billion people live without access to the Internet (United Nations, 2021).
- 80% of India's likely infrastructure in 2050 is yet to be built (Bhattacharya and Stern, 2023).
- Sub-Saharan Africa counts for about 80% of people living without electricity (IEA, IRENA, UNSD, World Bank, WHO, 2023).
- Infrastructure lasts for decades and **70% of the increase in emissions from developing countries is expected to be associated with infrastructure yet to be built** (UNOPS, UNEP and the University of Oxford, 2021).

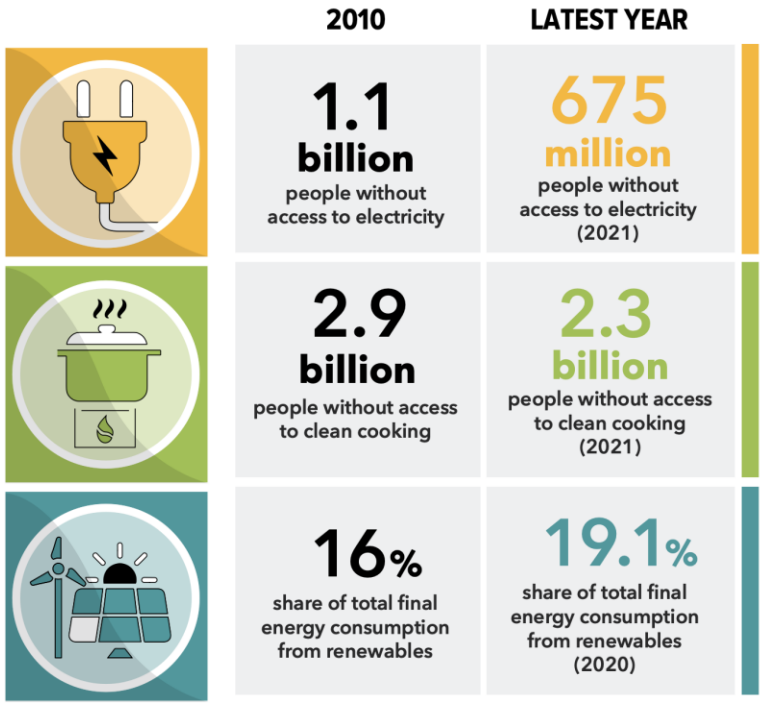
Share of global population with access to electricity in 2021

Source: IEA, IRENA, UNSD, World Bank, WHO (2023).

Renewable energy systems at the core of the energy transition

Among key systems transformations, energy is critical to sustainable growth and development. Growth and decarbonisation of transport, industry, buildings… all depend on electrification. Energy access, affordability, and security are key issues for delivering a just energy transition.

Global progress toward SDG 7 (affordable and clean energy) targets

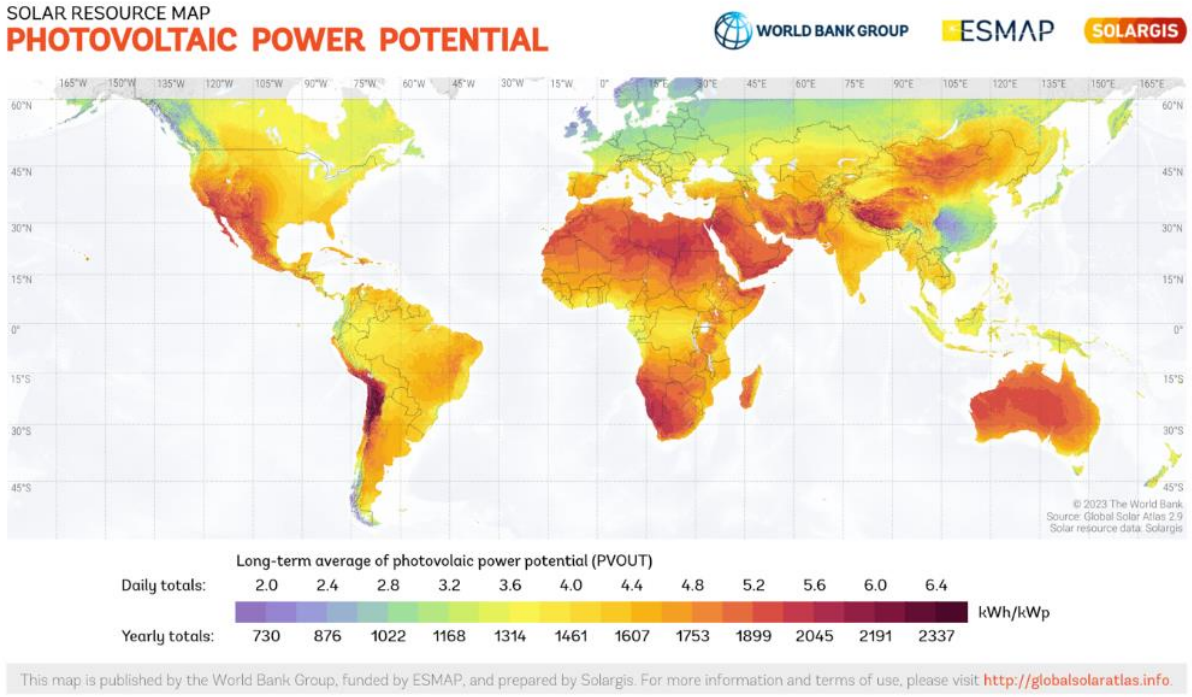


Source: IEA, IRENA, UNSD, World Bank, WHO (2023)

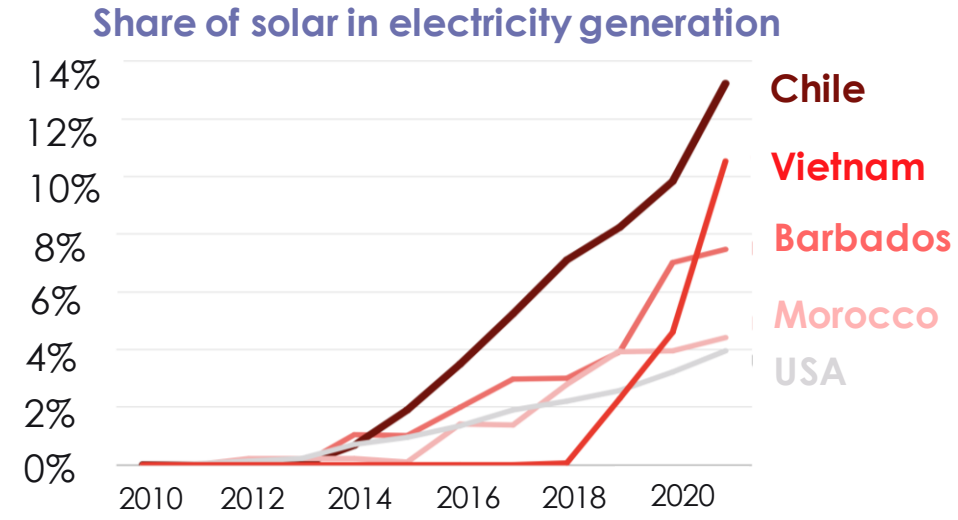
- In 2022, there were 760 million without access to electricity and billions with meagre and unreliable supplies (IEA, 2023d).
- **The demand for energy in developing countries to support economic growth and reduce poverty is rapidly increasing.**
- Without faster change, rising demand for energy could translate into a significant increase in GHG emissions, as energy is by far the biggest contributor - **responsible for 34% of global GHG emissions** (Pathak et al., 2022).
- In 2020, the share of renewable energy in total final energy consumption (TFEC) was 19.1%. To be on track with the 1.5°C target, the **share of renewables must reach 33-38% by 2030.** And **60-65% in electricity generation**) (ETC, 2023a).
- **India** will need to increase its **electricity generation fivefold by mid-century** to support population and economic growth, higher living standards and the electrification of the economy necessary to decarbonise. By then it should all be zero carbon. Most of the infrastructure for achieving net-zero by 2070 (its NDC target) will be built in the next 20–30 years (ETC, 2023b).

Tremendous opportunity for EMDEs to leapfrog and avoid the dirty technologies of the past

The 'pollute first, clean up later' approach is no longer viable if we are to achieve sustainable growth and climate goals. Most of the infrastructure that developing countries will need by 2050 will be constructed over the next three decades, and there is a tremendous opportunity to leapfrog and avoid the dirty technologies of the past. But finance, technology and skills are needed.



The Global South has enormous access to renewable resources that can be **unlocked through falling costs of clean technologies,** provided that the cost of capital is manageable.



Source: RMI (2023b)

Many countries in the Global South are already taking advantage of the new technologies. Chile, Vietnam, Barbados and Morocco for example already overtook the United States in terms of share of solar in electricity generation.

Some EMDEs are also catching up on wind – e.g. Uruguay is producing over 30% of electricity with wind compared to only 10% in the US (OurWorldinData, 2023b).

Structure

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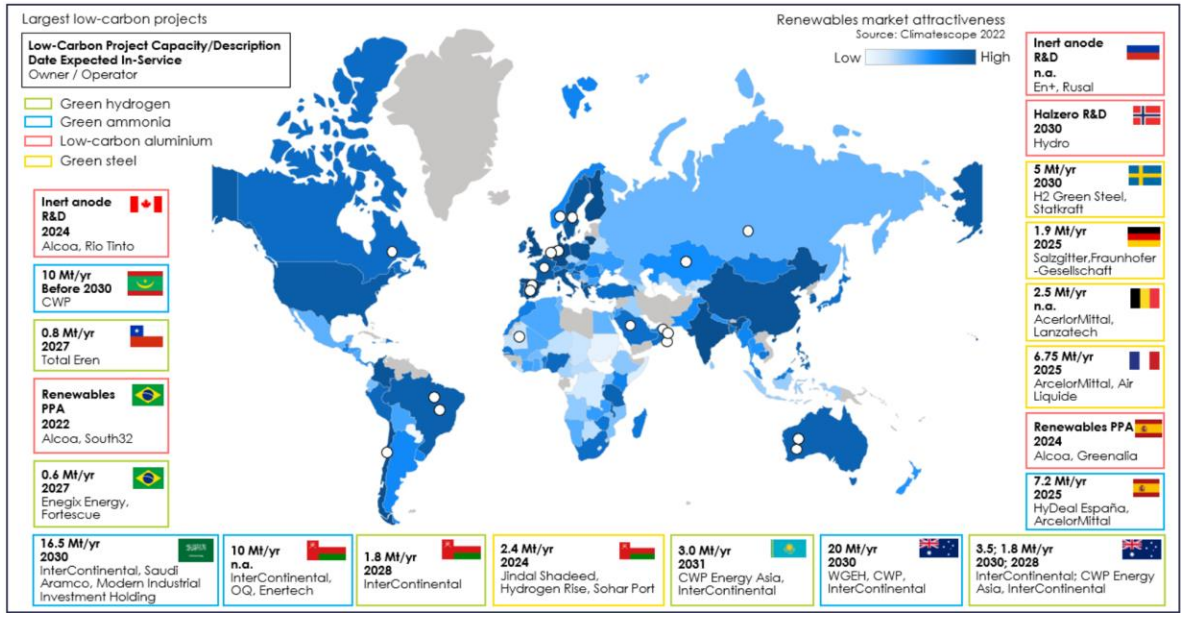
- Closing call

Clean technologies are changing the world's economic geography

Faster growth of EMDEs and location of renewable energy sources are changing the world's economic geography and patterns of trade. But challenges in attracting low-cost capital in some of these economies risk undermining their natural advantage.

