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IGC White Paper on Sustainable Growth

Innovation, growth, and the environment

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Contents

Executive summary

Three factors make achieving sustainable growth in developing countries a global imperative.

1. Developing countries have a pressing need for economic growth to raise living standards.
2. Developing countries bear the greatest burden from climate change.
3. Developing countries are where future emissions are forecasted to grow most rapidly.

As people move across the arc of development, they shift from unproductive self-employment in subsistence-type firms to specialised productive employment in large firms. This movement generates both spectacular improvements in living standards and greater environmental externalities.

We argue that innovations – technological, organisational, social, and political – now allow us to better balance the need for growth with the need to protect the natural environment. As these innovations take hold and diffuse in diverse areas such as clean energy, clean transportation, natural resource management, and clean manufacturing, it becomes possible to envision a future where developing countries can continue to grow without further worsening the health of the planet or their citizens.

Developing new low-emissions technologies is a first step. Then the entire economy – from markets and regulation to taxation, redistribution, and international trade – needs to be reshaped. In section two (on energy and environment), we consider how innovation and diffusion of clean energy, the management of natural capital, and climate adaptation are central to achieving this balance. Innovations here will not only have to slow emissions but also protect households and firms from unfolding climate damages.

In section three (on firms, jobs, and trade), we focus on the critical role that firm and job upgrading plays in the generation of growth, and how various regulations and taxes can enable growth in a way that minimises environmental damages. Establishing adequate skill creation and worker-firm matching policies is a critical means of allowing workers to move into more productive jobs which, in turn, protect them from environmental damages.

In section four (on urbanisation, rural development, and migration), we argue that sustainable growth requires large investments in clean energy, services, and transportation infrastructures. These are needed both in urban areas, which will drive productivity growth, and in rural areas, where many of the most vulnerable individuals live. Special consideration is given to how migration from rural to urban areas, but also across countries, can be managed as climate change unfolds.

In section five (on state effectiveness), we look at how the functioning and organisation of the state must be transformed to both protect vulnerable populations and decarbonise the economy. To confront these challenges, innovative institutions, often spanning different government departments and ministries, need to be designed. Tax and non-tax revenue generation will also need to be increased to finance the new investments underpinning sustainable growth.

Lastly, we consider how international policy and coordination can assist countries with achieving sustainable growth. Many of the damages that citizens in low- and middle-income countries are experiencing today are due to industrialisation in high-income countries. New thinking is needed on how to design international assistance in the areas of innovation and diffusion of clean energy technologies, climate finance, and loss and damage funds.

1 Introduction

Is sustainable development in today's low- and middle-income countries possible? At least three reasons make this an imperative policy question. First, as these countries are home to the majority of the world's poorest populations, they have a pressing need for economic development. Second, these countries are also the most affected by environmental damages. Third, these countries are central in reducing environmental damages going forward. Despite low historical average contributions, these countries will produce the majority of future greenhouse-gas (GHG) emissions.

Figure 1 depicts a strong overlap between the incidence of climate damages and extreme poverty in low- and middle-income countries and makes it clear that they stand to gain the most from sustainable growth. These countries are the focus of this paper.

We begin by recognising that economic development can transform societies and deliver vast improvements in human welfare. Consider the story of South Korea, the so-called "miracle on the Han River". In 1950, South Korea was poorer than South Sudan and Niger. Today, it is richer than Spain and Italy, thanks to an astounding 30-fold increase in income per capita. Within half a century, South Korea spanned the arc of development.

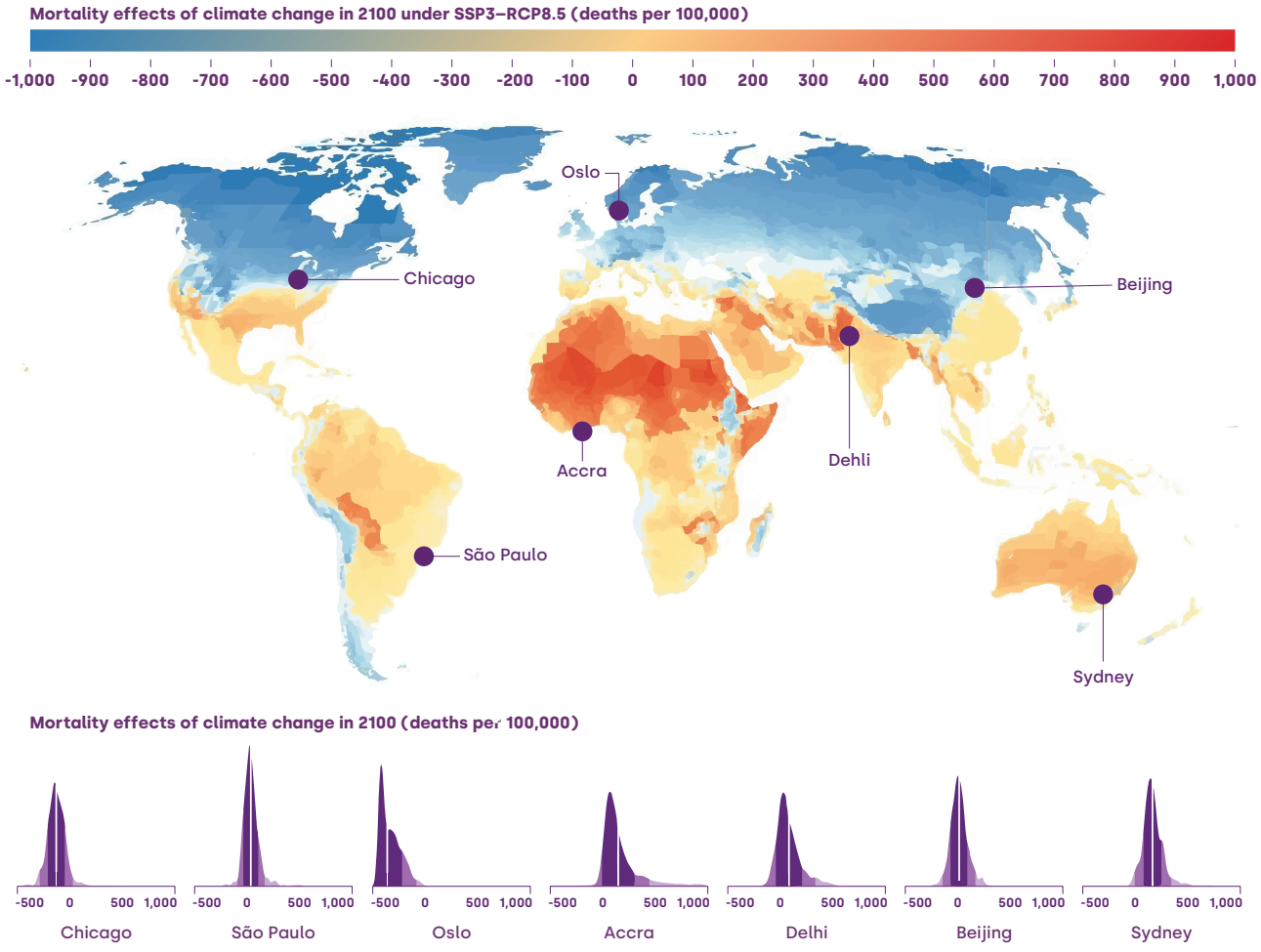
Economic development is fundamentally about productivity growth. Productivity growth occurs mostly as the result of innovation, broadly defined. This includes technological, organisational, social, and political innovations. Innovation is held back by a combination of 'market failures' and 'government failures'.

- Market failures – for example, positive knowledge externalities – create a wedge between the private and social return to innovation. As private returns are smaller than social returns, from the point of view of society as a whole, the economy produces too little innovation.
- Government failures refer to barriers that prevent governments from setting up policies which correct existing market failures. A common and pernicious form of government failure stems from a non-inclusive development model. This skews political competition: efforts are directed towards capturing existing rents, and away from the delivery of policies that boost innovation and increase the size of the economy.

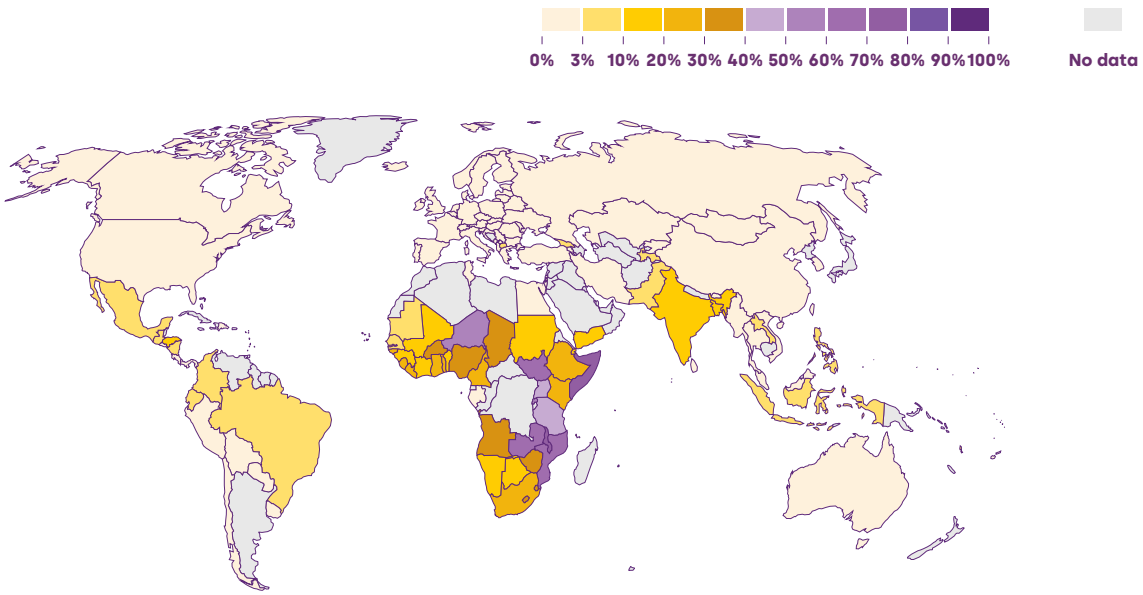
The standard view is that countries travel across the arc of development by progressively removing government and market failures, thereby boosting innovation and productivity. This generates economic growth and, in turn, vast improvements in human welfare, as people move from unproductive self-employment in subsistence agriculture and casual labour to specialised, salaried employment in large complex firms (Bandiera et al., 2022).

FIGURE 1: CLIMATE CHANGE DAMAGES AND THE INCIDENCE OF EXTREME POVERTY

(A) MORTALITY EFFECTS OF CLIMATE CHANGE (ADAPTED FROM CARLETON ET AL., 2022)



(B) PERCENTAGE OF INDIVIDUALS LIVING BELOW US$ 2.15 A DAY (ADAPTED FROM HASELL ET AL., 2022)



Source: World Bank Poverty and Inequality Platform (2022). OurWorldinData.org/poverty – CC BY
Note: This data is expressed in international-US$ at 2017 prices. Depending on the country and year, it relates to income measured after taxes and benefits, or consumption, per capita.

This view, however, misses a key fact: left untouched, development generates significant negative externalities on the environment (see Box 1).[1] One such externality is GHG emissions and the adverse climate change that these gases generate. Another is the pollution of water and air. A third externality comes from the depletion of natural assets, most notably, forests, oceans, and biodiversity. These externalities can slow down future economic growth and threaten essential amenities, severely reducing development's potential to improve human welfare. To deliver on the promise of radically increasing the standards of living in society, including for the world's poorest populations, these externalities must be addressed.

In this paper, we chart the key elements of a sustainable development strategy and an accompanying research agenda that will enable governments to implement this strategy. We define a development path as sustainable if it delivers the maximum possible gains in human welfare after properly accounting for the damaging effects of environmental externalities. It is a path that balances growth and environmental protection in the way that best promotes human welfare.

The fundamental challenge, in our view, is that many of the standard economic solutions to environmental externalities – such as carbon taxes, emission quotas, or deforestation bans – face enormous political opposition. These policies typically generate well-defined groups of 'losers' who can organise and effectively lobby governments to block their implementation. Further, these policies are often perceived to be detrimental to economic growth. No government will support an anti-growth agenda.

We argue that innovation can help solve this political gridlock. This is chiefly because innovation – which, in developing countries, includes both primary innovation and the adoption of technologies and products from richer economies – can ease the growth-environment trade-offs that make political action on the environment so difficult.[2] A clear example of this is the recent development of cheap solar energy, which makes low-emissions growth not only viable but also financially attractive. In this paper, we lay out a new research agenda on understanding the key market failures preventing innovation for sustainable development.