Large low-carbon industrial projects announced across the globe, bolstered by attractive renewables markets and growing capacity

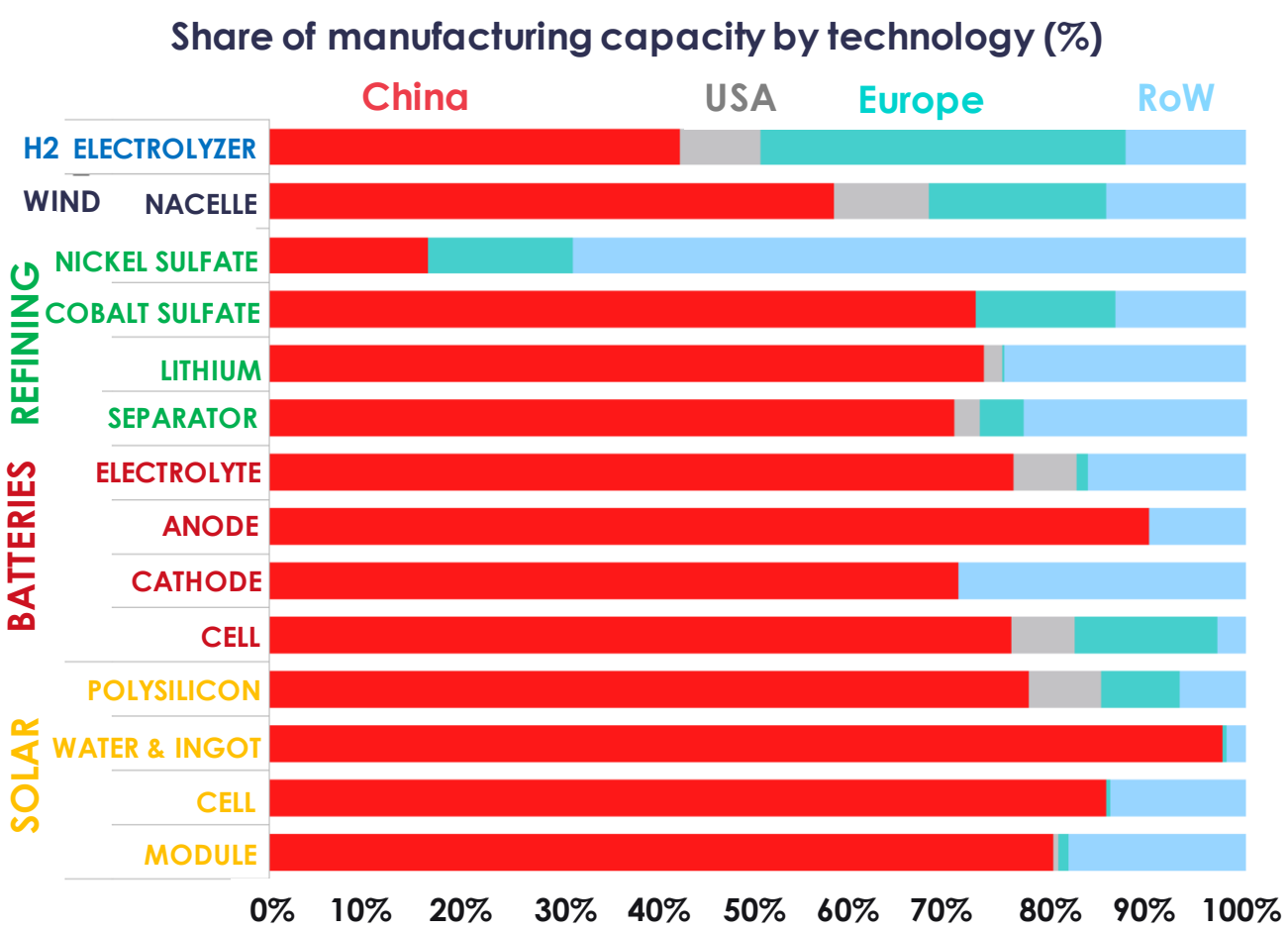


Source: Stern and Romani (2023).

- **Different energy and industrial production map emerging**, especially in emissions-intensive trade-exposed industries (steel, aluminium and base chemicals). The geography of 19/20th centuries saw these concentrated near endowments of heavy raw materials (iron, coal).
- The outcomes of recent renewables auctions suggest that many countries in the **Global South are well positioned to gain market share as low-cost zero-emissions power producers** (IEA, 2019).
- **Middle East and North Africa** are among the most **competitive** regions (IEA, 2019).
- Electricity requires strong investment in transmission lines for efficient transport. Hydrogen is costly to transport (although ammonia is less so). Hence the **advantage of local industrial use of clean, cheap electricity**.
- Major industrial parks are taking shape - e.g. Chile, Brazil, Saudi Arabia, UAE, Mauritania, Namibia and Kazakhstan are all developing landmark projects that could see them evolve as strong players in net zero industry (Stern and Romani, 2023). So too is China. Many developers see regulation obstacles to such parks in richer parts of world (particularly Europe).

And they are reshaping many of the segments of global supply structures: potential risks associated with high geographic concentrations

Concentration at any level along a supply structure can create vulnerabilities that can affect the entire supply structure for a given technology. And over time, excessive concentration can slow technical progress. Diversification and competition are important objectives (see later in Lecture) in mineral extraction and processing and in manufacturing.



Source: BNEF (2022).

The rapid rise of clean energy has underpinned **significant growth in minerals demand. In many cases supply is highly concentrated**, e.g.:

- Cobalt is mostly mined in the DRC and refined in China.
- Lithium is mostly mined in Australia (46%), Chile (24%), China (16%) and refined in China (60%).

However, **lithium is being discovered across the world** and recent discoveries in the USA suggest it can be self-sufficient for decades. Economic geography will continue to change with **new discoveries and technological change**, e.g., new battery options. **Industrial revolutions involve booms and busts.**

Manufacturing operations of clean technologies are also highly geographically concentrated.

- In 2022, **China accounted for 80% of the global installed manufacturing capacity of solar PV** modules. China is the single largest producer for all three sub-components (cells, wafers, polysilicon), accounting for 85-97% of global installed capacity at each stage in the supply chain (IEA, 2023e).
- In 2022, China accounted for **75% of global installed manufacturing capacity of batteries**, and the EU and the US accounted for 8% and 7%, respectively (IEA, 2023e).

Major economies are already competing to secure their position in this future geography of growth

Countries across the world are looking to be strong players in new technologies: transforming green industrial policy and reshaping global trade flows.

A wave of new country-level green industrial policies designed to strengthen their own supply of clean technologies:

Minerals

- European Union's battery regulation and Critical Raw Materials (CRM) Act
- US's Inflation Reduction Act (IRA)
- Australia's Critical Minerals Strategy
- Canada's Critical Minerals Strategy

Nearly 200 policies and regulations from 25 countries and regions worldwide, with over 100 of these enacted in just the past few years (IEA Critical Minerals Policy Tracker).

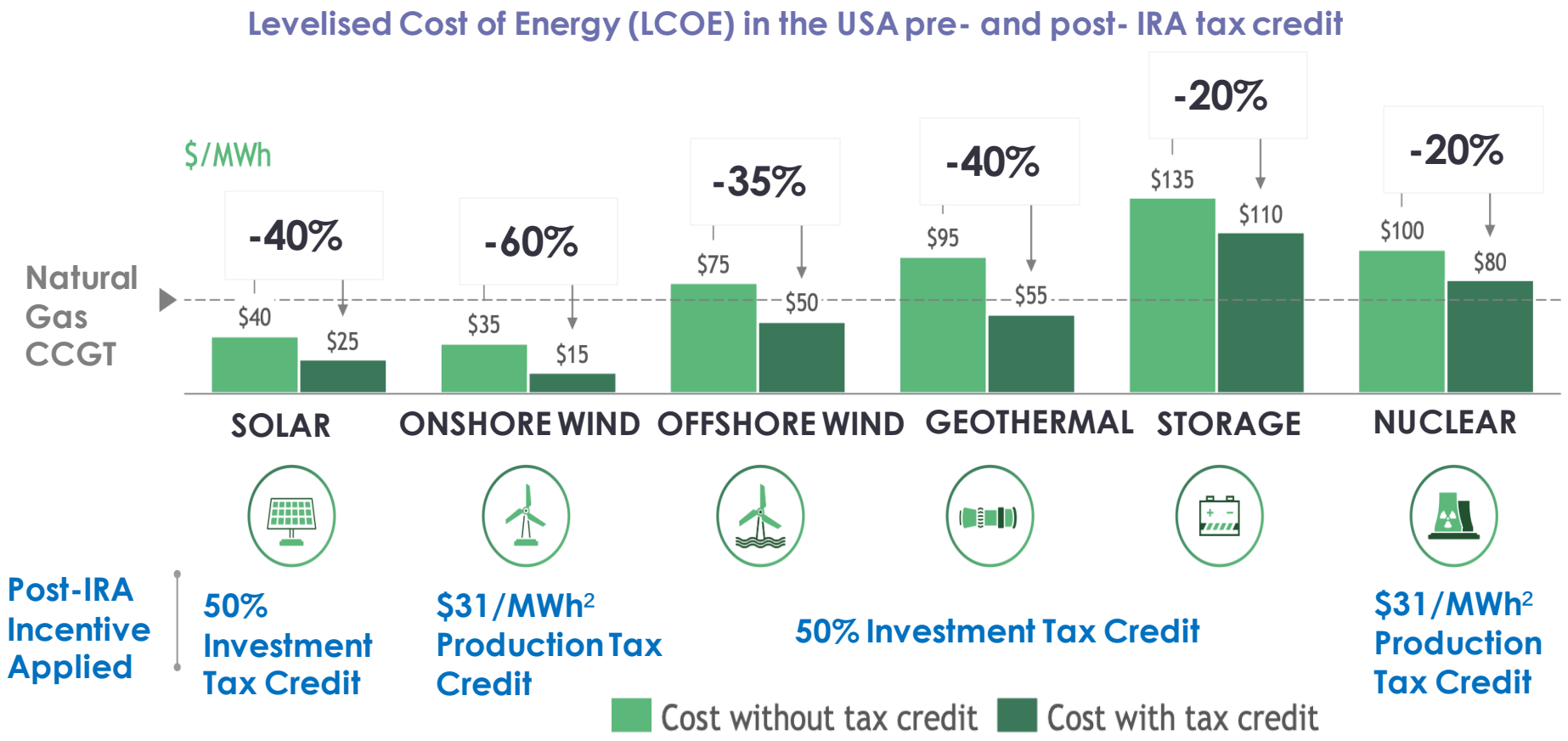
Domestic clean technology manufacturing

- US's Inflation Reduction Act (IRA)
- European Union's Net Zero Industry Act (NZIA)
- Japan's Green Transformation programme
- China's latest Five-Year-Plan (2021-2025); "Made in China"
- India's Production Linked Incentive scheme and "Make in India" strategy
- India's Union Budget, Energy Access and Green Hydrogen policies

All combine incentives and finance for green technology and investments with legal, regulatory and policy support.

Green national industrial policies can create the enabling conditions to bring down costs and reach technological tipping points

The new wave of green industrial policies can catalyse competition between countries and spur technological innovation worldwide. Rapid falls in costs of new technologies together with supply chain resilience can benefit all.



- China's scale and leadership in the manufacture of solar panels has played a key role in bringing solar PV costs down by more than 80% over the last decade (IEA, 2022a).
- IRA funding is expected to significantly reduce the cost of clean technologies in the US – **down by 40% for solar and by 60% for onshore wind by 2030,** enabling a rapid scale-up (BCG, 2023a), and potentially both economies of scale and innovation.

Source: BCG (2023a)

1. Geothermal values reflect average of traditional flash and EGS technologies 2. New small modular reactor (SMR); 2.Assumes $15/MWh incentive, inflation adjusted and with bonuses;
Note: All technologies assume base + prevailing wage bonus + domestic production bonus + energy community bonus. All numbers rounded
Source: Lazard, IEA, BCG Analysis

But their impact on innovation, competitiveness and trade depends on the way policies are designed

The global challenge in terms of desired outcomes is to have multiple low-cost, high scale, competitive industries to foster innovation and resilience. Local content requirements (LCRs) should be time-limited.

Efficiency loss

Discriminatory provisions, such as **LCRs (see both IRA and NZIA**) might lead to inefficient supply structures, shifting production to less efficient producers, making the energy transition temporarily more expensive and potentially slowing down decarbonisation.

Investment exclusivity risk

There is a risk **that only high-income countries** with access to financial markets will be able to engage in the green subsidies race. This could lead to limited investment in developing countries and leave many countries behind, making the transition **inequitable and politically contentious**.

Trade distortions and tensions

The LCRs included in the subsidies may also **trigger trade tensions and protectionist responses** in other countries, making international trade in green technology more fragmented and less efficient. Green industrial measures may be interpreted as trade-distortive subsidies, which are **prohibited under WTO rules** (Article 4 ASCM; (GATT Article III:4). Greater stress on an already weakened WTO.

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The global challenges and necessary urgency and scale of action in a differentiated and changing world require collaboration in five key areas

Global challenges demand urgent, large-scale action in investment and structural change; in a changing geography. International collaboration necessary in trade, technology, land use, managing climate overshoot, and finance, with each area requiring both competitive and cooperative approaches to achieve the necessary speed and magnitude of response.

- The necessary **global urgency and scale of action** were set out in Lecture 1, and the opportunities and policies for creating a new growth story were presented in Lecture 2.
- We have just seen the strong **differentiation in circumstances across countries** and some of the dynamics of a changing economic geography.
- These circumstances and the nature of the global challenges and necessary action require collaboration across countries in **setting shared global goals and finding shared understanding of structures of growth, investment, innovation and transformation. See Lecture 1 and 2**.
- Specific collaboration in five key areas are crucial: **trade; technology; land; overshooting; finance.**
- We examine the first two in this section, building on the analysis in the previous slides, and then turn to the other three. Our particular focus in this lecture will be **finance,** without which the necessary investment in EMDEs will not happen.
- **Competition and collaboration can mutually reinforce** in all five areas, but **major collaboration in all will be essential to achieving the necessary scale and pace of action.**

Shaping the global trade and supply structures to foster lower cost, innovation, and robust supply chains: policies, clubs, coalitions

Global trade and supply chain strategies must, for an effective transition, foster innovation and resilience, balancing domestic green policies with international openness and competition. They must also seek to foster green investments in all economies especially in EMDEs, which will be the main drivers of global growth.

In key industries (e.g. solar, wind, batteries, minerals, chips, AI) the world needs **industrial structures with (at least) a few players with real scale** and openness to competition to drive down costs and create resilience in supply chains.

Policies

- Current inward-looking national policies could encourage the scaling of additional major players and help with robustness, but there should be a clear path to openness and competition.
- In designing green industrial policies, countries should bear in mind the concept of **'predictable flexibility' in public policy**. While there are multiple advantages in providing public support to domestic manufacturing of green technologies, eventually the domestic support should phase down. **Criteria for doing so should be stated in advance** (Lecture 2).
- **Incentive structures to avoid a race to the bottom (such as CBAMs) will likely be necessary**. If enough of the world adopts such provisions, then incentives to make investments green are enhanced. However, it is important to keep them **limited to a few key sectors, operate on clear criteria, and allocate a major part of the revenues to developing countries.** This can avoid the risk of protectionism, international friction and divisiveness, and vexatious administrative barriers.

Clubs

Sectoral Clubs and Climate Clubs – e.g. Global Arrangement on Sustainable Steel and Aluminium; G7 Climate Club - can enable greater ambition, provide technology transfer vehicles and mobilise private finance channels. They can also help address concerns around competitiveness and trade-related action. Together with CBAMs, they can incentivise and support greening of activities in EMDEs. Additionally, they can work to **strengthen the WTO as a key trade forum**.

Coalitions

The Coalition of Trade Ministers on Climate can play a role in boosting international cooperation on climate, trade and sustainable development. So too the **Coalition of Finance Ministers on Climate Action** and the **Network for Greening the Financial System** (central banks).

International collaboration on technology

International cooperation will be required to foster the availability and affordability of green technologies for all countries. The chances of realising a positive tipping cascade in clean technology that can drive costs down are stronger when actions are aligned internationally so that there are prospects of large and dynamic markets, with coherent standards (Systemiq, 2023).

Facilitating technology exchange and joint R&D investment

Trade liberalisation and reforms focused on green: Developed economies can support technology sharing through **green trade liberalisation and reform of trade-related measures** that may restrict the diffusion of clean technologies to developing countries. Other options to enhance technology adoption include the use of **de-risking mechanisms** like loan guarantees, in developing economies (IMF, 2021). **However, it is no longer solely an issue of "technology transfer from developed to developing" as technological advances are taking place across the world, from AI to agriculture.**

Reducing the cost of capital: Will be fundamental, many of the required technologies are capital intensive.

Co-operation to build national innovation and diffusion frameworks: Efforts are required to support greater **technology innovation and diffusion frameworks and capacity** linking up firms, governments and civil society (e.g. Aghion et al., 2021). National innovation strategies (Freeman, 1992; Mazzucato, 2018; Stern and Valero, 2021).

R&D coordination: Necessary in some key areas, for instance where AI can be applied to accelerate research into gene-editing, synthetic biology, fusion, carbon capture, utilisation, storage (CCUS) and direct air capture. Work is also necessary on geoengineering; critical to examine risks of unintended consequences and possible mechanisms of international science policy and governance (see below).

Collaboration networks: **The Breakthrough Agenda**, launched at Glasgow COP26, brings together 45 countries and businesses to accelerate the development and deployment of clean technologies and drive down costs by 2030, so that "clean is cheaper" (IEA, IRENA, and UN Climate Champions, 2022). Collaboration can take the form of joint innovation (e.g. Mission Innovation), converging around standards (e.g. **International Partnership for Hydrogen and Fuel Cells**, or the **Global Cement and Concrete Association**), creating buyers' clubs or coordinated green procurement programmes for pioneering products and processes (e.g. **First Movers Coalition or the Industrial Deep Decarbonisation Initiative**). See also coordination of **procurement across cities, C40. International Solar Alliance.**

Structure

- Vulnerability, history, and opportunity: differences across countries
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- International action, responsibilities, and collaboration: five key areas: trade; technology; land; overshooting; finance
- **Land, forests, biodiversity**
- Overshooting, removal, geoengineering
- Fundamental reform of MDBs and international finance system
- Closing call

Building effective global conservation and restoration

The conservation and restoration of nature requires dealing with market failures, arising from open-access resources and the global commons, and with vested interest relationships with governments.

International collaboration is essential

- Effective global conservation and restoration action **requires international efforts, transboundary measures and cooperation.**
- Issues such as climate change and biodiversity loss in global public goods such as the high seas **cannot be addressed by a single nation.**
- Degradation of natural assets unilaterally can have implications **well beyond a nation's borders.**
- **Engaging the private sector and civil society** in conservation initiatives is crucial to amplify impacts and to leverage additional resources (e.g. Tropical Forest Alliance, consumer labelling movements).

Policy recommendations

- The Dasgupta Review suggests **supra-national institutional arrangements**:
  - Explore compensating countries for protecting ecosystems within their borders (for example, some tropical rainforests).
  - Charge for the use of, and restrict access to, global ecosystems beyond national jurisdictions, such as the high seas.
- Suggestions **for international taxation or control of this kind have been longstanding but very difficult to construct systems that work**, given national sensitivity to "external" taxation. International fishing agreements with quotas (can be zero) have had partial success. Possibilities of international carbon taxes on maritime fuels, so **specificity helps** (e.g., fish, maritime fuels).
- **Multilateral Environmental Agreements** that are particularly relevant to biodiversity loss and ecosystem degradation: the UN Framework Convention on Climate Change, the Convention on Biological Diversity, the Convention to Combat Desertification, and the Convention on International Trade in Endangered Species. The first three have COPs in 2024. UNFCCC has COPs every year, the others every 2 years. These generally pursue **shared goals and standards, mutual assistance and voluntary compliance.**

Integrating policy

- Climate change and biodiversity loss share common drivers (see Lecture 1). **How to integrate policy?** Stronger prices could be set on VCMs for higher quality reductions with positive effects on biodiversity, work opportunities, etc. Similarly, standards/regulation in agriculture could be designed with both climate and ecosystems in mind.
- Action should be **strongly influenced by the potential proximity of dangerous tipping points** e.g. Amazon (see next slide).
- International co-operation in **satellite monitoring**.
- In some countries, at certain periods, **governments have been deeply influenced by vested interests** in deforestation, including Brazil, Indonesia, and DRC, the most important tropical forest countries.

Recent momentum

There has been increasing attention from policymakers on halting biodiversity loss, but, mostly, progress in achieving these commitments is weak.

- ✓ **The Montreal Protocol (1987)** is a longstanding example, phasing out HCFCs, **which has been successful in restoring the ozone layer**. Specific, voluntary, user standards, supported by voluntary funding. Advantage of **availability (through R and D and innovation) of alternatives**.
- ✓ **The Kigali Amendment (2016)** to the Montreal Protocol to phase down hydrofluorocarbons (HFCs), potent greenhouse gases.
- ✓ **The Kunming-Montreal Global Biodiversity Framework (GBF) (2022)** is a landmark treaty adopted by nearly 190 countries at Biodiversity COP15. The Framework aims to set in motion an economic transition that puts biodiversity on a path to recovery by 2030 and to reach the global vision of a world living in harmony with nature by 2050. It set a range of targets for 2030, including the headline target of '30x30', **an ambition to conserve 30% of the world's land and seas for nature by 2030**. The Framework aims to mobilise at least $200 billion per year in biodiversity-related funding from public and private sources and sets a goal for developed countries to mobilise $30 billion a year for developing countries by 2030.
- ✓ **The High Seas Treaty (2023)** adopted by UN members to protect oceans and sustainably use marine biodiversity. While the treaty does not set specific conservation targets, it can help nations designate marine protected areas, requires environmental impact assessments for potentially harmful activities, and provides for the transfer of marine technology to developing countries.
- ✓ **The Glasgow Leaders' Declaration on Forests (2021)** by the heads of 145 countries who committed to halt and reverse forest loss by 2030. This was followed by a summit of the leaders of the 8 Amazon Basin countries (August 2023), the first in 14 years, resulting in an agreement to join forces to protect the crucial rainforest from 'reaching the point of no return'.
- ✓ **COP28 UAE Declaration on Climate, Nature and People (2023)** signed by 18 countries in 2023.

One year on after the Glasgow Declaration (agreed in 2021), global deforestation **reached more than 1 million hectares above** the level needed to meet the 2030 target (WRI, 2023b).

Threats to ecosystems and proximity of tipping points require **stronger integration** of action on climate and biodiversity.