Innovation, however, will not address all tensions between growth and environmental conservation, and some difficult trade-offs are likely to remain. For these, governments need to find effective ways to respond to

1 Early work by Ayres and Kneese (1969) models residual waste from consumption and production, arguing it is different than other externalities as it does not exist in isolation. Environmental externalities are therefore not exceptional to consumption and production. This point motivates the need for the state to address environmental externalities.

2 This is not to say that there are zero trade-offs. With scarce resources and an abundance of competing demands, governments will inevitably have to make decisions on allocating funds which may not maximise growth (or the environment). Our argument is simply that innovation makes the slope of these trade-offs flatter. The curve may already be flatter than we think. For a review on the theory of green innovation policies and their efficacy on reducing the trade-off, see Stock (2019).

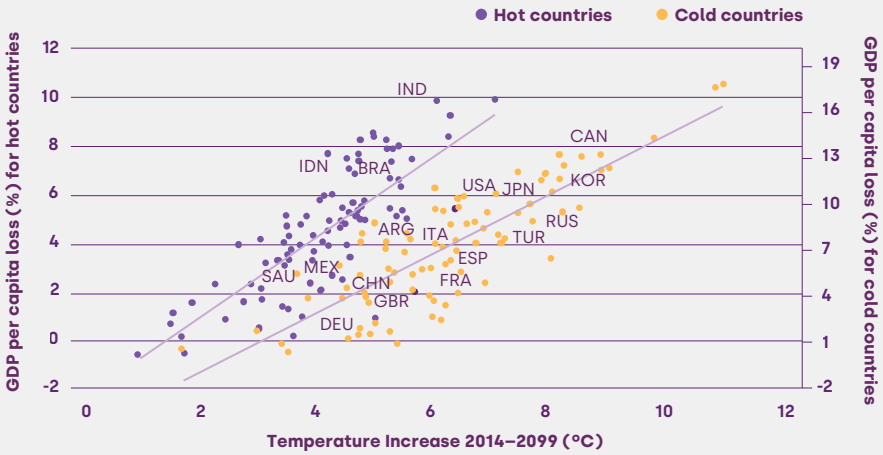
environmental externalities. Here, researchers can support policymakers by highlighting ways in which policies can be implemented at lower costs and considering existing constraints on state capacity. This includes studying the design of social protection for those who are most vulnerable to unaddressed environmental externalities.

BOX 1: THE COST OF ENVIRONMENTAL EXTERNALITIES

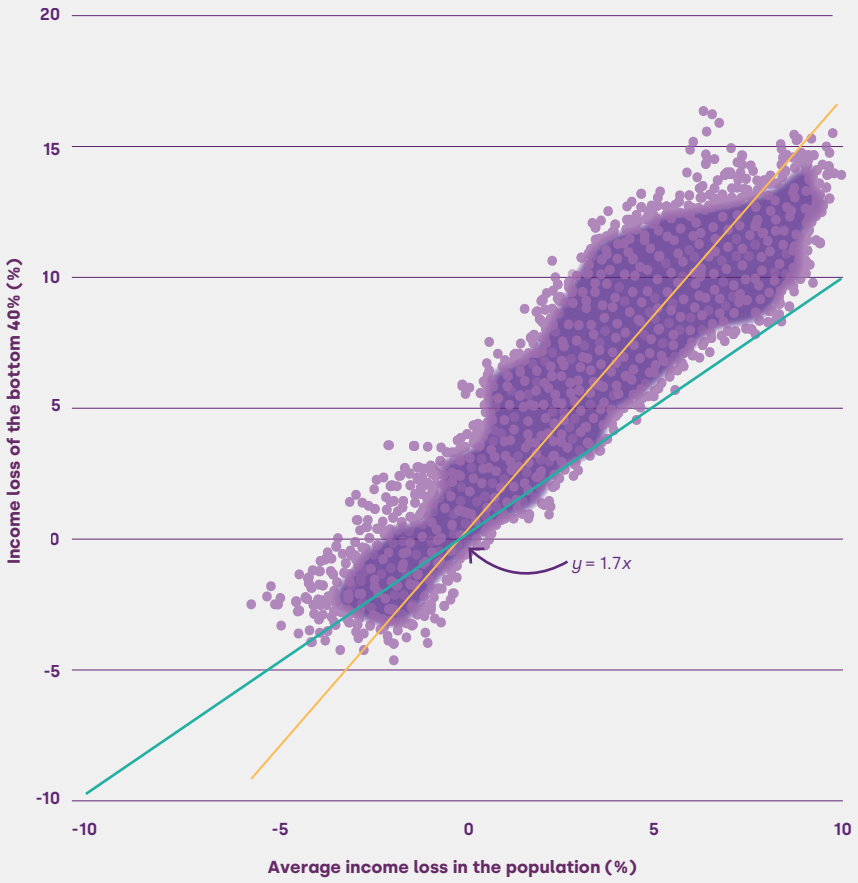
After the early work Economics of Climate Change by Stern in 2008, economics research began to rapidly undertake measurement and assessment of global and local costs of climate change. Short-run costs are well documented in the literature, including changes to GDP (Burke et al., 2015b; Hsiang et al., 2019), mortality (Barreca et al., 2016; Carleton et al., 2022; Jayachandran, 2009), productivity (Burke et al., 2015b; Hsiang, 2016) and crop yields (Auffhammer and Kahn, 2018; Schlenker and Roberts, 2009). Mortality from climate-induced temperature rise alone is predicted to cause a 3.2% global decrease in GDP by the end of the century (Carleton et al., 2022). This figure rises to 8% without income growth or adaptation investments. Raising individual incomes and planning for climate hazards is necessary to reduce future costs of climate change.

Moreover, climate hazards and vulnerabilities fall unequally across populations (Hallegatte and Rozenberg, 2017). At the household level, climate shocks can reduce individuals' ability to accrue and maintain assets – including human capital (Dercon, 2004). The variability of climate shocks affects the poorest populations disproportionately from the negative impacts (Hsiang et al., 2019). Temperature rise could increase mortality by 17% in places like Accra in Ghana (Carleton et al., 2022).

PANEL A: GDP LOSS PER CAPITA IN HOT *PURPLE*, COLD *YELLOW*, COUNTRIES (ADAPTED FROM KAHN ET AL., 2019)



PANEL B: INCOME LOSS RELATIVE TO BOTTOM PERCENTILE
(ADAPTED FROM HALLEGATTE AND ROZENBERG, 2017)



In Panel (a) modelled by Kahn et al. (2019), the authors review IPCC predictions for future temperature scenarios through 2100. Panel (b) similarly indicates income losses are higher for those in the bottom percentile (Hallegatte and Rozenberg, 2017). Overall, temperature increases will cause significantly higher GDP losses in less developed countries and will cause higher income losses for the bottom 40% of households relative to the average loss across the population.

These losses are just the beginning of our understanding of the cost of climate change. Long-run costs carry deep uncertainty (Tol, 2009; Weitzman, 2011). Tipping points can have knock-on effects (Pörtner et al., 2022) that lead to a feedback cycle of high damages. Uncertainty coupled with the spatial inequality of damages will accrue costs in areas already struggling to move along the development curve.

Six policy areas are central to this sustainable development strategy:

1. **Energy:** The development of cheap and efficient clean energy technology has changed the landscape for sustainable development. Policies that scale up renewable energy generation and distribution need to be top priority, as they will fundamentally change the strict growth-environment trade-offs that have historically characterised economic development.
2. **Conservation:** Developing countries enjoy abundant reserves of valuable natural assets, such as forests and biodiversity. Their depletion severely affects human wellbeing and is a major source of emissions. Conserving these assets in a way that minimises economic costs is of paramount importance.
3. **Firm upgrading:** Firms do not have the right incentives to deliver the necessary amount of innovation for sustainable development. There is thus a strong case for the government to promote green innovation through firm-upgrading policies, using a mix of subsidies, taxes, and regulation.
4. **Labour markets:** Unemployment among youth and in urban areas are major policy problems for low- and middle-income countries. Tackling these issues has become more urgent due to climate change, since formal jobs can offer protection against climate shocks. Hence, establishing adequate skill creation and worker-firm matching policies will be essential to fairly sharing the gains from development with the new generations and broader sections of society.
5. **Spatial:** Economic development is accompanied by fast urbanisation and large movements of people across space. Governments in developing countries need to make the necessary investments to ensure their cities offer maximum protection from environmental externalities. Further, they need to minimise barriers that may prevent the reorganisation of labour and capital across space in response to a changing environment. Place-based policies can maximise the gains of spatial reallocation, boosting productivity in winning locations and offering policy support to rural locations that will experience large out-migration.
6. **Social protection:** Unaddressed environmental externalities cause the most harm to the poorest populations. This creates a new set of challenges for social protection, which will be called on to serve a broader population and to offer insurance for a wider set of shocks. Additionally, social protection policies need to be designed to promote adaptive decisions that reduce risk exposure among target populations and, where possible, increase productivity. For example, they could enable people to move into jobs that are less climate-affected.

2 Energy and environment[3]

2.1 Introduction

The natural environment provides the essential resources for economic development: food, water, energy, and a variety of materials. However, it can also produce major threats to development and human wellbeing, such as droughts, floods, and diseases. Without plentiful resources, raising the living standards of the poorest populations will be impossible. At the same time, environmental shocks such as those brought about by climate change will impose heavy costs on poor populations. Policymakers thus need to find a way to harness environmental resources to spur economic development while minimising the negative externalities arising from their extraction and use. They also need to find innovative ways of enabling household and firms to adapt to the externalities that cannot be mitigated.

In this section, we will explore three policy areas that are central to achieving a balance between resource use, mitigation of externalities, and adaptation of households and firms to externalities.

- First, we will discuss the design of energy policy. Recent developments in clean energy technology have created new opportunities for expanding energy use while minimising the associated environmental externalities - chiefly, GHG emissions and air pollution.
- Second, we will explore the management of natural capital, another critical policy area for the reduction of environmental externalities in low- and middle-income countries. For example, deforestation is both a major contributor to GHG emissions and a key driver of biodiversity loss in developing economies.
- Third, we will discuss the need to enable households and firms to adapt to the new risks posed by climate change. We will argue that existing environmental crises necessitate a major rethink of existing climate adaptation policies.

2.2 Energy

Economic growth in developing countries cannot occur without a major expansion in energy use (Lee et al., 2020b; Steinbuks and Foster, 2010). Energy consumption per capita in low- and middle-income countries is only 15% of the level of energy consumption in high-income

3 Please refer to the IGC Evidence Paper: Energy & Environment (Greenstone, Reguant, Ryan and Dobermann, 2021b) and the IGC Evidence Paper: Energy & Environment (forthcoming, 2023) for a fuller treatment of the issues covered in this chapter.

countries (Ritchie et al., 2022). In low-income countries, electricity access varies from extremely low (for example, Chad, 9%) to moderate (for example, South Sudan, 55%) (Ritchie et al., 2022).

Limited access to high-quality energy has large economic and social costs in the form of lower levels of employment (Dinkelman, 2011), firm entry (Allcott, 2018), and human development outcomes (Lipscomb et al., 2013), especially in the long run (Fried and Lagakos, 2023). Expanding energy use is thus a first order policy priority.

Historically, this expansion in energy use would have inevitably required the production of substantial environmental externalities in the form of GHG emissions and pollution. Governments were beholden to accepting environmental externalities in exchange for greater energy use today (Chakravarty and Tavoni, 2013). Despite low- and middle-income countries often suffering the most from these externalities (Burke et al., 2015b; Carleton et al., 2022; Dietz and Rosa, 1997; Fankhauser and Stern, 2016), pollution was deemed necessary for growth.

Together, new technologies and new market institutions can enable low- and middle-income countries to chart a development pathway combining greater energy use, higher living standards, and lower environmental externalities.

Today, however, innovation in clean energy technology has fundamentally changed the nature of this trade-off. Solar and wind power generation enable the production of electricity without the simultaneous release of greenhouse gases and fine-particulate-matter pollution. The cost of these technologies has, until recently, remained prohibitive. But not anymore: costs have significantly plummeted, so that solar energy has now achieved lower marginal costs than coal, the next cheapest (and highly polluting) energy generation source (IRENA, 2023; Ritchie et al., 2022).[4] This makes it possible, in principle, to produce low-emissions electricity at a large scale (Burgess et al., 2023; IRENA, 2017; Itskos et al., 2016; Popp, 2010).

Even for activities that do not require electricity, new technologies are allowing individuals to consume more while polluting less. For example, clean fuels for cooking and heating substantially improve household air quality, lowering morbidity and mortality, and curbing deforestation (Berkouwer and Dean, 2022; Hanna et al., 2016; Lipscomb et al., 2013; Roser, 2020).[5]

4 The globally weighted average levelised energy cost (LCOE) for new utility-scale solar PV projects is currently US$ 0.048 per kilowatt hour of energy. Similarly, on-shore wind costs are currently US$ 0.033 per kilowatt hour. In 2021, two-thirds of newly installed non-fossil energy capacity was installed at a lower cost than coal (IRENA, 2023).