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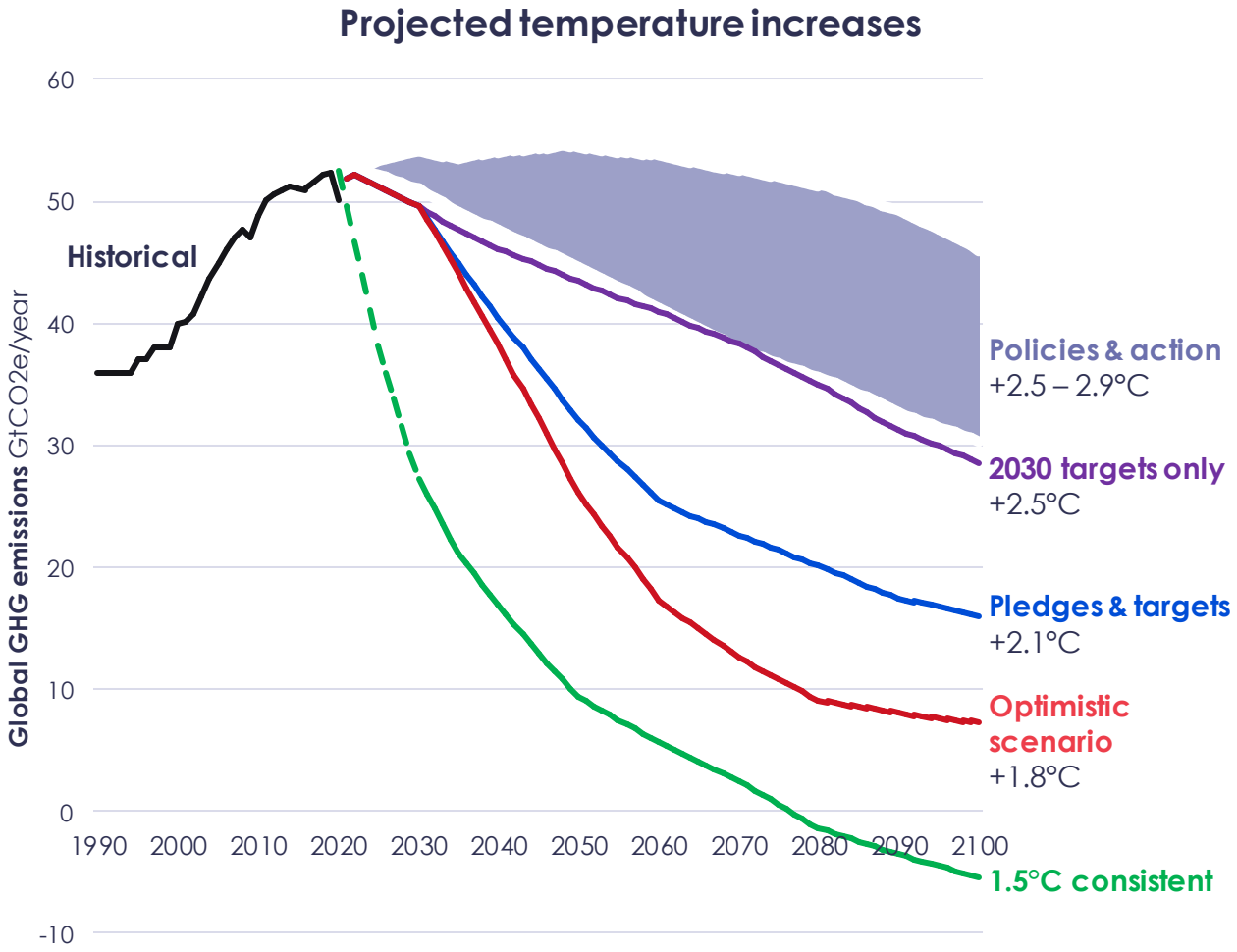
The risk of climate overshoot is strong and threatens irreversible damage

Overshooting warming targets poses serious risks, with breaches of 1.5°C increasing the likelihood of irreversible environmental tipping points. Critical need for rapid action towards net-zero emissions.

- Global temperatures **have already risen by about 1.2°C** above pre-industrial levels. In 2023, the average global temperature increase was 1.55°C (Copernicus). Temperature on some days **crossed 2°C for the first time** in modern recorded history (Freedman, 2023).
- The IPCC estimates that on the current path of GHGs, global temperatures are **likely to reach 1.5°C between 2030 and 2035** (as underlying trend) (IPCC, 2023).
- Reaching net-zero GHG emissions would, with a lag, stop temperature rises. Temperatures would begin to decrease if net zero is maintained as concentrations dissipate.
- **While the possible overshoot of warming targets may be temporary, not all the associated impacts are necessarily reversible.** Temporarily exceeding 1.5 °C may increase the risk of crossing climate thresholds and tipping points, e.g. impacts on species, coral, sea level rise, loss of ice sheets, permafrost carbon release; potentially triggering further temperature increases and tipping points.
- **The higher the warming level and the longer the duration of overshoot**, the greater the risk of crossing thresholds and tipping points.



Source: Climate Action Tracker (2023), December 2023 update

Carbon dioxide removal (CDR) is necessary to meet the Paris temperature goals

CDR is crucial for meeting the Paris Agreement goals in addition to reducing emissions. The core governance question is not if but how, by whom, and by when CDR should be deployed.

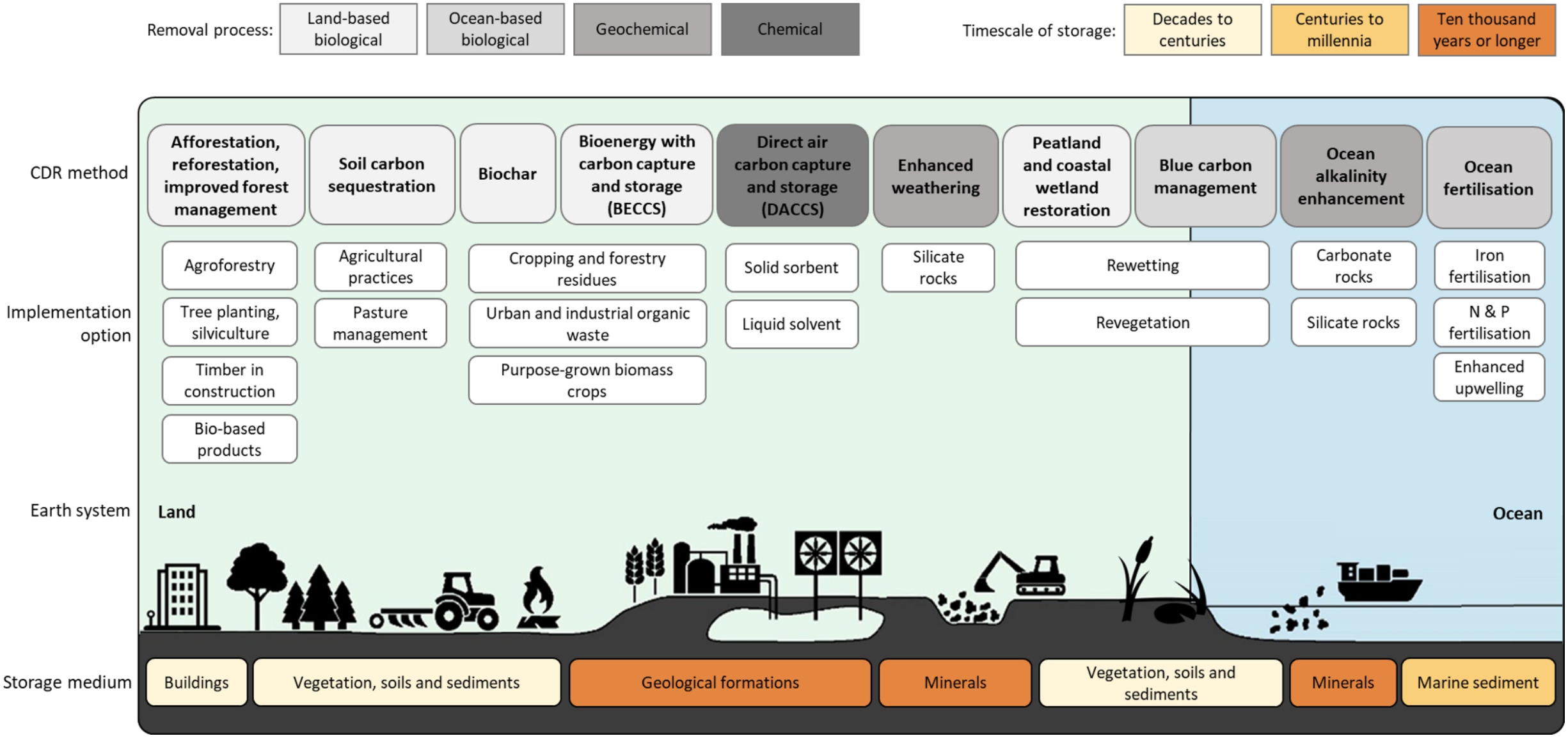
Since **it is impossible to fully eliminate all CO2 or GHG emissions through stringent emissions reductions**, residual emissions must be balanced by removals to reach net-zero emissions. It is a **feature of all scenarios that meet the Paris temperature goals, in addition to reducing emissions.**

"**The core governance question** is not whether CDR should be mobilised, but **which CDR methods governments want to see deployed by whom, by when, at which volumes and in which ways"** (Babiker et al., 2022).

CDR is already **deployed today – mainly in the form of conventional, land-based methods, e.g. restoring degraded land or peat, afforestation**, **reforestation**, mainly in developing countries. But forests are vulnerable to burning, cutting, diebacks. **Novel CDR will play a role later in the century** to reach net-negative emissions.

Achievement of the gigatonne levels of CDR necessary is **associated with several risks**. Conventional-based CDR pose issues on **land competition, the protection of land tenure and rights, and sustainability risks of forest-based CDR** (including from forest fires and other disturbances). Novel CDRs pose other types of risks, including that the **technical, economic and political requirements** for large-scale deployment may not materialise in time; **and they are expensive**.

Carbon dioxide removal (CDR) taxonomy



Source: Castellanos et al. (2022)

The economics of CDR vary across methods

Current very high costs hinder Direct Air Capture (DAC) investment; natural CDR methods are much less costly. Increased public and private support for innovation and deployment might eventually reduce DAC costs to below $100 per tonne of CO2 removed. Would give an upper bound on carbon price.

DAC

- DAC can play a role by removing CO2 and providing climate-neutral CO2 for products like synthetic fuels. According to the IEA Net Zero Emissions by 2050 Scenario, **DAC will need to scale up** from capturing 0.01 MtCO2 now to about 980 MtCO2 by 2050 (IEA, 2022b).
- **DAC has multiple advantages**: it is straightforward, has a small physical footprint, can be done anywhere and is a backstop technology for hard-to-abate emissions (Friedmann, 2023).
- **Current system's high prices (between $600 and $1100/tCO2 removed (BCG, 2023b)) are a barrier to investment** and deployment. With deployment and innovation, capture costs might eventually fall to under $100/tCO2 (IEA, 2022b). **This would give an important upper bound on carbon price**.

Nature-based CDR methods

- CDR methods based on natural processes generally have **lower cost per tonne of CO2 removed**. For example, afforestation and reforestation cost between $10-$50/tCO2 removed (Bednar et al., 2023) and microalgae current spot price is $50/tCO2 (CDR.fyi, 2023)".
- Examples of nature-based CDR include:

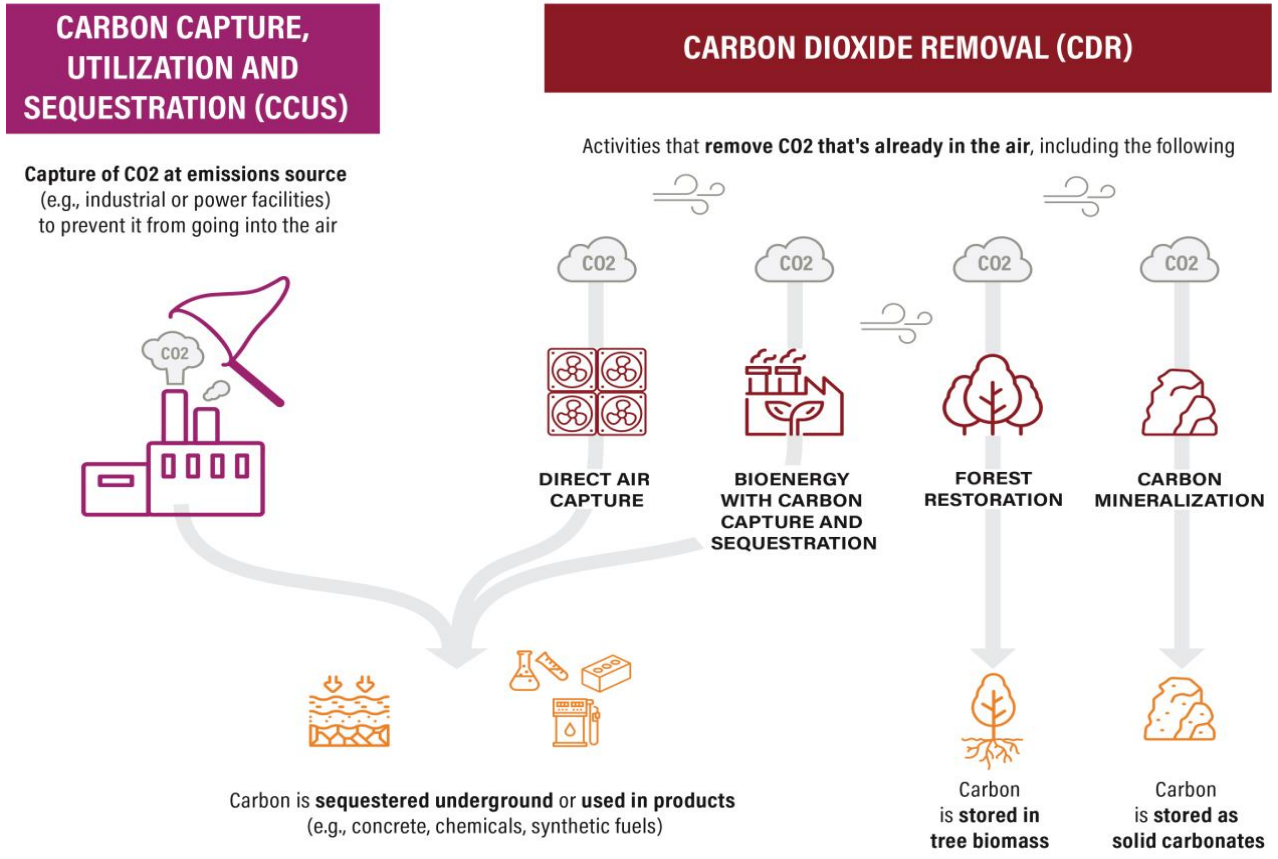
Enhanced weathering which involves spreading crushed minerals on land or in water to speed up their natural absorption of CO2 from the atmosphere.

Algae farming which employs algae to naturally absorb CO2 from the air, converting it into biomass and reducing atmospheric carbon levels.

The role of Carbon Capture, Utilisation and Storage (CCUS)

CCUS differs from CDR as it captures CO2 emissions at source. It has an important role for achieving the Paris Agreement's goals by decarbonising sectors where alternatives are limited (some "hard-to-abate" sectors), and in e.g. facilitating BECCS.

- Point source carbon capture technologies like CCUS capture CO2 emissions directly from industrial and energy-related sources before they are released into the atmosphere.
- CCUS will be **needed in three contexts** (ETC, 2022):
  1. In industrial processes which produce CO2 and cannot be decarbonised via other zero-carbon solutions. Point source capture is more cost-effective than DAC, because concentration is much higher.
  2. To provide crucial engineered CO2 removals from the atmosphere (e.g. BECCS and DAC).
  3. Where it is the lowest-cost decarbonization solution given local resources and costs.
- **Cost of CCUS** (no single cost of carbon capture, $15-25/tCO2 for some industrial processes to $40-120/tCO2 for some processes with "dilute" gas streams (IEA, 2021b)) is significantly lower than DAC, which costs as much as $1,100 per tonne today, and potentially falling to $300-$400 per tonne by 2030 (BloombergNEF, 2023c).



Note: For CO2 used in products, the lifetime of the product determines the duration of CO2 storage; some utilization options only provide temporary storage. Source: WRI.

Source: Lebling et al. (2023)

Geoengineering could introduce new risks

In contrast to CDRs, geoengineering encompasses a range of technologies and methods aimed at altering the Earth's climate system. Rather than tackling the root cause of climate change (increase in GHGs in atmosphere) it introduces a "mask" to the problem. It is highly controversial and raises significant ethical, political and environmental concerns.

Emerging methods

Solar radiation management (SRM) aims to increase the reflection of sunlight back into space. Proposals include:

- **Stratospheric aerosol injection (SAI):** dispersing reflective particles into the stratosphere to reflect sunlight away from Earth.
- **Marine cloud brightening**: increases the reflectivity of clouds over the ocean by spraying seawater droplets into the atmosphere.
- **Space-based reflectors:** placing large mirrors or reflectors in space to deflect sunlight.
- **Cirrus cloud thinning**: since cirrus clouds trap heat, thinning these clouds could potentially reduce global warming. Techniques might involve seeding the clouds with substances that alter their physical properties.

Other emerging techniques include:

- **Ocean alkalinity enhancement**: Increasing the alkalinity of ocean water could enhance its capacity to absorb CO_2 .

Considerations and risks

- **Research: Largely led by a few experts in the Global North**, with limited diversity potentially skewing research and policy priorities (Patt et al., 2022).
- **Global governance**: **Strong international agreements are required to manage risks**. Existing treaties like the UN Convention on Biological Diversity or the Vienna Convention on the Protection of the Ozone Layer partially address SRM, but the absence of comprehensive governance poses severe risks to stability (Patt et al., 2022).
- **New risks**: Geoengineering could introduce **new global risks to ecosystems, health, international collaboration and peace**. These consequences could be large and difficult to assess ex ante (e.g. biodiversity loss, unintended changes in climate patterns, increased air, water and ocean pollution).
- **Termination shock**: Sudden cessation of SRM methods without cutting GHG emissions could lead to rapid warming, known as **"termination shock,"** posing severe risks to ecosystems and human societies (McCusker et al., 2014; Trisos et al., 2018;).
- **Moral hazard:** The prospect of geoengineering **could reduce the urgency to mitigate climate change** through emissions reductions and sustainable practices.

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EMDEs (other than China) are being left behind

While global climate efforts are increasing, EMDEs are facing obstacles in every critical aspect of the transition.

The energy transition

Developed economies and China **attracted over 90% of the increase in clean energy investment** since 2021 (IEA, 2023b).

Adaptation and resilience

- Estimates of adaptation costs/needs in developing countries **are now around 10-18 times as much** as international public adaptation finance flows (UNEP, 2023b)
- Finance commitments for adaptation **dropped by 15%** in 2021 (UNEP, 2023b).

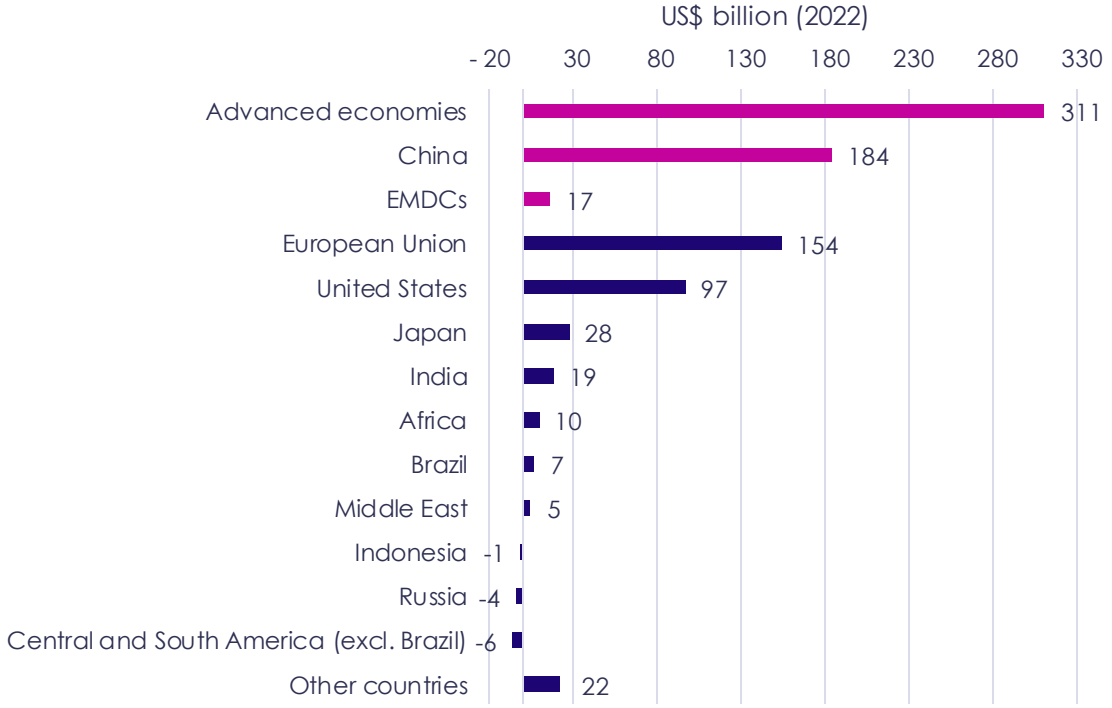
Loss and damage

Funding pledged for loss and damage (just over $700 million at COP28) **is less than 0.2% of the estimated needs** by 2030 (CISL, 2023).

Nature

Close to **80% of global nature finance flows originate from and are directed to developed economies**, while EMDEs account for 90% of the investment opportunity in nature conservation and restoration (Turner et al., 2021).

Increase in annual clean energy investment, 2019 - 2023



Source: IEA (2023a)

Note: Advanced economies include countries in the OECD regional grouping and Bulgaria, Croatia, Cyprus, Malta and Romania. EMDEs include all other countries (including the selected regions/countries also presented on the graph such as Africa, Brazil, India, etc.) excluding China.

The rich countries, given their polluting history, their wealth and technology, **have a moral obligation to both take strong domestic action to reduce emissions and strongly support developing countries** to adapt to climate impacts and transition to a low-carbon economy; ethics discussion in Lecture 1.