5 On the ground, the adoption of low-emissions fuels for cookstoves has been suboptimal due to household preferences, maintenance costs and social norms (Bonan et al., 2017). Similarly, Berkouwer and Dean (2022) find credit constraints depress willingness-to-pay.

Indian engineer positions solar panels at the construction of the Roha Dyechem solar plant at Bhadla in Rajasthan, India. Photo by Money Sharma/AFP via Getty Images.

A new wave of economic research has charted the policies that are required for the development of well-performing low-emission energy markets (Burgess et al., 2020; Elliott, 2022; Fowlie et al., 2018; Gonzales et al., 2023; Jha et al., 2022; Joskow and Wolfram, 2012; Reguant and Kellogg, 2021). Together, new technologies and new market institutions can enable low- and middle-income countries to chart a development pathway combining greater energy use, higher living standards, and lower environmental externalities (Acheampong, 2018; Greenstone et al., 2021b; Lee et al., 2020b; Ratledge et al., 2022; Stern, 2004).

In the rest of this section, we discuss how to expand energy use in low- and middle-income countries through boosting the production of clean energy. The section is organised around the three key stages of the energy economy: production (Section 2.2.1), distribution (Section 2.2.2), and retail (Section 2.2.3).

2.2.1 Energy production

An increase in energy production is essential to generate economic growth. To minimise externalities, this energy must be produced using the most effective clean technologies. In the long-run, this requires electrifying almost all activities that rely on combustion for energy – be it wood for cooking, fuel for cars, or coal for boilers – and producing this electricity with less emissions (Allcott, 2018).[6] Along the way, improvements in energy efficiency, like adopting more efficient cook stoves or LED lighting, can

6 For the subset of hard-to-decarbonise sectors, such as producing steel or cement, other technologies may be necessary.

make significant contributions towards flattening the trade-off between emissions and growth. Much of our focus, however, will remain on making the production of electricity cleaner.

Many low- and middle-income countries have great potential to deliver this increase in energy production through solar and wind power generation (IEA, 2022c; IFC, 2023). These energy sources have in principle become cheaper than the fossil fuel-based alternatives (Arkolakis and Walsh, 2023; Ball et al., 2017; Banares-Sanchez et al., 2023; Besley and Persson, 2023; Borenstein, 2012; Lazard, 2023; Ritchie et al., 2022). In fact, accounting for full system costs, the transition to renewables can result in substantial net savings once appropriate cost declines are modelled (Way et al., 2022). The costs of key green technologies such as solar, wind, and batteries have followed a power law based on deployment ('Wright's Law'). Despite this, the current energy mix remains strongly skewed towards fossil fuels. In 2021, 71% of global electricity production was sourced from fossil fuels (IEA, 2022a; Ritchie et al., 2022). In developing countries, 90% of energy consumption remains fossil fuel-based (Ritchie et al., 2022).

The diffusion of solar and wind energy is likely slowed down by (i) weak incentives resulting from distorted price mechanisms (Davis, 2017; Gonzales et al., 2023; Joskow and Tirole, 2007; Wolfram et al., 2023), (ii) poor information (Mahadevan et al., 2023), (iii) adoption risks (including leakage) and high cost of capital (Emory, 2023; Foster and Briceno-Garmendia, 2010; Lee et al., 2020b; Ryan, 2020, 2023; Srivastav, 2023), as well as (iv) lack of a trained workforce (IRENA and ILO, 2021).

A large institutional infrastructure has been built to handle the swings of fuel costs; creating a similar infrastructure for handling the swings of renewable generation is therefore a matter of investment and policy design.

Which policies can lift these barriers? Where private actors are involved in energy generation, it will be essential to ensure there are clear economic returns to expanding clean energy generation capacity. This may involve subsidies that compensate private actors for start-up (Nelson and Shrimali, 2014) and infrastructure costs (Ryan, 2021), and feed-in-tariffs that limit the risks of adoption (Arndt et al., 2019; Doris, 2012; Schmalensee, 2012). The state may have a key role to play in training the workforce with non-general skills (Wasmer, 2006), and those specific to the large-scale adoption of clean energy technologies (IEA, 2022b). High quality evidence on the impacts of interventions designed to boost private entry into renewable energy production will be particularly valuable.

In most low- and middle-income countries, producers of electricity do not compete in a spot market. Instead, electricity is produced on the basis of long-term, rigid contracts known as power purchase agreements (PPAs), typically between the government and a public or private

producer.[7] PPAs are critical instruments for providing certainty over future returns and lowering the costs of capital in otherwise risky investment environments. However, if they are not competitively awarded, such as through procurement auctions, they risk locking in disadvantageous terms. Importantly, they cannot easily be exited, meaning that cheaper and cleaner alternatives like solar or wind cannot displace existing thermal plants.

The movement towards wholesale markets for electricity production, where plants bid against each other to supply power at frequent intervals (for example, daily), opens up more opportunities for new technologies to displace old ones. Establishing such markets, however, is a complex institutional endeavour that takes years or decades of planning. An important area of research is how markets for electricity production can help deliver welfare gains for society through cheaper costs, as well as the adoption of the latest and cleanest forms of production. While these gains may seem obvious on paper, they may be limited in practice by the emergence of monopoly power or collusion. For example, recent evidence from Colombia exposes how the prevalence of collusive practices between energy producers in a privatised market drove up consumer prices (Bernasconi et al., 2023).

It is also important to consider how fossil fuel energy production will respond to the expansion of renewables. There is a risk that clean energy will displace gas proportionally more than coal (Cullen, 2015; Knittel et al., 2015; Reguant and Kellogg, 2021). As burning coal produces more emissions than burning gas, it may be possible to obtain further gains in emission reductions by providing incentives for energy producers to discontinue coal rather than gas. Auctions for phasing out coal plants, such as those seen in Germany, are being looked at as possible mechanisms for ensuring a timely exit from coal (IEA, 2021a; Jewell et al., 2019). These auctions, and policies aimed at the same outcome, will have to be careful in their design to ensure additionality.

Where energy generation is mostly in the hands of a public monopolist, on the other hand, this monopolist should be given the resources and the mandate to expand production capacity for clean energy and to gradually phase out fossil fuel energy sources. We flag the need for additional evidence on the costs and benefits of the public monopolist model, especially with respect to coordinating the transition towards clean energy production.

Intermittency is an often-cited barrier for the rapid uptake of renewables (Borenstein, 2012; Gowrisankaran et al., 2016; Heal, 2010; Joskow, 2011; Joskow and Tirole, 2007; Reguant et al., 2023; Wilson, 2012). This issue

7 These contracts typically span the life of a power plant (20–30 years) and often include generous terms for indexing costs (fuel costs, foreign exchange, inflation, interest rates, and more).

is amplified in countries that have large swings between peak and off-peak electricity consumption. For instance, peak times typically occur in early evenings when solar does not generate electricity.

Handling this issue will require significant investments into expanding grid capacity and interconnections, improving grid management systems, and introducing new incentive mechanisms to ensure timely dispatch. However, for the majority of countries that have extremely low wind and solar penetration rates, intermittency is unlikely to be a large grid management issue in the near term, and hence should not be viewed as an argument against their deployment. Improvements in grid management, such as using highly accurate forecasting of near-term power generation based on the weather to help schedule load, can help ensure system stability.

Demand-side measures to flatten the gap between peak and off-peak consumption, such as incentivising industries to consume more during daylight hours, should also be considered. Returning to Way et al. (2022), utility-scale renewables with storage may surpass even the cheapest forms of thermal generation sooner than we might expect.

Overall, the gains from cheaper electricity generation (even without storage) are likely to offset the additional system costs that an intermittent source of generation imposes. Lastly, while existing renewables face uncertainty over production, there is no uncertainty over their costs as they consume no fuel. Thermal plants have more certainty over production, but uncertainty over fuel costs. A large institutional infrastructure has been built to handle the swings of fuel costs; creating a similar infrastructure for handling the swings of renewable generation is therefore a matter of investment and policy design.

2.2.2 Energy distribution

A key challenge in the energy economy is that of transporting energy from the place where it is generated to where it is used. The existing distribution infrastructure – the transmission and distribution systems comprising the electricity grid – often does not serve poor communities adequately (Granoff et al., 2016; Hallegatte et al., 2019; Jha et al., 2022; Lee et al., 2020a).

Additionally, the existing electricity grid is often insufficient to accommodate large-scale clean energy generation. This is because clean energy is often produced in scarcely populated areas, such as deserts, which are not currently connected to the grid (Fowlie et al., 2018; Gonzales et al., 2023). The locations of generation, such as offshore wind, do not typically overlap with main demand centres. As discussed above, the existing diffusion infrastructure is ill-equipped to cope with a substantial share of electricity being derived from intermittent flows of electricity like solar and wind energy generation (Borenstein, 2012; Greenstone et al., 2021b; Joskow and Wolfram, 2012). This reduces the opportunity to benefit from the widespread innovations in clean technologies.

Investment in expanding and strengthening the electricity grid is therefore paramount. The same economic ideas of gains from trade arising from enhanced market access and integration apply to the diffusion of energy. Transmission lines in developing countries are often severely overloaded or face critical choke-points, preventing them from realising the gains from energy trade (Ryan, 2021).

In India, recent evidence suggests that the expansion of grid infrastructure can generate high levels of consumer surplus (Burgess et al., 2023). In Chile, it can foster considerable private entry in upstream production markets, especially in renewables (Gonzales et al., 2023). However, it should also be noted that some studies, especially those focused on last-mile electrification in rural areas find small short-run impacts (Burlig and Preonas, 2021; Lee et al., 2016, 2020a,b), possibly due to the lack of complementary investments (Moneke, 2023; Walter, 2021), bringing households to favour off-grid electricity (Burgess et al., 2023). Finally, there is significant evidence of depressed demand for both grid connected and off-grid renewable energy due to either household credit or liquidity constraints (Grimm et al., 2020; Lee et al., 2020b).

2.2.3 Energy retail

Energy usage is also fundamentally misallocated in some low- and middle-income countries (Burgess et al., 2020; Jha et al., 2022). This is because non-payment and theft are common, and because political pressure keeps energy prices below marginal costs. This forces utilities to run at a loss and makes it impossible to fund investment in a high quality diffusion infrastructure (Allcott et al., 2016; Fried and Lagakos, 2023; McRae, 2015). Utilities, saddled with debt, then often fall behind payments to power producers, in turn jeopardising future investments into generation as investor risk increases. As a result of all of these factors, energy is not systematically allocated to those who have the highest marginal willingness to pay for it. Fixing the retail of energy will directly contribute to ensuring that the production of energy can take advantage of the latest leaps in technology.

Introducing tools to minimise non-payment is a first-order priority to change this equilibrium (Burlig and Preonas, 2021; Szabo and Ujhelyi, 2015). One particularly promising technology to boost payment collection is pre-paid meters (Jack and Smith, 2015, 2020; Jack and Jayachandran, 2019). Smart meters, which can incorporate payment features, have similar benefits in that they can be remotely disconnected. However, more evidence is required on whether the introduction of such meters can push some households into energy poverty. Ideally, technology would allow policymakers to reduce moral-hazard-driven non-payment, while providing some insurance against liquidity-driven non-payment. Using technology to solve the non-payment problem is also very capital-intensive. Further, it falls subject to similar political pressures to not enforce disconnections as with regular meters.

Aligning prices to marginal costs is a second priority. Where energy retail is organised by the state, this may require lifting some indiscriminate subsidies while providing some additional support for the poorest households. Support to these households need not come through the energy sector. Existing social protection channels might be better forms of targeting support than energy consumption. Where energy retail has been privatised, fostering competition among private retailers is also essential to unleash the full benefits of privatisation. Even with private competition, independent regulators are necessary to ensure consumers are not unduly impacted.

2.3 Natural capital

Natural capital and environmental sustainability are vital components of economic development (Arrow et al., 2012, 2004; Cohen et al., 2019; Costanza and Daly, 1992; Dietz and Neumayer, 2007; Millner and Dietz, 2015a; Pearce and Turner, 1989).

We are only just beginning to understand the myriad influences they can have. For example, in India, the collapse of the vulture population led to an increase in waterborne diseases and mortality, producing mortality impacts on the same order of magnitude as those expected from excess heat by the end of the century (Frank and Sudarshan, 2023). Allowing the stock of natural capital to collapse, as it has been doing in recent decades (Pörtner et al., 2022), is exposing us to additional risks.

This collapse is happening on multiple dimensions. We are witnessing the sixth great historical extinction (Kolbert, 2014). Global coverage of living coral has fallen by more than half since the mid-20th century (De'Ath et al., 2012; Eddy et al., 2021), greatly compromising the services they provide to society, such as food or coastal protection (Eddy et al., 2021). Tropical peatland degradation has also risen rapidly (Barbier and Burgess, 2021; Hsiao, 2023a; Pörtner et al., 2022). The diminishing quality of soil, water resources, and forest ecosystems is well documented (Dasgupta, 2021). Deforestation continues at an alarming pace: subtropical forest loss doubled during the 21st century (Feng et al., 2022) and the rate of global forest cover loss increased in every region, except Brazil, from 2000 to 2012 (Hansen et al., 2013). Deforestation is driven by conversion of forested land to agriculture, timber and fuel wood use (Balboni et al., 2023a; Ritchie and Roser, 2021). The dramatic reduction of deforestation rates in Brazil during the period 2006–2014 demonstrates that with enough political will, deforestation can be effectively reduced (Burgess et al., 2022). However, the fact that some of these gains were then reversed points to how fragile the conservation equilibrium can be.

We owe some of our improved understanding of natural capital conservation to advances in monitoring technologies. Thanks to the rise in the availability of remote-sensing products we can now detect land use change at a very fine level of aggregation and use this data to evaluate conservation policies. For instance, Hansen et al. (2013) have

created a comprehensive measure of global land use change through observation satellite data. They map global forest loss (2.3 million square kilometres) and gain (0.8 million square kilometres) at a spatial resolution of 30 meters. Balboni et al. (2023a) use this and other remote sensing data to assess the use of fire for land clearing and its associated negative externalities in Indonesia.

While the problem is clear, there is still a substantial evidence gap on how to best integrate natural capital into economic policy. Research is needed in two broad areas. The first is the measurement of the benefits and costs of conserving natural capital and its distribution. The second relates to designing and evaluating policies to manage natural capital, taking into account how the distribution of costs and benefits overlaps between stakeholders and geographies. A clear grasp of local economic and political incentives is critical for implementing effective and politically feasible policies for natural capital management.

The most straightforward approach to mitigating environmental damage is conservation.

These two areas are mutually dependent. To identify priorities, the first step is to measure the benefits and costs of the usage of natural resources, and to identify who benefits from their use, depletion, or outright destruction (as is the case of deforestation for land use change). Conserving natural capital generates 'winners and losers' as those who benefit from conservation may be different from those who gain from extraction. This requires studying how to overcome conflicts or coordination failures that may arise when managing natural capital. When there are clear local complementarities, as is the case for fishermen who want to sustainably harvest the local stock of fish, policies can effectively shift outcomes to a new, stable equilibrium (Huang and Smith, 2014). However, in most cases, the benefits are not restricted to local users (or spread heterogeneously in an area), and the threats can come from inside as well as outside. These are the instances in which careful research on the design and evaluation of markets and institutions for managing natural capital is needed.

The most straightforward approach to mitigating environmental damage is, of course, conservation. This includes, for example, the creation of protected areas for old growth forests, savannah, coastal wetlands or parts of the ocean. Conservation efforts are designed to maintain the critical functions of these ecosystems – habitat provision, carbon sequestration, adaptive benefits and other environmental services. But the efficacy of conservation programmes, particularly in developing economies, continues to be a contested topic in both the environmental management (Cooney et al., 2017; Hauenstein et al., 2019) and the economics literature. Evidence on whether conservation programmes reduce poverty at both the local and macro level is inconclusive (Adams et al., 2004; Andam et al., 2010; Naidoo et al., 2019).

A man tests soil health in Western Kenya. Photo by Georgina Smith/CIAT.

Services can be derived from a number of environmental assets including biodiversity, forests, and water, all of which have high economic value with low substitutability. Trees absorb and store carbon dioxide (Bellassen and Luyssaert, 2014); bees support pollination (Gallai et al., 2009); and water is essential for agriculture and for hydropower generation (Foster and Briceno-Garmendia, 2010). Still, more research is needed on valuing natural resources using methods that are well-suited for low- and middle-income countries. Valuation methods based on revealed preferences may be severely downward biased, especially for poorer people in environments with more market failures and lower access to abatement technologies (Greenstone and Jack, 2015).

Overall, the knowledge of scientists (ecologists, climate scientists, forest scientists, hydrologists) and local communities is essential for this task. The former can help to identify priorities in the face of highly complex systems by pointing to the relevant keystone species, threshold effects, or emissions contributions. The latter will know about their local ecology and about the importance of different natural resources in their daily lives.

Understanding the value of natural capital and who benefits from it does not guarantee sustainable usage. Institutions and markets must create the right conditions and incentives for conservation. We need more research to shed light on the main market failures and political tensions that block sustainable outcomes.

This leads to our second broad area: improving our understanding of the benefits and costs of, as well as the incentives for, resource conservation. For example, consider the central tension between government, firms

and citizens to exploit forests and convert land for other uses (Burgess et al., 2012). A global imperative (climate change) may compel the national government to preserve the forest; local firms may be driven by a desire for rent extraction; and individuals may lack attractive economic alternatives that disincentivise deforestation. For countries like Indonesia, Brazil and the Democratic Republic of Congo (DRC), the exploitation of forest land is critical for national development.[8]

Thus, there is an urgent need to devise feasible and effective policies that balance local development and global conservation objectives. Since the benefits of conservation accrue at different geographic scales relative to the benefits of resource exploitation, there will be winners and losers. A large portion of the benefits of these resources are external to the populations that live close to them and can profit from their depletion. Effective policies must therefore think about the ideal conservation finance schemes that will make them politically feasible at all relevant scales.

One popular policy is payment-for-ecosystem-services (PES). While some PES interventions have showed clear benefits, for example in the case of deforestation (Jayachandran et al., 2017), the evidence on their performance remains mixed (Jayachandran, 2022; Pattanayak et al., 2010). More evidence on when and why these programmes can be effective is needed (Jack and Jayachandran, 2019). Another potential intervention focuses on strengthening property rights (for example, through land titling). These interventions have also had mixed results (BenYishay et al., 2017; Holland et al., 2022; Jayachandran, 2022; Tseng et al., 2021; Wren-Lewis et al., 2020). Conservation interventions also hold promise to protect biodiversity, but rigorous evidence on their impact is largely missing. Explicit command and control regulation to avoid deforestation or habitat degradation in the Amazon was found to be far more costly than incentive-based mechanisms (Souza-Rodrigues, 2019). Thus, we encourage further research into different incentive schemes to ensure cost-effective natural capital protection.

2.4 Climate adaptation

Unaddressed environmental externalities cause the most harm to the poorest populations who are concentrated in the low- and middle-income countries that are the main focus of this report. Restoring a balance between economic development and the natural environment requires innovation in the climate adaptation space. Otherwise environmental damages can reverse poverty reduction gains. This calls for a major expansion and reform of climate adaptation policies to deal with the new risks that climate change poses. At the core of our thinking is the idea that innovations that increase the productivity of

8 For instance, Edwards (2019) estimates that the palm oil sector lifted up to 2.6 million rural Indonesians out of poverty this century.

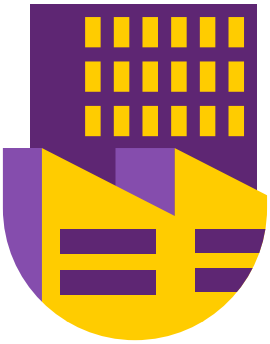
households and firms will be central to minimising the damaging effects of environmental change. Only in this way can we continue to reduce extreme poverty and confront climate change.

Here it is critical to recognise that the problem of measuring and enhancing climate adaptation is complicated by the fact that climate change manifests not only via a 'falling floor' (for example, the gradual increase in global temperatures causes lower crop yields and lower firm and worker productivity) but it also brings an increase in the likelihood of uncommon, but extremely costly events commonly referred to as the 'fat-tail problem' (Weitzman, 2011).

Rethinking climate adaptation must also take into account that there may be multiple, overlapping barriers to climate adaptation. For some households and firms the absence of insurance may be a key constraint (Burgess et al., 2017; Karlan et al., 2014; Lane, 2023; De Mel et al., 2012). In other cases, access to liquidity may be the most important barrier, especially in the aftermath of a major shock or to cover upfront adaptation costs (Macours et al., 2022; Pople et al., 2021). Additionally, a lack of information about new technologies and practices – like improved seed varieties offering higher yields and greater tolerance to droughts or floods – can significantly reduce climate resilience in exposed communities (Dar et al., 2013; Emerick et al., 2016). Climate adaptation programmes should target the most pressing constraints with appropriate interventions.

There is now mounting evidence that climate change and extreme events have large negative effects on outcomes like income and mortality and that these can transmit across space via supply relationships or migration, and persist across time, including in some instances for decades (Kala et al., 2023). The literature also indicates that while households and firms can benefit from a variety of adaptation measures – financial products, new technologies, mobility, and government policies – these are seldom able to mitigate climate impacts completely, indicating that policies to facilitate adaptation will likely have large welfare gains (Kala et al., 2023).

Innovative policies and strategies, both public and private, to enhance adaptation to climate change are thus urgently needed. This is a theme that runs through the whole report. In section three we look at how firm upgrading, skills and training, and trade can help firms and workers adapt to the effects of climate change. In section four we look at how investments in infrastructure can make households and firms in cities both more productive but also more resilient to climate change, given recent evidence by Liu et al. (2023) finding the substantial deceleration effect that rising temperature has on moving agriculture workers into more productive, non-agriculture jobs. In section five we look at how improvements in governance, reorganisation of the state, rethinking social protection, raising revenue and international policy and coordination can be used to increase the resilience of household and firms to climate change.



3 Firms, jobs, and trade[9]

3.1 Introduction

Firms are both a vehicle for economic growth and a source of environmental externalities. As economies grow, firms expand and adopt new technologies (Kuznets, 1973). At the same time, the organisation of labour experiences a dramatic transformation. In the poorest economies most workers are self-employed; as countries become richer, wage labour in complex organisations becomes increasingly predominant (Bandiera et al., 2022). Workers employed in these complex organisations have access to upgraded technology and are better managed. This raises their productivity, boosting their earnings and living standards.

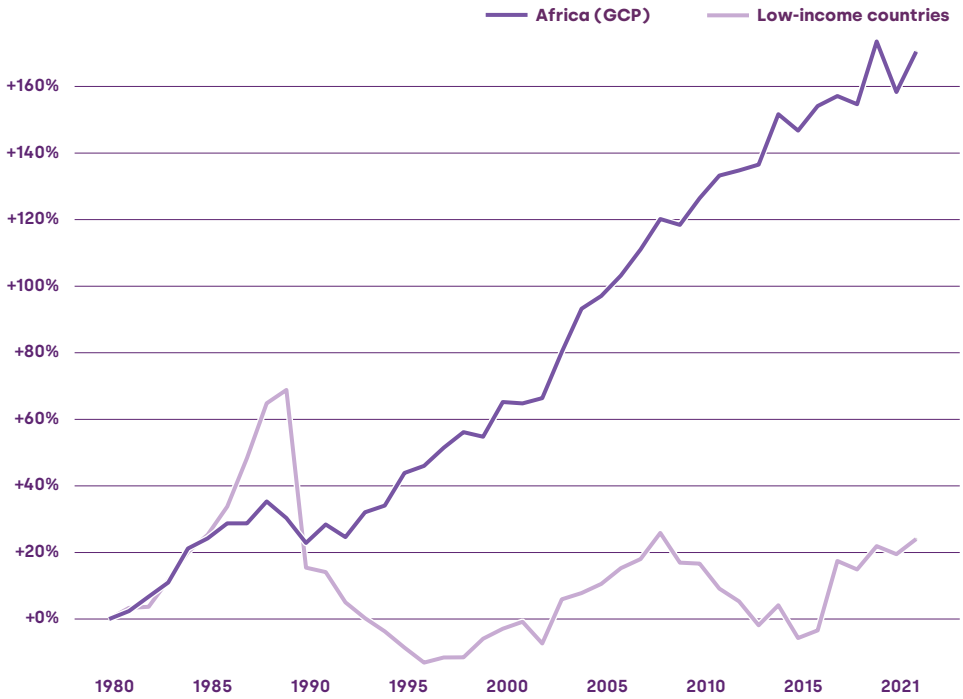
Firms also generate substantial environmental externalities (see Figure 2). While GHG emissions have been declining or plateauing in the EU, they are on the rise in low- and middle-income countries (Ritchie et al., 2020). Industries such as cement manufacturing are massive emitters: by one estimate, cement manufacturing alone contributes to 8% of global emissions (Lehne and Preston, 2018). China's cement production emits around 850 million tonnes of CO_2 each year; the total of all low-income country emissions is a mere 200 million tonnes. All of Africa emits 1.4 billion tonnes (Friedlingstein et al., 2022).