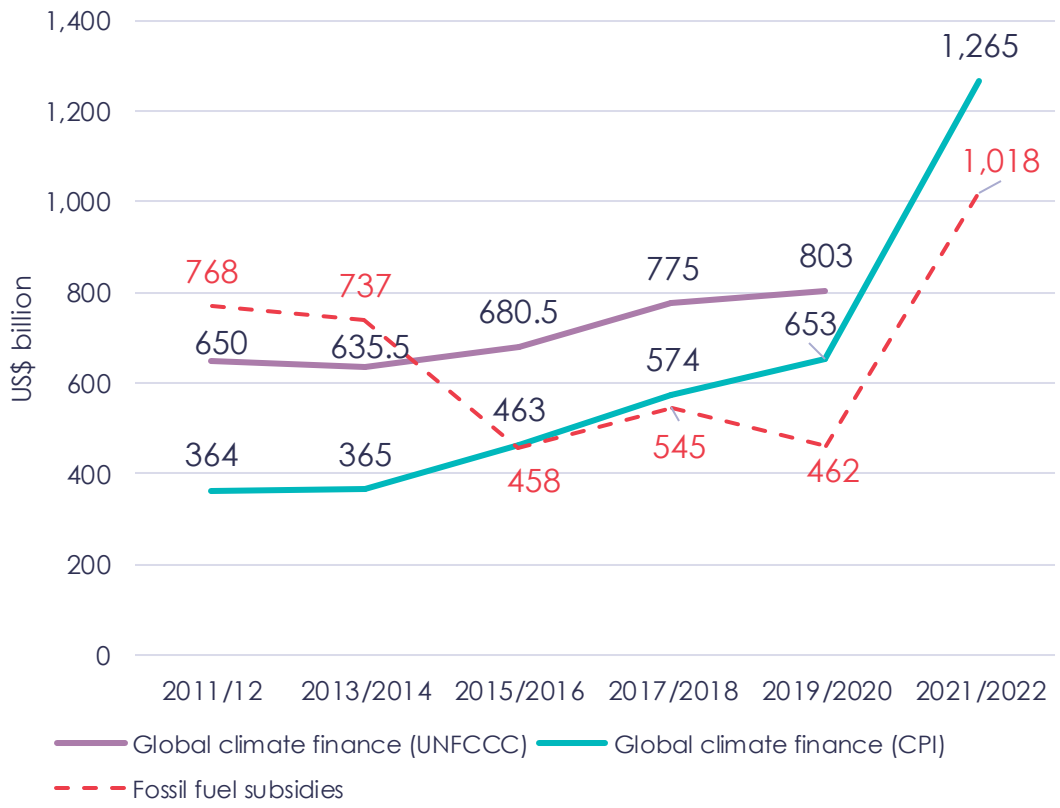
Where are we on climate finance?

Global climate finance* more than tripled in the decade to 2021/2022, reaching $1.27 trillion (around 1% of global GDP), but there are important shortcomings from the perspective of EMDEs (other than China). For many countries and activities high perceived risk and cost-of-capital deters investment.

While climate finance is increasing, there are a number of difficult issues (Buchner et al., 2023):

- **It is concentrated in developed economies and China** (only 14% goes to EMDEs other than China). Perceived risk raising cost-of-capital for EMDEs.
- **It is concentrated in mitigation** (representing 91% of global climate finance flows).
- **Energy and transport attract the most finance** (68% of total flows). The AFOLU sector attracted only 3% ($43 billion) despite being the third largest source of emissions and key to reversing nature loss.
- **Private finance is increasing but at an insufficient rate and scale** (accounting for 49% of overall climate finance with 91% spent domestically).
- **Climate finance is primarily delivered in the form of debt** (61% of total flows vs 5% provided in grants).
- **Most financing remains in its country of origin** (84% raised and spent domestically).
- **The $100 billion by 2020 Paris goal was not met**, with a shortfall of around $10 billion in 2021 (although it was likely met in 2022) (OECD, 2023).
- **Harmful subsidies in fossil fuels, agriculture and fisheries are large** ($1.97 trillion explicit subsidies, $6.3-11.1 trillion implicit subsidies) (Bhattacharya et al., 2024).

Global climate finance in 2011-2022, biennial averages



Sources: Buchner et al. (2023), UNFCCC Standing Committee (2018; 2020; 2022), IISD and OECD (2023)

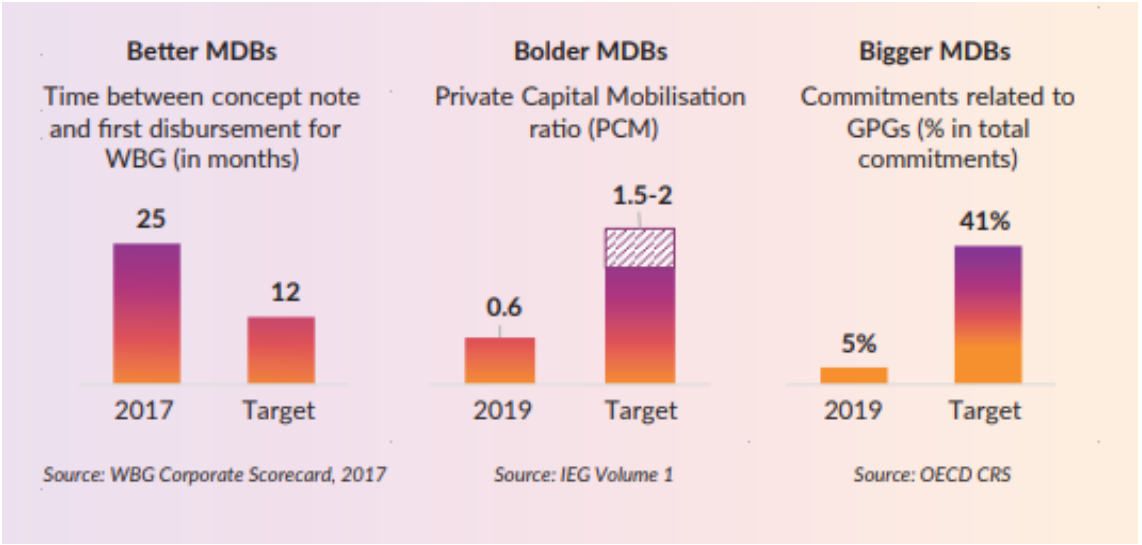
*This covers mitigation finance, adaptation finance, finance that benefits both objectives. It covers a range of sectors including energy systems, transport, AFOLU, buildings and infrastructure, industry, water & waste, others & cross-sectoral.

Finance for what? Relation with SDGs; work of G20 IEG on MDBs

Climate action and finance are nested within and contribute to SDG action and finance. Investment in human capital is part of a strategy for sustainable development. All investment should be sustainable and "Paris aligned" but not all of it will or should be directly on climate action.

- **The action agendas for SDGs, climate, nature preservation** and other global public goods **are mutually-reinforcing.** These goals coalesce in their need for larger investment (and larger finance), particularly in sustainable infrastructure. Building momentum towards **a more ambitious finance agenda** (e.g. Bridgetown Initiative, Paris New Global Financing Pact).
- **The G20 Independent Expert Group (2023a,b) recommends a triple agenda** to harness the potential of MDBs:
  1. **Adopting a triple mandate** of eliminating extreme poverty, boosting shared prosperity, and contributing to global public goods.
  2. **Tripling sustainable lending levels** by 2030.
  3. **Creating a third funding mechanism** which would permit flexible and innovative arrangements for purposefully engaging with investors willing to support elements of the MDB agenda.
- It estimates that **additional spending of $3 trillion per year is needed by 2030 in EMDEs (other than China)** to achieve both climate and development goals. This includes $1.8 trillion increase in investments in climate action (x4 2019 levels) and $1.2 trillion increase to attain other SDGs (a 75% increase in health and education).
- **Critical role of MDBs** both in reducing, managing, and sharing risk to enable and mobilise the private sector and in critical public sector programmes. They are crucial to **bringing down the cost-of-capital**.

What an ideal MDB should look like by 2030

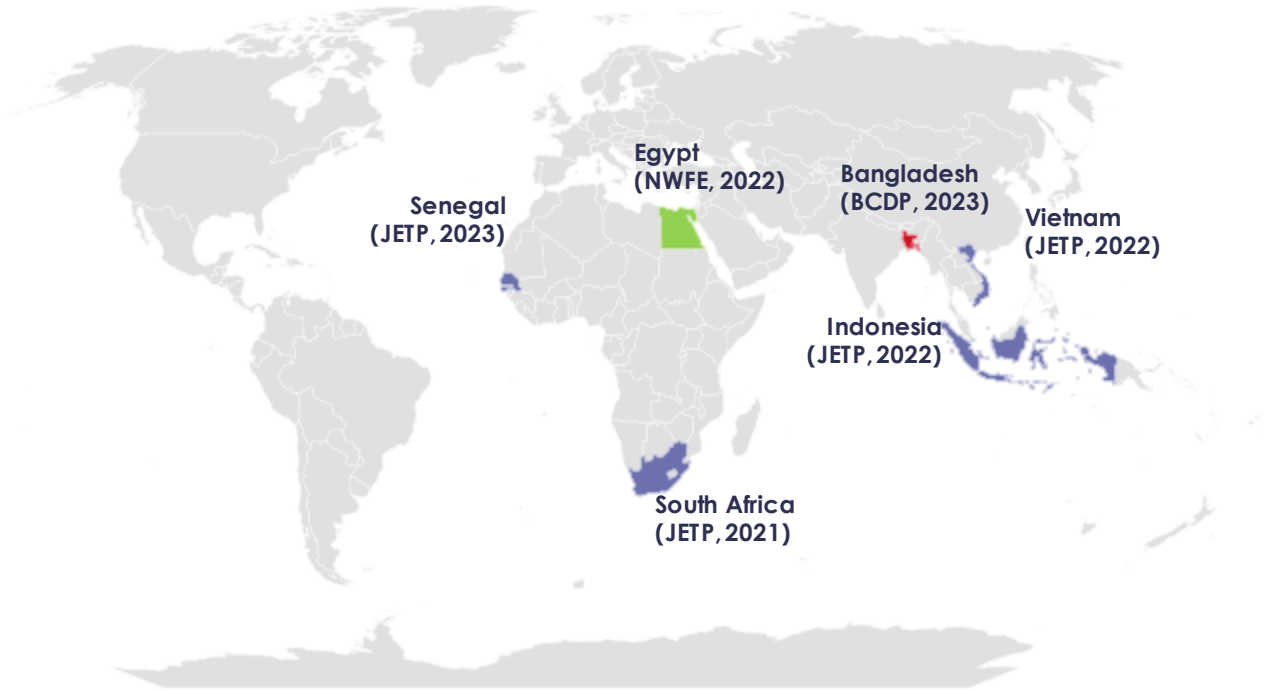


Source: G20 IEG (2023b). Chaired by NK Singh and Larry Summers. Stern a member. Welcomed by G20 finance ministers and central bank governors (Marrakech, October 2023).

Fostering investment climate and country/sector platforms

Effective country leadership will be crucial to foster successful collaboration/co-creation with the private sector, DFIs, and external development partners around well-defined investment strategies and country/sector platforms to create a strong climate for sustainable investment.