Firms are also responsible for a significant amount of air and water pollution. Concentrations of particulate matter have been consistently rising in most developing countries. Approximately 40% of PM2.5 in sub-Saharan Africa can be attributed to the combustion of fossil fuels for energy and industry (Brauer, 2022), while the misuse of nitrogen-based fertiliser by agricultural firms has driven fresh water eutrophication (Damania et al., 2019).

The development of large, technologically-advanced firms offers several sustainable development opportunities. First, these firms are better placed to mitigate environmental externalities through innovation compared to smaller, less productive firms. For example, large firms can make production more efficient, for example by electrifying it, and adopt other effective pollution reduction measures more easily (Cainelli et al., 2012; Perkins and Neumayer, 2008). Smaller firms face more constraints in making these investments, and there is evidence that in the long run, capital will migrate out of climate-impacted areas if they are unable to insure against climate shocks (Albert et al., 2021).

9 Please refer to the IGC Evidence Paper: Firms, Trade and Productivity (Atkin, Donaldson, Rasul, Teachout, Verhoogen and Woodruff, 2021) and the IGC Evidence Paper: Firms, Trade, and Productivity (forthcoming, 2023) for a fuller treatment of the issues covered in this chapter.

FIGURE 2: GROWTH IN ANNUAL CO_2 EMISSIONS IN AFRICA AND LOW-INCOME COUNTRIES (ADAPTED FROM FRIEDLINGSTEIN ET AL., 2022)



Source: Global Carbon Budget (2022). OurWorldInData.org/co2-and-greenhouse-gas emissions. CC BY

Note: **Fossil emissions:** Fossil emissions measure the quantity of carbon dioxide (CO_2) emitted from the burning of fossil fuels, and directly from industrial processes such as cement and steel production. Fossil CO_2 includes emissions from coal, oil, gas, flaring, cement, steel, and other industrial processes. Fossil emissions do not include land use change, deforestation, soils, or vegetation.

Second, larger firms, especially those with multinational linkages, are likely to be more resilient to environmental shocks. Hence, they create jobs that offer greater protection against such shocks (Balboni et al., 2023b; Castro-Vicenzi, 2022). This protection can be both physical – for example, when jobs are performed indoors in safe environments (Otto et al., 2021) – and economic – since these firms are better integrated with markets, they can easily access credit, and are potentially less sensitive to climatic shocks (Blakeslee et al., 2020; Colmer, 2021). Their multinational linkages may also make them yield to international pressure to green their own supply chains.

Fostering the growth of efficient firms that generate high-quality jobs and produce limited environmental externalities should be a key policy objective of the sustainable development agenda.

These firms also tend to offer formal jobs that provide job-loss insurance (Gerard and Naritomi, 2019; Ulyssea, 2020). Worryingly, evidence has shown environmental shocks can set back the growth of private, non-agricultural enterprises in an area due to a lower demand for these goods in impacted areas. This can create a vicious cycle of low firm growth and unaddressed

environmental externalities (Liu et al., 2023). More research is needed to understand if, in the long-run, environmental shocks have a positive reallocation effect where more emission-efficient firms displace smaller, polluting firms.

Fostering the growth of efficient firms that generate high-quality jobs and produce limited environmental externalities should be a key policy objective of the sustainable development agenda. To achieve this goal, governments need to focus on at least three complementary policy areas: firm upgrading to promote green innovation, skills and matching policy to promote employment and job quality, and trade policy to leverage maximum benefits from green comparative advantage. We will review each area in turn.

3.2 Fostering firm upgrading for sustainable growth

There are two distinct sets of market failures that firm upgrading policies should tackle (Acemoglu et al., 2012). First, those arising from the positive externalities generated by firm innovation that are central to economic growth. In developing countries, firms innovate – or 'upgrade' – both by changing technologies and by changing products. Further, innovation includes both the first-hand discovery of new products and technologies, and the adoption of products and technologies that exist elsewhere in the world, but are not part of the local technology or product frontier (Verhoogen, 2023). Crucially, the benefits of innovation are widespread, and are typically not fully captured by the firms who bear the cost of generating new ideas. As a result, there is often too little innovation in the economy (Acemoglu et al., 2004; Bloom et al., 2013; Hausmann and Rodrik, 2003).

Second, we have to consider the negative environmental externalities produced by firms. These include GHG emissions, effluent waste in water and particulate matter in the air (Ayres and Kneese, 1969); and, for agricultural firms, the externalities generated by the extensive use of land (Hong et al., 2021). The costs of these are typically not fully paid by firms. Incentives coming from socially-minded consumers – though a real force in some sectors (Aghion et al., 2023; Atkin et al., 2017; Boudreau, 2022; Hiscox et al., 2020) – are generally insufficient to fully internalise social costs. As a result, the economy produces excessive environmental degradation.

There are four broad categories of policies that governments can enact to address these externalities. First, the government can provide the basic infrastructure required for economic development. Without reliable access to electricity, an effective communication system, and a well-developed transport network that enables people and goods to move and be traded, firms may not find it worthwhile to invest in innovation, since their capacity to implement new ideas or to find markets for them would be severely

Employees of a factory work on solar lamps in Burkina Faso. Photo by Ahmed Ouoba/AFP via Getty Images.

limited. For example, the recent investments by the Chilean government in the electricity grid, which better connects centres of solar energy production in the north of the country to centres of energy demand in the centre of the country, spurred the creation of new solar power plants and generated an estimated 185% increase in solar energy generation (Reguant and Kellogg, 2021).

Second, the government can provide subsidies to strategic sectors or activities that have the potential to generate clean growth. A good example of this are the subsidies designed to support the nascent solar energy sector (Banares-Sanchez et al., 2023). Subsidies can target production (for example, tax rebates or the provision of cheap credit for the construction of production plants), demand (for example, government price guarantees for a good as in the case of feed-in tariffs for solar energy), or innovation (for example, grants targeted for research and development activities). In practice, governments implement a mix of these tools (Burgess et al., 2023; Harrison et al., 2017; Rodrik, 2014). Feed-in-tariffs were a key part of Germany's policy to foster the development of solar electricity. China used local demand, production and innovation subsidies, but recent evidence shows that it was mostly the production and innovation subsidies that generated growth and cost reductions in its solar energy sector (Auffhammer and Wolfram, 2014; Burgess et al., 2023; Harrison et al., 2017). Finally, India introduced local content requirements to boost demand for local firms involved in the solar energy value chain, but the policy failed to ignite domestic growth in the sector due to its flawed design (Harrison et al., 2017).

As of 2023,

37

carbon tax schemes exist around the world, covering about 6% of global GHG emissions.

A related topic is support for the diffusion and adoption of agricultural technologies and practices. Expanding access to agriculture inputs and more productivity-improving technologies can increase yields, improve resilience, and lower externalities. But, some evidence indicates that an expansion of inputs without proper management, such as the case with the provision of electricity subsidies to Indian farmers, increase emissions and reduce the quality of electricity provision (Badiani et al., 2012).[10] Directed innovation in climate change-exposed crops has reduced climate impacts on US agricultural yields by 20% (Moscona and Sastry, 2022). Adopting these innovations – be they high-yielding seeds or more heat-resistant varieties – will be important for sustainable development.

An open area for research remains whether the innovation in agriculture happening at the global frontier is skewed towards crops found in richer countries (Moscona and Sastry, 2023). There are well-documented market failures in agriculture, from credit to information to land (Jack, 2017). These are especially pertinent for smallholder farmers, and all make them more vulnerable to climate change. While there is evidence that smallholders can overcome some of these challenges of scale (Bassi et al., 2022), in the long-run, as in other sectors, larger agricultural firms will be best placed to drive resilient growth.

Third, the government can use taxes to increase the price of pollution, carbon and methane emissions. These are often referred to as Pigouvian taxes, and are designed with the objective of closing the gap between market prices and the marginal social cost of externalities. A Pigouvian tax that has received considerable attention is the carbon tax. As of 2023, 37 carbon tax schemes exist around the world, covering about 6% of global GHG emissions (Metcalf, 2021; Timilsina, 2022). The rate varies from US$ 1 per tonne to US$ 134 per tonne (Boulez, 2023). The existing evidence shows that carbon taxes have been effective at reducing emissions in the EU, the UK and Canada (Metcalf, 2021). Increasingly, the use of emissions trading schemes has been found to be effective in promoting low-GHG technological adoption and net emissions reductions (Greenstone et al., 2023). Finally, Aghion et al. (2016) show that tax-driven increases in fuel prices boost clean innovation in the automobile sector.

An alternative policy that can be used to internalise the price of an externality such as GHG emissions is a cap-and-trade system, where the government caps the total amount of emissions allowed by a sector or geography, but lets firms trade permits, so that the price of emissions is determined by the market.[11]

10 See Section 2.2 for a more complete discussion on the need for reliability in electricity provision to derive additive benefits of service.

11 See Figure 3 for the global adoption and implementation of both cap-and-trade systems and Pigouvian (carbon) taxes, covering energy and industrial pollutants.

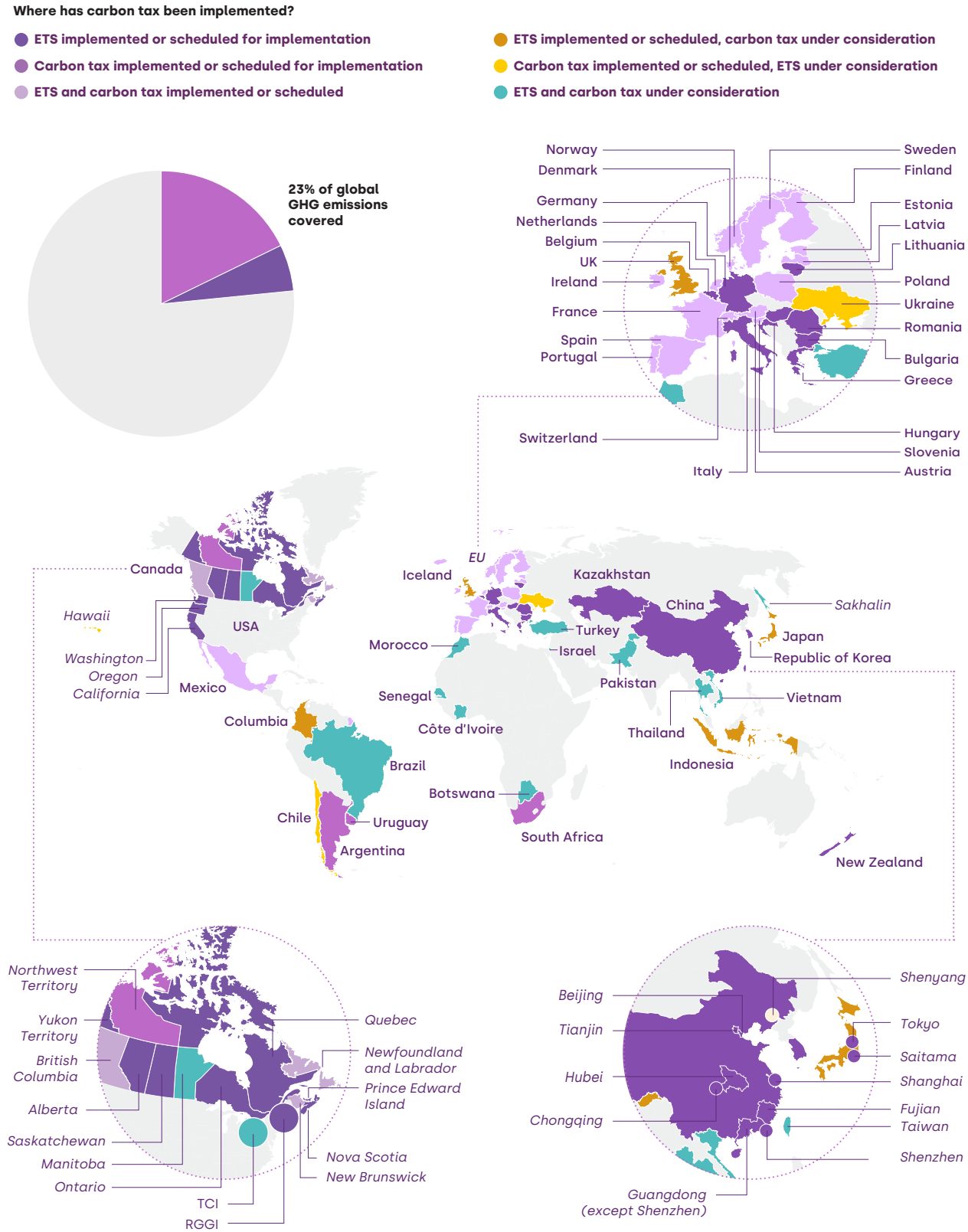
Figure 3 shows the global adoption and implementation of both cap-and-trade systems and Pigouvian (carbon) taxes covering energy and industrial pollutants. Colmer et al. (2020) show that the European cap-and-trade system delivered reductions in CO_2 emissions of the order of 8 to 12%, with no concomitant contraction in output (which they attribute to the fact that in the absence of the policy, firms might have failed to implement cheap emission saving measures). Greenstone et al. (2022) show that an experimental cap-and-trade mechanism for particulate matter pollution in Gujarat, India reduced pollution by 20 to 30%. Cap-and-trade systems are attractive as they do not require governments to commit to a particular price for emissions. However, they are often more complex to set up than Pigouvian taxes and, in the case of carbon, they have not been able to deliver carbon prices anywhere near the estimated social cost of carbon (Metcalf, 2021).

Fourth, the government can regulate externalities, by setting production standards or individual quotas on pollution or emissions. An example of this are fuel efficiency standards in automobiles (Metcalf, 2021) or pollution quotas in India (Duflo et al., 2013). In India, the enforcement of these standards has proven to be challenging, a point we explore in more detail later in this paper. In China, however, command-and-control pollution regulation is credited to have played an important role in the large reduction in air pollution experienced by major cities in the last decade (Zheng and Kahn, 2017).

Furthermore, uniform emission standards tend to be economically inefficient since the cost of emission abatement are often highly heterogeneous across firms, making price-based interventions more desirable. The structural estimates in Greenstone et al. (2022) suggest that the cap-and-trade mechanism decreased the cost of emission abatement by 12% compared to a uniform command-and-control emission standard. Similarly, the structural estimates in Song (2022) reveal a considerable degree of heterogeneity in pollution abatement costs in the highly-polluting cement industry in China, which again suggests that flexible price-based instruments are more efficient than uniform standards.

In the analysis of Acemoglu et al. (2012), the optimal policy to raise living standards in a world with substantial environmental externalities combines two separate tools: research and development (R&D) subsidies to spur green innovation and a tax on the negative environmental externality (for example, a carbon tax). In their model, taxes alone could avoid an environmental catastrophe, but they would do so at an excessive economic cost. R&D subsidies alone would also be sub-optimal due to path dependence in innovation – accumulated knowledge makes further innovation easier – which gives an initial advantage to innovation in the "dirty" sectors of the economy. An interesting extension to the standard directed technical change framework is to consider how these optimal policies change in a dynamic world where there are first-mover advantages (for example, "winning the green race") or a clear end date to an industry is mandated (for example, net zero by 2050).

FIGURE 3: CARBON TAXES AND EMISSION TRADING SCHEMES (ETS) IMPLEMENTED, SCHEDULED, OR UNDER CONSIDERATION (ADAPTED FROM WB, 2023)



Source: World Bank (2021)

A fundamental question is whether Pigouvian taxes will be politically viable in developing countries. There are three distinct problems: (i) these taxes can reduce growth, (ii) they can have negative distributional effects and (iii) in the case of carbon externalities, may be unjust with respect to historical emissions. A more in depth discussion of these challenges occurs in Section 5.5. Here, we conclude by noting that the challenges to taxation highlight the importance of fostering innovation within firms to harness low-emissions production technologies which uses politically-acceptable tools that can reduce the need for taxation.

3.3 Promoting employment through skill creation and efficient matching

Unemployment and underemployment, especially among the urban youth, are first-order problems for policymakers across developing countries. In Africa, only about 30% of adults have regular, salaried jobs (Bandiera et al., 2021b). Unemployment can worsen mental health (McDaid et al., 2008), and evidence suggests that crime rises after mass layoffs of workers (Britto et al., 2022).

Economic growth will not necessarily reduce unemployment. In fact, recent cross-country evidence suggests that unemployment rates tend to rise with development, especially among the least educated workers, possibly due to fact that returns to skills increase when countries become richer (Feng et al., 2018; Rossi, 2022). In turn, the provision of skills is likely to be insufficient due to a combination of worker liquidity constraints

Electric three-wheeler taxis with solar panels on the roof drive in Ivory Coast. Photo by Sia Kambou/AFP via Getty Images.

(Abebe et al., 2020; Bandiera et al., 2021b) and barriers to firm investment in skills (Abebe et al., 2023a; Acemoglu and Pischke, 1998; Becker, 1974), leading to an equilibrium with significant unemployment.

Given that skills are likely to be under-provided, we should expect high returns to well-designed programmes aimed at boosting skills, especially among the youth. Indeed, the most effective interventions show large impacts on employment and earnings (Attanasio et al., 2017; Bandiera et al., 2021b; Bertrand et al., 2021; Kala, 2019; Maitra and Mani, 2017). However, the returns of the average programme are relatively modest (Blattman and Ralston, 2015; McKenzie, 2017), possibly due to the low relevance of the skills taught or the quality of the instruction.

Vocational training programmes are ubiquitous in developing countries, and very expensive. The World Bank estimates that US$ 1 billion per year is spent on these programmes (Blattman and Ralston, 2015). There is a lot of interest in finding ways to make these programmes more financially sustainable. BRAC, for example, currently offers fee-based vocational training schemes to unemployed youth in Bangladesh. These programmes are designed to recover their costs. Similarly, the Addis Ababa School of Commerce offers fee-based management training programmes for workers who want to increase their chances of career progression (Abebe et al., 2021a). These programmes recoup costs, possibly at the risk of excluding the poorest youth in programme communities. Bandiera et al. (2023) explore the potential of income-sharing schemes to achieve both financial sustainability and expand participation of poor individuals in training programmes. Their initial findings show that decreasing the upfront costs of BRAC's training programmes through an income-sharing scheme significantly boosts demand for training.

Strategically, governments may decide to use their involvement in vocational training to promote the creation of green skills – that is, the skills necessary to adopt green innovations such as renewable energy. Currently, we do not have evidence on the extent to which the lack of these skills is a bottleneck for the development of green sectors of the economy, and we flag it as a promising area for future research. To the extent to which a lack of skills keeps individuals in occupations that damage the environment, such programmes may also have positive benefits for the environment.

In addition to skills in sectors that reduce emissions (such as renewable energy), more thought should be given to the role of vocational training and other skills programmes in creating opportunities for adaptation and resilience. As climate change intensifies, there may be a greater mismatch between the supply of human capital entering a local labour market and the demand for it. Left unaddressed, these imbalances could impede the ability for individuals to find suitable opportunities for adaptation.

Finally, an intriguing recent finding in this literature is that the costs that firms have to bear to train their workers are surprisingly high. In Colombia, Caicedo et al. (2022) find that 58% of firms prefer to pay a fine to the government rather than training a worker. Their structural estimates

suggest that training costs amount to between US$ 1,000 and UD$ 2,000 per person. Finding ways to decrease firm training costs is an exciting avenue for future research.

A second area where policy intervention may be beneficial is job search and matching. Labour markets in developing countries display an unusual level of worker turnover (Donovan et al., 2020), which is consistent with the existence of labour market frictions that prevent the formation of productive matches between firms and workers. These frictions could be financial (Abebe et al., 2021a; Caria et al., 2023), related to the observability of worker skills (Abebe et al., 2020; Abel et al., 2020; Bassi and Nansamba, 2021; Carranza et al., 2022), or to worker motivation and biased expectations (Abebe et al., 2020; Abel et al., 2019; Alfonsi et al., 2023; Bandiera et al., 2021b). Recent evidence suggests that firms also face significant search frictions (Abebe et al., 2021b; Hensel et al., 2022; Singh et al., 2023).

In general, the hiring process in developing countries' formal labour markets is poorly understood and this is a promising area for further study. Overall, we need more evidence, particularly through estimates from macroeconomic models, to fully quantify the impacts of search barriers, and of the resulting misallocation of talent on the overall performance of

Workers at a chocolate factory workplace remove husks from cocoa beans in Accra, Ghana. Photo by Cristina Aldehuela/AFP via Getty Images.

the labour market. Search and matching issues are pertinent if we expect large-scale reallocation of labour across occupations and locations due to climate change. The ability of an area or sector to absorb additional labour matters for evaluating the opportunities for local adaptation.

A final important area is that of job quality. The literature has devoted much less attention to this issue, with the notable exception of the study of Boudreau (2022); Corradini et al. (2022); and Tanaka (2020) on the impacts of health and safety committees. In ongoing work, Abebe et al. (2023b) show that an intervention that improves the provision of job loss insurance in Ethiopia boosts expenditure and wellbeing. In principle, formal jobs in upgraded firms are best placed to offer protection against climate change. The extent to which they do so in practice, and the interventions that policymakers can rely on to improve job quality, are promising open areas for future investigation.

3.4 Boosting trade and FDI

Trade and FDI have a central role to play in promoting growth and environmental protection. A core mechanism is through their role in inducing technology spillovers across countries (Atkin et al., 2017, 2021; Helleiner, 1992). These spillovers can boost productivity in developing countries (Abebe et al., 2022; Alfaro-Ureña et al., 2022b). Crucially, they can also be harnessed to diffuse existing low-emissions production technologies (Ahakwa et al., 2023; Bhattacharya et al., 2022; Murshed, 2018; Pörtner et al., 2022; Stern and Stiglitz, 2023) or enforce environmental standards (as Alfaro-Ureña et al. (2022a) suggests).

In a large class of models, trade openness tends to benefit large firms the most, since these firms can best take advantage of export opportunities (Maggi et al., 2022). The expansion of large firms can be beneficial when firms in the economy are inefficiently small due to a number of barriers to firm growth. Larger, more technologically-advanced firms are also likely to be better placed to adopt cleaner production processes that reduce environmental externalities (Macchiavello and Miquel-Florensa, 2019; Saurav et al., 2023). Finally, domestic trade can also be an important force to reduce misallocation and to increase aggregate national productivity (Ramondo et al., 2016).

Intuitively, trade may have a particularly important role in moderating the damages from climate change, as the impacts of climate change are projected to be highly heterogeneous across locations and sectors. The literature has produced a set of nuanced findings on this point, and it remains an active area of investigation. Nath (2022) argues that, due to high trade barriers, the low-income countries that will be most affected by climate change will specialise more in food production, despite the fact that climate change will decrease the productivity of agriculture by more than it will affect the productivity of manufacturing. In the model of Nath (2022), increasing trade openness will result in a major reduction in the cost of climate change in developing countries. On the

other hand, the analysis of Costinot et al. (2016) shows that, while climate change will alter the relative productivity of different crops across space, trade will play an important role in the reallocation of plots to the most productive crops.

In developing countries, the export of agriculture and food products is essential to local economic activity and growth. Agriculture markets are highly globalised, accounting for approximately 35% of global export value, where 40% of this value is derived from low-income and emerging markets (Nenci et al., 2020). But, climate change will have direct consequences on agriculture yields – both positive and negative (Costinot et al., 2016). For developing countries, particularly in Asia and Africa, agriculture productivity is to decline against a baseline scenario (FAOSTAT, 2022).

Even with the ability of producers to change location and trade patterns to adjust, Costinot et al. (2016) find that one-sixth of total agriculture crop value may decrease relative to a business as usual (BAU) scenario by 2100. But, the expansion of global trade networks will play a vital role in dampening the spatial shift of agriculture's comparative advantage towards developed countries (Conte et al., 2021; Nath, 2022). Greater openness to trade reduces the rise of food prices caused by the spatially differentiated impacts of climate change (Nath, 2022). A projected shift in agriculture exports away from low-income countries will require mitigation to stay competitive, through technology and insurance uptake (Kala et al., 2023; Lane, 2023), as well as new investments in a different variety of agriculture productions (Conte, 2022; Costinot et al., 2016), manufacturing or services (Conte et al., 2021). Governments must choose to plan around these new changes.

Trade barriers in developing countries remain considerable. For example, Ethiopia and Nigeria face estimated domestic trade costs that are approximately four to five times larger than in the US (Atkin and Donaldson, 2015). Tariffs constitute an additional major source of trade costs. Recent evidence suggests that tariffs are actually biased in favour of those sectors that produce the largest amount of GHG emissions (Shapiro, 2021).

To promote trade, governments can focus on four central policy areas. First, they need to improve the physical trading infrastructure. This includes roads, railways and ports. For example, road quality improvements in Turkey reduced domestic transport costs by an estimated 70% (Coşar and Demir, 2016). Second, they need to upgrade the infrastructure for custom collection. Djankov et al. (2010) find that each day of delay in clearing customs increases trade costs by as much as increasing trading distance by 70 km. Third, governments need to promote exports. Domestic firms may benefit from support in different areas such as marketing and credit (Atkin et al., 2017). Fourth, they need to reform and lift tariff barriers to trade, including tariff uncertainty (Handley and Limão, 2022).

Low- and middle-income countries will also have to adapt to changes in trade policy implemented in rich economies, in particular through mechanisms such as carbon border adjustments. The EU has recently developed a plan for a regional carbon border adjustment mechanism (CBAM), which would require importers to buy carbon credits to cover the carbon cost of goods procured (Grubb et al., 2022). CBAM aims to reduce the reallocation of production towards countries with lower carbon prices and weaker GHG legislation, as well as to make low-GHG production more attractive in low-income countries. Understanding the full impacts of border carbon adjustment policies in the economies of developing countries is a research area of first order importance.