Overview of existing country platforms



Notes: JETP (Just Energy Transition Partnership); NWFE (Nexus of Water, Food and Energy); BCDP (Bangladesh Country and Development Platform)

Priorities for action

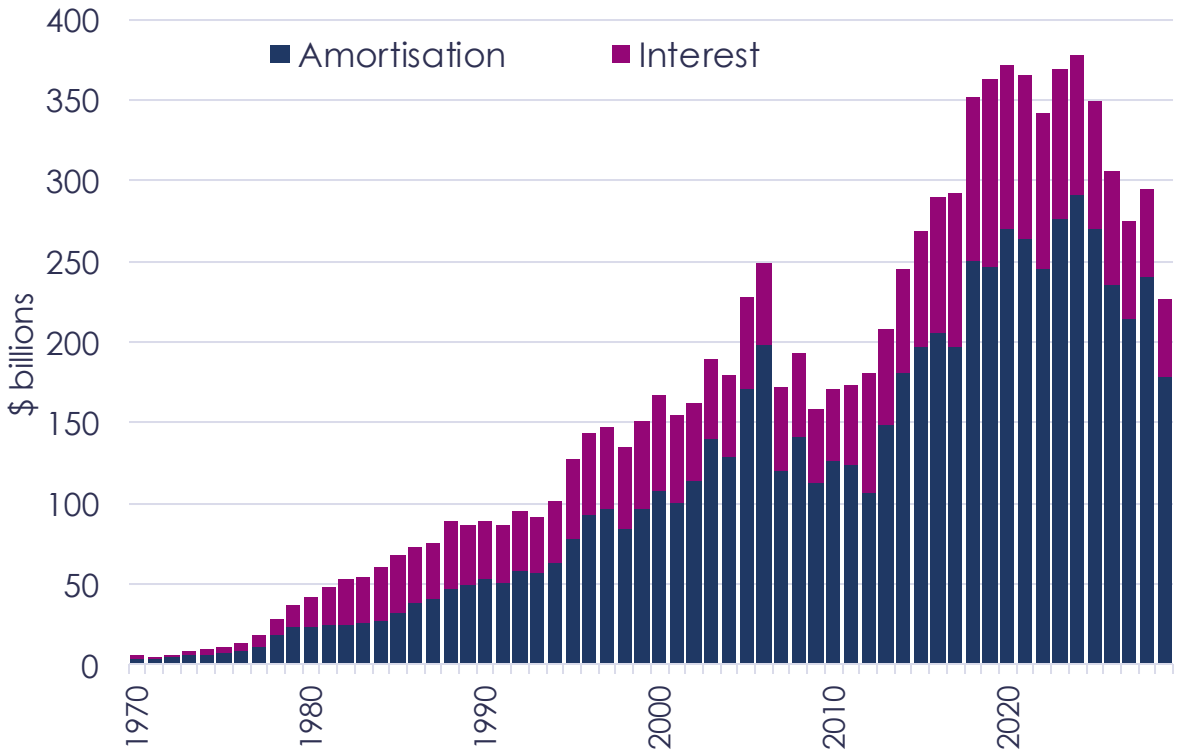
- ✓ Develop long-term climate and development strategies.
- ✓ Translate strategies into tangible investment programmes and project pipelines.
- ✓ Implement strong and sustained policy and institutional reforms to generate confidence in revenues and ability to implement.
- ✓ Set up country/sector platforms led by host countries.
- ✓ Promote international cooperation on policy.

Source: Bhattacharya et al. (2024)

Tackling debt and fiscal constraints

Investments to ramp up climate action in EMDEs will remain infeasible/academic unless measures are put in place to tackle festering debt difficulties, especially those of poor and vulnerable countries. With the rise of interest rates in 2023, net transfers (disbursements less repayments less interest) from MDBs became negative for many countries individually and for developing countries as a whole.

EMDEs (other than China) debt service, 1970 to 2029 ($ billions)



Note: Public and publicly guaranteed (PPG) debt service, current $US.
Source: World Bank International Debt Statistics

Priorities for action

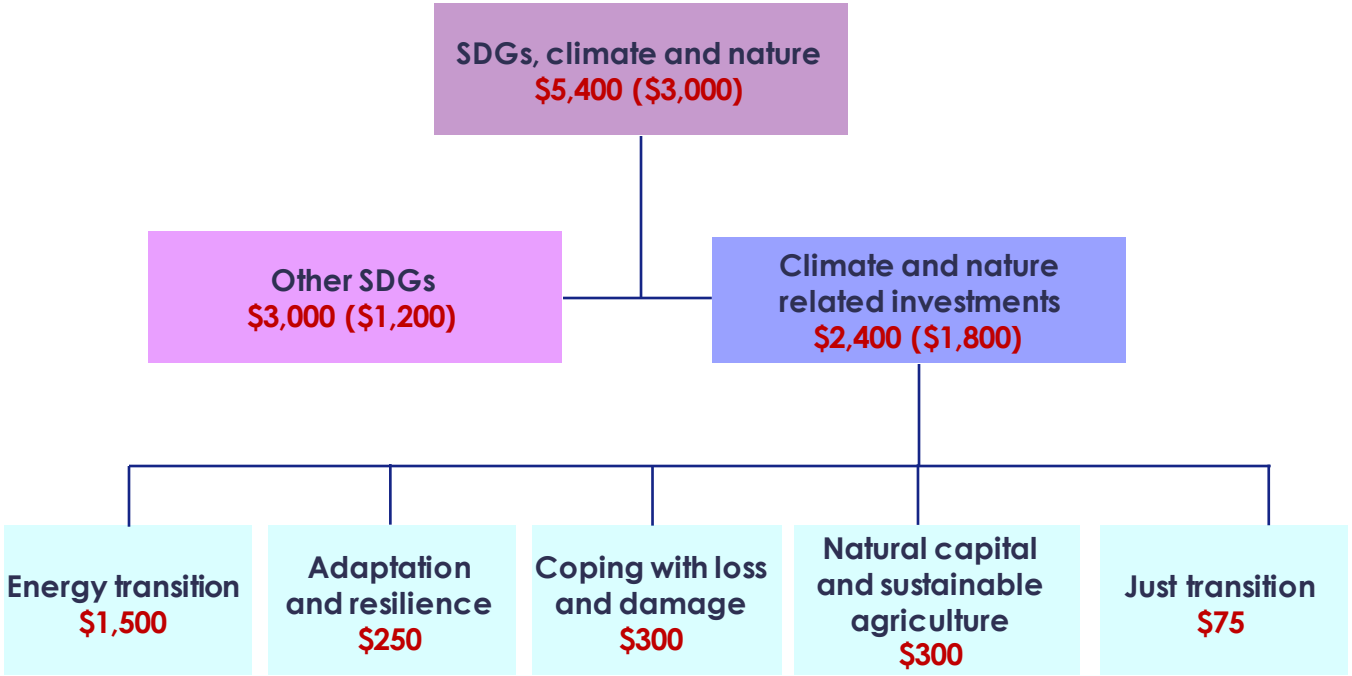
- ✓ **Provide fiscal space for investment in climate action**
  - ➢ E.g. through state contingent debt clauses (e.g. pandemic and natural disaster clauses), and pre-emptive, five-year, debt service cash flow relief from all bilateral creditors that do not make fresh money commitments.
- ✓ **Address situations of debt insolvency and acute debt distress**
  - ➢ E.g. through purchasing private debt at a discount, and expeditious and pre-emptive IMF agreements to forestall imminent defaults.
- ✓ **Break the vicious cycle between debt and climate vulnerability**:
  - ➢ E.g. through disaster- and pandemic-related clauses in debt contracts, and an adequate architecture of concessional international assistance with the highest priority for investments to improve resilience.
- ✓ **Adapt fiscal rules, with countries considering options that preserve fiscal sustainability while creating room for sound investments**:
  - ➢ E.g. through establishing politically-independent Fiscal Councils and carving out selected high-priority, high-return investments for climate-related spending into a separate category, exempt from fiscal rules.

Source: Bhattacharya et al. (2024)

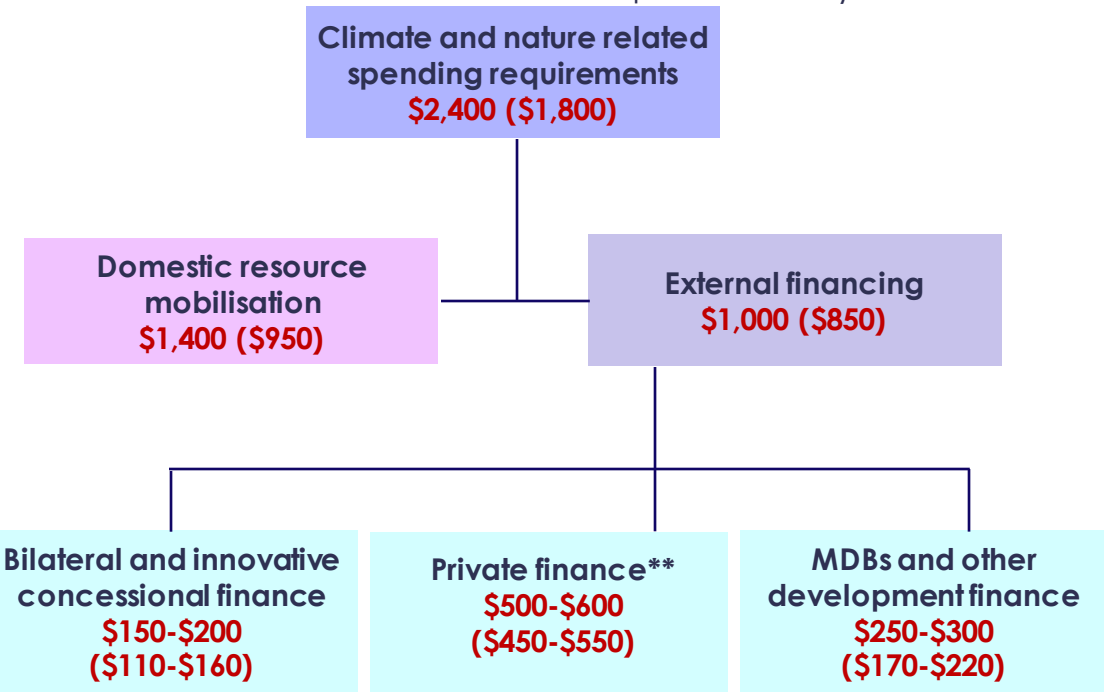
Creating finance for necessary* $2.4trn p.a. of climate investment, by 2030 in EMDEs (other than China): collaborations to manage and share risk

The four sources (DRM, private, MDBs, concessional) are complementary and mutually supportive. Different activities will need different mix of financing. Private sector is deterred by actual and perceived risk. By managing and reducing risk through appropriate collaborations, particularly involving MDBs, and through guarantees, etc., can bring down cost-of-capital. See work of Independent High-Level Expert Group on Climate Finance (Bhattacharya, Songwe, Stern) for COPs 26, 27, 28.

Investment / Spending Requirements for Climate and Sustainable Development ($ billion per year by 2030, increment from 2019 in parentheses)



Financing the Green Transition ($ billion per year by 2030, increment from current in parentheses)



Source: Bhattacharya et al. (2024)

Note: these are total flows that need financing. The increases are relative to 2019 not relative to some BAU counterfactual.

*See also section 3 of Lecture 2; "necessary" for delivery on Paris.

**More than half of this private finance would be directly and indirectly catalysed by MDBs, other development finance institutions, and bilateral finance.

A new climate finance framework: scale, urgency and options

A framework for a climate finance system that supports climate and development must:

- ✓ **Scale up all sources of finance (domestic and international, public and private) and utilise them more effectively**
- ✓ **Embody justice and inclusion** (based an equitable distribution of resources, recognising the differential impacts of climate change on countries and communities, and recognising historical responsibilities).