4 Urbanisation, rural development, and migration[12]

4.1 Introduction

Economic growth runs in tandem with the spatial transformation of the economy. Historically, rural livelihoods were the central focus of development research and policy, since poverty was concentrated in rural areas (de la Roca and Puga, 2017; Johnston and Mellor, 1961). Additionally, a long-standing literature has argued that, in low-income countries, the urban elite captures a large share of the economic rents that are generated in the agricultural and natural resource sectors, thus leaving an inequitably low share of the gains to rural communities (Bates, 2014; Gollin et al., 2016). However, in the context of a rapidly changing climate, rural development can no longer be seen in isolation. The movement of individuals away from climate-shocked areas and towards areas of protection and opportunity, demands a fundamental rethinking of how structural transformation may occur in the future.

Solar panels on the roofs of houses in Dhaka, Bangladesh. Photo by Mamunu Rashid/NurPhoto via Getty Images.

12 Please refer to the IGC Evidence Papers: Cities (Bryan, Glaeser and Tsivanidis, 2021 and 2023) for a fuller treatment of the issues covered in this chapter.

Until recently, urban development has been relatively neglected. Cities, when managed well, can be a major growth lever and present considerable opportunities for sustainable development. However, the extreme density that results from urbanisation, particularly in the poorer cities of low- and middle-income countries, could potentially aggravate existing problems such as traffic congestion, crime, and larger environmental externalities (Kahn, 2009). In these countries, the rapid speed of urbanisation is producing large amounts of emissions – a major issue we have to confront when designing policies to encourage sustainable development (see Box 2). The urban population of Africa is projected to triple by 2050 and that of Asia to grow by 61% (Secretary-General, 2018). This means an additional 950 million new people living in cities in Africa and 1.2 billion in Asia (Sahel and Club, 2020; UN-Habitat, 2023). By 2050 these two continents will account for 70% of the world's urban population (UNDESA, 2018). Climate change is partly responsible for these trends: dry conditions drive urbanisation in African cities with manufacturing centres (Henderson et al., 2017).

These developments give critical importance to urban climate policies. How policy can harness the opportunities cities provide for climate change mitigation and adaptation has received little attention in the literature, particularly in the context of developing countries. The high population density in cities often also offers opportunities to provide key public goods and services, such as health, waste disposal and education, more consistently or at a higher quality (Glaeser and Kahn, 2010; Gollin et al., 2021). These public goods alongside the higher living standards of city life provide significant protection against environmental externalities (Delbridge et al., 2022). For example, on average, heatwaves are considerably less deadly in cities compared to rural areas (Burgess et al., 2017). Why this is the case, and whether it holds across the income distribution, is an area for research.

Much of the recent literature on urbanisation has focused on explaining the fact that productivity and wages are substantially higher in cities than in rural areas (Chauvin et al., 2017; Gollin et al., 2014; Young, 2013). These differences could be driven by an urban productivity premium, agglomeration externalities, or the fact that more productive workers are more likely to move to cities. Importantly, under the first two explanations, the growth of cities provides an opportunity to raise overall productivity, generate economic growth, and hence facilitate climate change adaptation. Under the third explanation, rural-urban differentials are only driven by worker selection, and hence urbanisation would not generate any growth dividends (Bryan et al., 2020, 2021). Empirically, while there is evidence that worker selection accounts for some of the observed differentials (Young, 2013), recent studies suggest that there are meaningful productivity gains from decreasing barriers to permanent migration and fostering the growth of cities (Bryan and Morten, 2019). Importantly, these gains may grow in future years if climate change increases the urban productivity premium (Alvarez and Rossi-Hansberg, 2021).

However, the combination of climate change and rapid growth of urban populations also poses policy challenges. By 2050, 800 million people are projected to live in coastal cities at risk of flooding and storm surges and the number of cities exposed to extreme heat will almost triple to 970 (Cities, 2018). Both threats particularly affect cities in developing countries, such as India (Cities, 2018). We need much more research on how climate policy can both reduce urban climate risks and harness the agglomeration effects of cities to achieve sustainable growth.

The renewed attention to the development of cities should not justify a neglect of rural areas. The persistence of rural poverty and the vulnerability of rural populations to environmental externalities are major policy problems that a sustainable development agenda must grapple with. We will discuss a set of policies to foster rural development. These should be seen as complements, rather than substitutes, to urban development policies.

4.2 Investment in city infrastructure and services

At least four key areas of investment in cities deserve policymakers' attention. First is transportation infrastructure. Cities in low- and middle-income countries often suffer from heavy traffic and congestion (Akbar et al., 2023). Intuitively, congestion reduces the urban productivity premium and the size of agglomeration externalities. Congestion can be reduced by changing prices (Kreindler, 2023), or by directly restricting traffic – for example, through the use of vehicle-occupancy restrictions (Hanna et al., 2017). These policies have been shown to create positive, but sometimes modest gains.

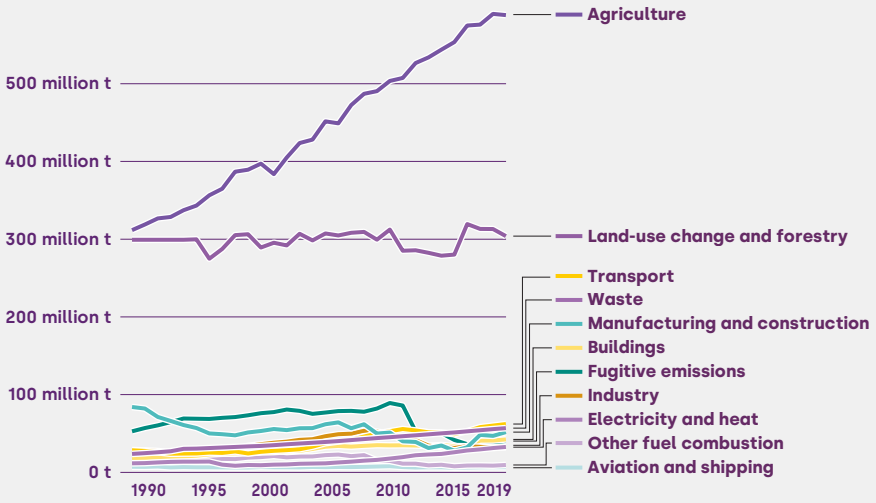
Often, a combination of both behavioural incentives and infrastructure can best reduce congestion and other externalities that arise from density. In areas with existing congestion, the gains to new road infrastructure are highly variable (Allen and Arkolakis, 2022). Therefore, the government can build transport higher efficiency infrastructure such as Bus Rapid Transit (BRT) systems, or light rail systems. These system-wide improvements of the transportation network could reap considerable benefits. For example, Tsivanidis (2022) finds that Bogota's BRT system raised GDP per capita by up to 4% and was responsible for almost a third of the population growth experienced in the city between 2000 and 2016.

Finally, the transportation sector produces substantial environmental externalities – both GHG emissions and local air pollution. Policies that limit congestion have the potential to improve air quality. Investing early on in the infrastructure required to electrify transport may provide large future gains. Measuring the benefits of public infrastructure is an area that still requires more research, both in terms of understanding where returns are the greatest and the political economy constraints that urban policymakers face.

BOX 2: EMISSIONS BY SOURCE IN LOW- AND MIDDLE-INCOME COUNTRIES

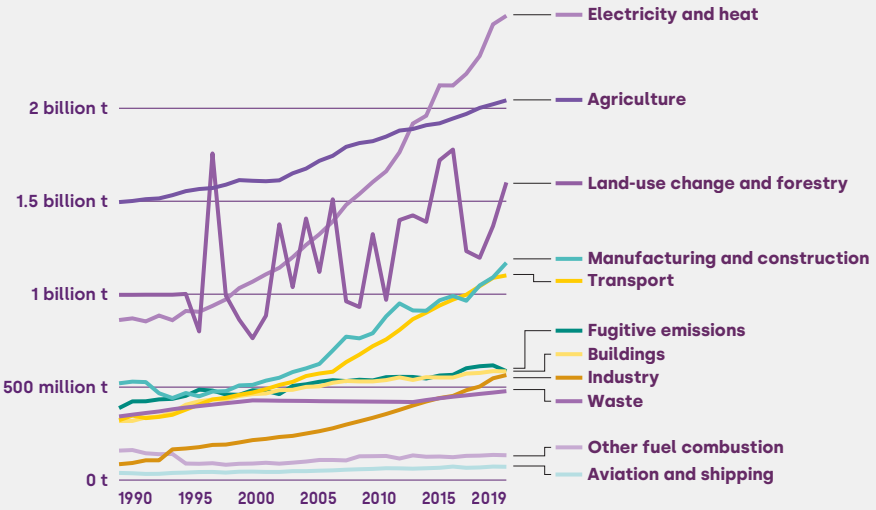
Low-income countries primarily generate emissions in the agriculture and land use sectors. As countries move along the arc of development, the emissions from lower-middle-income countries rapidly increase in electricity, heat, manufacturing and transportation (Ritchie et al., 2020). This change in the sectoral composition of emissions is also mirrored across geographies. Industrial emissions from manufacturing and construction and as well as pollutants from transportation and electricity production will concentrate more heavily in urban areas. This new growth in emissions, even if tied more loosely to development, will materialise as urban pollution, dampening potential gains from agglomeration.

PANEL A: LOW-INCOME EMISSIONS



Adapted from source: Our World in Data based on Climate Analysis Indicators Tool (CAIT). OurWorldInData.org/co2-and-greenhouse-gas-emissions CC BY.

PANEL B: LOWER MIDDLE-INCOME EMISSIONS



Adapted from source: Our World in Data based on Climate Analysis Indicators Tool (CAIT). OurWorldInData.org/co2-and-greenhouse-gas-emissions CC BY.

Transportation, industry and waste burning can make city skylines smoggy and local water sources anaerobic. Pollutants, both GHG emissions and particulate matter (PM2.5, PM2.10), have severe consequences for those living in proximity to the sources. Much is known on the damages these pollutants cause to local populations. PM2.5 greatly increase the risk of cardiovascular disease (Ebenstein et al., 2017), increasing mortality (EPIC, 2021). Air pollution lowers average life expectancy across the world by an astonishing 2.2 years (EPIC, 2021). More than half a billion people in India would live 8.5 years longer on average if the air they breathed was cleaner (EPIC, 2021).

Air and water regulation in developing countries is often insufficient to prevent the welfare impact of air pollution, especially when enforcement is weak. Greenstone and Hanna (2014) finds evidence that environmental regulation on air quality in India has a modest impact on reducing infant mortality, but no impact on water quality. Cement emissions in industrial processes have also steadily increased in India and Africa (as discussed in Section 3). Today, India is second only to China in emissions resulting from cement production. It is responsible for 8% of global emissions in this sector (Friedlingstein et al., 2022). As countries continue to develop, these emissions are likely to continue to rise and concentrate themselves in the same areas where people work, live and attend school. Therefore, further research is required to understand the emissions intensity of service provision in developing cities, and the effectiveness of policies to reduce quick and concentrated growth of emissions in urban areas.

Housing is the second key area. Cities in low- and middle-income countries often have slums – dense settlements with high levels of informality, low housing quality and poor service provision. Unhealthy living conditions and limited investment may trap individuals in these informal settlements, creating a poverty trap (Marx et al., 2013). Individuals living in low-quality informal housing are also likely to be particularly vulnerable to environmental externalities due to the lower quality of the building materials and the difficulty of insuring informal assets. Moreover, the mitigation gains from urbanisation – for example, those related to the use of clean sources of energy – may not materialise in informal settlements due to limited access to electricity and waste management systems.

A large literature studies how policy can improve housing quality in low- and middle-income countries' cities. Recent evidence shows that early public investment can improve later settlement quality (Rauch et al., 2017). Property rights reform also has the potential to boost investment in housing quality, but the evidence on land titling programmes designed to strengthen slum residents' property rights is mixed (Marx et al., 2013). Building public housing is a (costly) policy alternative. While this can generate clear gains in housing quality, recent evidence shows that it may not unlock additional economic returns for target households if relocation disrupts social networks, which are essential for business and employment (Barnhardt et al., 2017). Further, policies designed to promote the development of rental markets in affordable, non-slum locations are

understudied, and there is mixed evidence on whether the supply elasticity in these markets is sufficient to accommodate large inflows of new residents without major rental price hikes (Abebe et al., 2019; Rozo and Sviatschi, 2021).