A comprehensive, coherent, and integrated strategy is needed to deliver bigger, better and faster climate finance. **An overall financing strategy is much more than an aggregate number,** it must:

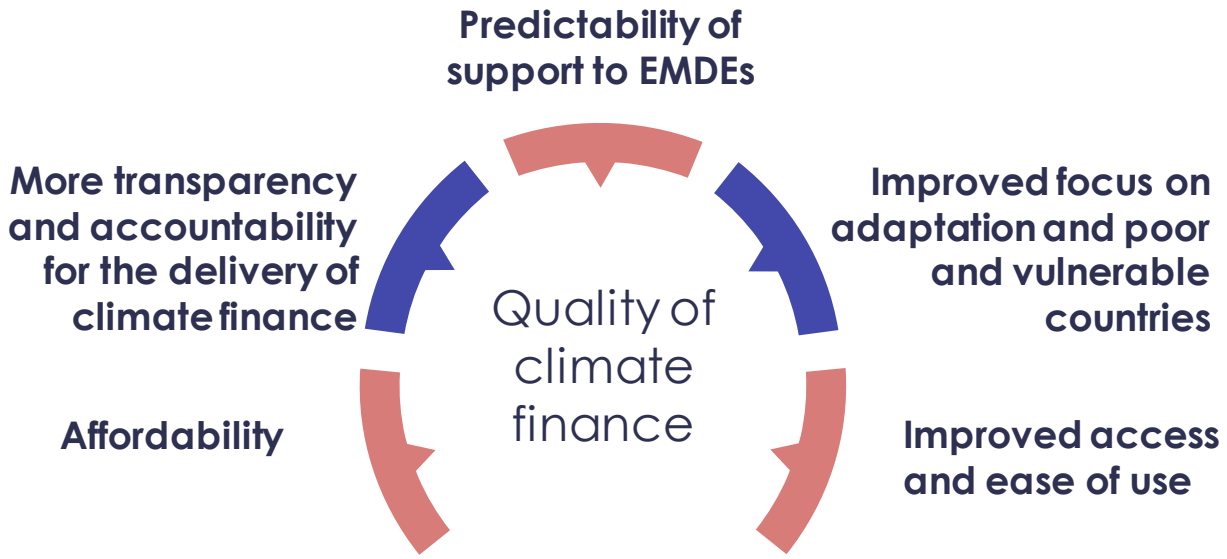
Utilise the complementary strengths of different pools of finance to ensure the right scale and kind of finance, particularly in relation to cost of capital and management of risk.

Align all finance with climate goals and the Kunming-Montreal Global Biodiversity Framework where applicable.

Create the necessary partnerships (public-private, domestic-international) to deliver concrete results.

Source: Bhattacharya et al. (2024)

Beyond scaling up, there is also a pressing need to tackle the shortfalls in the quality of finance provided, particularly around managing, reducing and sharing risks. Requires:



Climate finance is part of development finance. All investments should contribute to SDGs and be Paris alligned. Education and health are crucial to sustainable development and not somehow "counter" to climate.

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Multilateralism has never been more important

Tackling global challenges, particularly climate change, requires stronger multilateralism and international collaboration, with a focus on sustainable growth, innovation, and finance. Leadership must embody urgency of action.

The challenges we have examined, with **climate at the core, are global and they are interwoven**.

A shared, and growing understanding, of the potential and necessity of **a new form of growth and development** has been vital in making progress and building momentum.

So too, the recognition of the necessity for **collaboration** across a whole range of areas, especially around **investment/innovation and finance**.

Momentum is growing, particularly on **new investment and technology** but action has been too late and too small: **now is the time for strong acceleration**.

International leadership, creative ideas, sound analysis, and political pressure have never been more urgent and important.

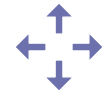
Economics and social sciences have never been more important but new thinking necessary across range of key concepts, perspectives, and analytical approaches; and urgency implies we must research and act at the same time

The biggest obstacles to transformation to a new form of sustainable, resilient, and equitable growth and development lie in the economics, politics, and society. Our subjects must foster:

Clarity of meaning of well-being, across broad set of dimensions. And of sustainability.

Understanding of determinants of sustainability, including four forms of capital; physical, human, natural, social.

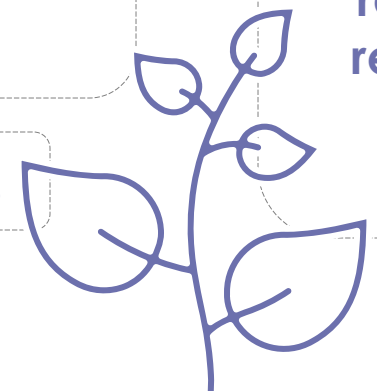
Analytics of dynamics of structural, systemic, technological change.



Public discussion of ethical frameworks.

Recognition of magnitude and nature of risks and necessary change.

New views on role of state.



Examination of broad range of instruments in relation to policies and institutions.

Can it be done? Five forces present us with a special opportunity to deliver at scale

Whilst the biggest obstacles are in economics, politics and society, clear analysis, creative ideas, strong communication, public action, and political leadership can overcome these obstacles. And deliver a new era of sustainable, resilient, and equitable growth and development. Much more attractive than the dirty, destructive paths of the past.

No shortage of global savings in relation to investment. Search for stronger and more sustainable growth driven by stronger investment.

Rapid technological change and falls in costs (digital, materials, biotech…).

International agreements have **provided political direction** and evidence that collaboration is possible.

Strong movements of **young people** across the world.

Growing **private sector commitments** to the investment and growth opportunities of the 21st century.

Seizing the opportunity requires rapid and fundamental change. Much of what we currently do will have to be done differently (technologies, institutions, business models, city design, planning processes, natural resource management…).

We have in our hands an attractive, sustainable, resilient, and inclusive form of growth and development. Do we have the political capability, strength, and wisdom necessary to take the opportunity and to avoid a catastrophic future? I am optimistic about what we can do but deeply worried about what we will do. Our task is to help turn "can" into "will".

Summary of Lecture 1

Looking back

In the past 70 years, advances in **human welfare and economic output have been remarkable and unprecedented**, albeit with persistent regional disparities. **The structure of the world economy has been transformed**; now multi-polar. **Severe climate, biodiversity, and environment stresses** have emerged from weight of output and dirty, wasteful and destructive processes.

A world redrawn

A series of crises, the transformation of the world economy, and the recognition of the **unsustainability of our economic methods and models**, where gains in well-being are marred by environmental damage and social division, has prompted **a re-evaluation of global objectives**. Sustainability and social cohesion as central issues. In particular, the SDGs and Paris climate agreement of 2015.

Climate and biodiversity crises

Accelerating climate and biodiversity crises demand urgent and fundamental systemic change. Meeting Paris Agreement targets crucial to avoiding severe impacts of warming and further damage to biodiversity. Need for **integrated and economy-wide and rapid action on mitigation, adaptation and sustainable development** in all countries.

The ethics, the economics and the politics

The underlying ethics point to an approach to sustainable development founded in **human rights and intergenerational justice,** based on the right to development, itself embodied in a notion of common humanity. Rejection of discrimination by date of birth. Recognition of role of past historical emissions and injustice. All this goes beyond standard "welfare function" approaches of most economics; but sensible application of standard "consequentialism" points in similar directions for actions. The necessary **transformative change requires public action and decisive political leadership** to navigate the disruption, foster intragenerational equity, and seize the opportunities the transformation presents. The **obstacles lie more in the economics, politics, and society** than in science and technology.

A decisive decade

The decisions of next decades, particularly on infrastructure in EMDEs, will dictate whether we lock in high carbon emissions or transition to **sustainable, resilient, and inclusive development**. **A big push on investment is central to this transformation**, requiring at least $4 trillion p.a. globally by 2030. **A new model of growth and development** is in our hands but action must be swift and strong. Much more attractive than the dirty, destructive paths of the past. A growth story for the 21st century: many opportunities along the way; rewards are great; obstacles and difficulties are real; but failure risks catastrophe.

Implication

Sustainable, resilient and equitable growth requires **integrating natural capital and social equity into economic analyses and actions.** And placing rapid **structural, systemic and technological transformation** at centre stage. As technology advances, we can see that the **major difficulties lie in economics, politics, and society**. International collaborations that foster and finance investments in new clean and robust activities in affordable ways, particularly energy infrastructure and resilience, are essential for transformative change at the pace now required. **Global cooperation and a new multilateralism are crucial**. **Economic analysis, policy, and action** should be oriented to fostering the transformation, realising the new growth opportunities, and underpinning global co-operation. **This is the new agenda for economics and the social sciences**.

Summary of Lecture 2

The new growth story: basics

The 21st century growth story centres on **six mutually reinforcing drivers,** embodying factors which are **mostly missing from standard growth analyses** (economies of scale, rapid innovation, networks, systemic changes, health, and new forms of investment). This transformative agenda requires substantial **investment and innovation**, supported by effective policies, institutions, collaboration, and leadership to foster **rapid, structural, systemic, and technological change and manage dislocation**.

Climate, development and poverty

Climate action intertwines with and supports development and poverty reduction. Well-designed adaptation and mitigation efforts stimulate economic growth, reduce poverty, and build resilience. **Inaction exacerbates poverty and stalls development.**

Investment and innovation

Achieving climate and development goals requires **substantial investment** in clean technologies, **with a focus on EMDEs and infrastructure**. Requires innovative and strong strategies in electrification of energy, transformation of cities and transport, recasting agriculture, and reviving forests. Strong **AI potential** to advance discovery and diffusion of green technologies and to manage systemic change.

The new growth story: analytics

Existing economic models fall short in capturing the magnitude and nature of climate risks, the dynamics of systemic, structural, and technological change, the full potential of sustainable growth, including health benefits, and the challenges of dislocation. Will require a **collection of analytical perspectives** to guide this complex transformation and careful thought, judgement and wisdom in combining different perspectives into action.

Policies and institutions

Robust policies and supportive institutions are essential for driving investment in climate action. Requires **clear signals** and a **stable investment environment**. Policy must tackle a whole range of market failures in R and D, capital markets, networks, information, and co-benefits such as reduced air pollution – not just the Pigouvian GHG externality. A comprehensive approach, including diverse instruments, such as standards and regulation, effective and responsive public institutions, city design, management of natural capital, and key public investments. **A focus on the dynamics; public economics as if time matters**.

The role of the state

Market fundamentalism has given way to recognising the **state's essential role** in promoting sustainability and tackling inequality. **Government intervention** critical to achieve sustainable growth and development in a world with many key market failures. Structural and systemic change in real time requires clear and purposive strategy. Will have to work closely with private markets and sectors to foster this change. Clarity on **objectives, metrics, strategies and signals. Public participation and co-creation** across stakeholders will be crucial to success.

Summary of Lecture 3

Vulnerability & opportunity	Global climate efforts **must take account of varying emissions, histories, endowments and vulnerabilities**. Focus on supporting developing countries to build sustainable, resilient and inclusive development. Centrality of infrastructure. Foundations in the Paris Agreement.
Technology, geography, trade	Clean technologies and EMDE growth are **reshaping global economic geography and trade.** Challenges include capital cost and access, and supply chain concentration. **Green industrial policies** encourage innovation but need thoughtful design and collaboration to prevent increasing global inequalities and trade tensions.
International action and collaboration	Global challenges require **international cooperation** to drive investment and innovation and the new growth story, particularly in EMDEs. Key areas for collaboration are: trade; technology; land; overshooting; finance. Combining co-operation and competition.
Land, forests, biodiversity	International collaboration and innovative financial mechanisms are essential for biodiversity conservation and ecosystem restoration; requires **integrated climate and biodiversity policies** supported by urgent multilateral action.
Overshooting, CDR, geoengineering	**The risk of climate overshoot is severe**. Achieving a strong path of emissions reductions leading to net-zero emissions is critical to avoid irreversible climate impacts. **CDRs will also be required**. Various options. Some very expensive, others problematic. Research is necessary. Geoengineering presents a controversial temporary fix associated with significant ethical and environmental risks.
Finance	Finance is of fundamental importance. EMDEs are being left behind in every critical aspects of the transition. Now require, for Paris, a **new climate finance framework** that supports global climate action and sustainable development. Major expansion of multilateral finance system is necessary, including a **tripling of finance from MDBs** by 2030, their closer working with private sector, and **finance available to EMDEs at an affordable cost** (risk management is crucial).
Closing call	**Multilateral collaboration** is essential to tackle climate change and achieve sustainable growth, with the success of this transformation resting also on **innovative economic thinking and decisive political leadership**. We have the economic understanding, technologies, and ingenuity to create this new form of sustainable, resilient, and equitable development and to avoid climate catastrophe. But do we collectively have the political will, skills, and cohesion to deliver? Challenge is to **transform what we "can do" into what we "will do".**