The third area is the utilities sector. There are likely to be major health gains from connecting households to the public water supply and reducing outages (Ashraf et al., 2017), from improving sanitation (Augsburg and Rodríguez-Lesmes, 2015) and from strengthening waste management systems (Strunz et al., 2014). These health gains will in turn generate clear economic dividends (Hamory et al., 2020). Communication infrastructure may also be critical to contribute to an efficient functioning of markets and to promote private enterprise (Hjort and Poulsen, 2019; Jensen, 2007). Finally, in cities, the state may be able to provide high-quality public education and health services at low unit costs, given the geographical proximity of the population to be served. However, municipal finance is central to any effort aimed at improving urban quality of life – a city with weak public finance capabilities may find it difficult to raise taxes and subsequently provide better public services. It is a valuable area of research to investigate what taxes, even simple land value taxes, may be easier to collect in low-capacity environments.

Municipal finance is central to improving urban quality of life. A city with weak public finance capabilities may find it difficult to raise taxes and subsequently provide better public services.

Finally, the fourth area is adaptation infrastructure. Large infrastructure investments made in urban areas will have direct implications for future mitigation and adaptation (Delbridge et al., 2022). As such, built environment decisions in cities need further economic investigation. We will focus on flooding defences as a particularly striking example. We flag that other important investments include green spaces to prevent the urban heat island effect, infrastructure to provide shade and protection from rainfall, cooling centres, and emergency roads for quick departure during hazard events.

Flooding is a major problem in several cities in low- and middle-income countries. For example, Jakarta, a mega-city of about 32 million people, faces frequent flooding causing an estimated US$ 300 million in damages every year (Hsiao, 2023b). In response, the government of Indonesia plans to build flood defences worth US$ 40 billion. However, this measure risks encouraging further development in flood affected areas, which will offset a large portion of the gains of the policy (Hsiao, 2023b). Indeed, Kocornik-Mina et al. (2020) find that low-elevation urban areas at high risk of flooding concentrate more activity per square kilometre than safer higher-elevation areas. Finding and documenting ways to provide protection whilst minimising moral hazard is a high priority area for future research on sustainable urbanisation.

4.3 Investment in rural infrastructure and services

Investment in rural regions is also likely to have high returns. There are at least four key policy areas that deserve attention. The first area is transportation. As of 2016, nearly one billion people lived more than 2km away from a paved road (Roberts et al., 2006). In low-income countries, access to railways is even more limited (Donaldson, 2018). The limited development of these road and railway networks generates high transportation costs, which in turn affects people's ability to trade. Atkin and Donaldson (2015) estimate that the impacts of distance on trade costs are four to five times larger in Ethiopia and Nigeria than in the US. Additionally, the absence of adequate transportation infrastructure negatively impacts employment and investment. Asher and Novosad (2020) find that the construction of rural roads in India led to a large increase in wage-employment in rural areas. Most of the effect is due to the roads enabling individuals to take up jobs in nearby cities.

Further, Donovan and Brooks (2017) show that, in Nicaragua, rural bridges enable rural residents to leave their village during seasonal floods, reduce floods' impacts on labour income, and foster greater participation in labour markets as well as higher agricultural investment. This demonstrates how transportation infrastructure may increase resilience to climate shocks through several channels. It can boost incomes prior to the shock, and guarantee mobility during a shock, thereby limiting disruption to economic activity.

Jenepher Wanjala at her farm in Kitale, Kenya. In order for farmers to adopt technologies and practices to adapt to a changing climate, rural education and increased access to weather and climate information are necessary.Photo by Jeffery M Walcott/IWMI.

Second, policymakers need to boost electrification. There are likely to be considerable gains from expanding access to electricity in rural areas, in terms of both employment and welfare (Allcott, 2018; Dinkelman, 2011; Lipscomb et al., 2013), especially when electrification happens alongside the expansion of transport infrastructure (Moneke, 2023; Walter, 2021). We provide a more detailed discussion of the challenges of electrification in Section 2, including its importance for adaptation for poor households in rural areas (Kahn, 2016).

Third, agriculture deserves specific attention (see Box 3). Labourers in rural areas who do not own any assets are amongst the poorest people. Recent evidence suggests that these individuals are stuck in a poverty trap: without a significant transfer from the state, they will not be able to lift themselves out of poverty (Balboni et al., 2022; Banerjee et al., 2015). This persistence of rural poverty is thus deeply inequitable and inefficiently reduces the size of the rural economy (Bandiera et al., 2022). Additionally, risk remains a key constraint that prevents investment and growth in agriculture.

Several studies concur that insurance unlocks farming investment that was discouraged by uncertainty. Evidence from Karlan et al. (2014) find that offering insurance significantly increase expenditure on farming, especially for low-expenditure firms in Ghana. It moves the 25th percentile of the expenditure distribution from US$ 875 to US$ 1,145. In Bangladesh, Lane (2023) find that an innovative product that offers a loan in the event of a flood also substantially increases ex-ante investments. These treatment effects are in line with the structural estimates of Donovan (2020), which suggests that agricultural risk substantially reduces the use of intermediate inputs in low-income countries.

Finally, inefficient land markets plausibly contribute to a sub-optimal performance of the agricultural sector. In Kenya, land rental subsidies raised output and value-added on rented plots, pointing to the presence of frictions in land rental markets (Casaburi and Willis, 2018). Recent evidence from Kenya and Uganda suggests that market design interventions can partially correct some of these frictions (Bryan et al., 2017).

The agriculture sector still provides a livelihood for many individuals in developing countries. In India, 42% of the labour force work in agriculture, as well as 70% in Mozambique and 50% in Zambia (Roser, 2023). Adaptation in this sector deserves particular attention (Kala et al., 2023). Interventions to help farmers who remain in agriculture often have low uptake (Gorst et al., 2018), even if the technology significantly mitigates losses to crop yields under heat and temperature stress. In order for farmers to adopt technologies and practices to adapt to a changing climate, rural education and increased access to weather and climate information are necessary (Auffhammer and Kahn, 2018). Even with productivity improving technology and the ability to plan further ahead, farmers may still migrate. We discuss this in more detail in Section 4.4. For example, water scarcity causes farmers to lose their income and wealth, migrating to new jobs in areas with a more developed manufacturing sector (Blakeslee et al. 2020).

In India,

42%

of the labour force work in agriculture, as well as 70% in Mozambique and 50% in Zambia.

Agriculture is also a major source of environmental externalities. These include: GHG emissions, deforestation and biodiversity loss, and other forms of local pollution. New technologies have the potential to reduce vulnerability to these externalities (Dar et al., 2013) as well as the magnitude of the externalities. These technologies include high-yield fertiliser responsive crops (Wright, 2012) and methane-reducing feed for livestock (CDRF, 2022). Other interventions leverage the environmental services of nature to reduce the reliance on externality-causing fertilisers. For example, silvopasture is the integration of trees on grazing land, and reduces the cost of buying feed for livestock while providing natural shade and nutrients for the soil. Other forms of nature-based solutions in agriculture, such as intercropping, reducing tillage of plants and increased tree cover on farms also directly mitigates land-use emissions from monocropping in agriculture. Finally, agricultural intensification will help reduce pressure on land – furthering the rational for technology uptake in the sector. The world needs farmers. Formalising the market for insurance and land, providing the tools necessary to adapt, and working to lower future emissions intensity is necessary to protect rural livelihoods.

Our final point is on land conservation as the fourth key domain. Rural areas host the majority of natural assets. Conservation can be an important source of revenue for rural communities. First, rural communities can benefit from substantial payments to implement nature-based solutions – investment to improve ecosystem performance with the aim of reducing or removing environmental externalities, such as CO_2 emissions (Mercer, 2022). For example, a recent intervention in Uganda paid private forest owners on the basis of the forest area that was present on their land, decreasing deforestation and improving the ecosystem's ability to sequester CO_2 (Jayachandran, 2022). Second, natural assets can be substantial drivers of tourism. Recent evidence suggests that the development of the tourism industry can catalyse the growth of other sectors such as manufacturing (although this may also reduce growth in areas that do not attract tourists) (Faber and Gaubert, 2019). In Section 2.3, we discuss conservation interventions and nature-based solutions in greater detail.

BOX 3: AGRICULTURE, FORESTRY, AND LAND USE SECTOR EMISSIONS

Deforestation, water pollution and biodiversity loss (Dasgupta, 2021; Frank and Sudarshan, 2023) are barriers to sustainable development. As seen earlier in Ritchie et al. (2020), deforestation and agriculture production constitute the largest share of current emissions from developing countries. In 2020, approximately 10% of tropical forest areas were classified as degraded (Vancutsem et al., 2021). Solutions to reducing deforestation while maintaining agriculture productivity – essential to developing countries – are greatly needed.

Some ecosystems are extremely relevant for emissions reductions, particularly large carbon sinks like peatlands (Barbier and Burgess, 2021; Dargie et al., 2017; Martin-Ortega et al., 2014). Protection of these areas is particularly nascent to developing countries. There is both high demand and low labour cost to establishing projects to restore or protect carbon sinks in developing countries. However, the opportunity cost of conservation is not timber extraction, but conversion to high profit agriculture, such as livestock farming, as seen in the case of Brazil (Balboni et al., 2023a). New evidence indicates that ecosystem restoration or conservation can be done in developing countries, where cheap land and labour minimise the costs of these projects across global mitigation interventions (Glennerster and Jayachandran, 2023).

In this new study, Glennerster and Jayachandran (2023) argue agriculture land in Malawi and Ethiopia is four times less expensive than land in the UK, making the cost of reforestation or preservation significantly lower in developing countries. Allocating large carbon sink projects in developing countries could create efficiencies in mitigating climate externalities, but require taking into account general equilibrium effects which may reallocate more productive uses away from local areas or disrupt global trade balances (Souza-Rodrigues, 2019). For example, Andam et al. (2010) find that in Costa Rica and Thailand, communities living near protected areas have below average incomes to start with – but the protection of these forests do reduce poverty outcomes in the long run.

Defining what interventions can provide benefits along the axioms of climate mitigation, adaptation and poverty alleviation within sustainable agriculture is on-going. This is an urgent issue – peatlands are responsible for an estimated 30% of agriculture emissions and yet when converted to agriculture, contribute a low amount of caloric output (Freeman et al., 2022). The trade-off in productive and adaptive interventions in agriculture is subtle, and deserves more investigation (Millner and Dietz, 2015b). A variety of interventions including PES, discussed in Jack and Jayachandran (2019); Jayachandran et al. (2017); Pattanayak et al. (2010); Reed et al. (2017), as well as silvopasture, low-tillage practices and agroforestry requires more investigation by researchers. Understanding both the short- and long-run benefits of these interventions on productivity and environmental outcomes is needed. The agriculture sector, given complementary investments in nature, may make substantial gains in productivity without perpetuating the damages to nature.

4.4 Migration

A third key area of intervention is migration. In 2020, there were an estimated 281 million international migrants in the world (about 1 in 30 people on the planet was an international migrant) (Migration, 2021). Additionally, large numbers of people migrate within their country, either to large urban centres or secondary cities (Christiaensen et al., 2021). For example, in India an estimated 37% of the total population migrates internally (De, 2023).

Individuals often migrate to pursue economic opportunity and to protect themselves against environmental externalities. Yet, despite these large flows, major differences in wages and productivity persist across and within countries. As explained in the introduction, one possible explanation is the existence of migration barriers that discourage people from moving. These barriers include a lack of information on job opportunities in other locations, the risk associated with the migration, its monetary costs and the need to finance them, and the psychological and social factors that may make it hard for people to settle in a different environment (Bryan et al., 2014; Diop, 2023).

When these barriers are large, they can prevent people from making the most of their talent, with major aggregate consequences for the economy. For example, in Indonesia, removing these barriers would lead to an estimated 22% increase in labour productivity.

In the coming years, climate change is expected to have major impacts on migration flows and on the returns to migration (Adger et al., 2015; Bilal and Rossi-Hansberg, 2023). The impacts of global warming are highly heterogeneous across space. Countries in different parts of the world will experience impacts of varying intensity. Even within countries, impacts will differ substantially across geographic regions (Byers et al., 2018). Furthermore, urban areas, as discussed above, are likely to offer greater protection against climate shocks.

The World Bank estimates that there will be about 260 million people who will move within their countries due to climate change by 2050 (Clement et al., 2021). 86 million of these will be in sub-Saharan Africa (though estimates for this region differ: Conte (2022) estimates that there will be four million migrants in Sub-Saharan Africa by 2100).

Two points are worth emphasising with respect to climate migration. First, it is likely that this migration will generate a major reduction in the economic and social cost of climate change. This is because it will enable some of the worst-affected individuals to find shelter in less-affected localities, thus, limiting losses in productivity and amenities. Alvarez and Rossi-Hansberg (2021) incorporate the shocks induced by climate change in a dynamic model of the global economy, and find that a 25% decrease in migration costs will reduce the welfare losses from climate change by about one third. Technology improvement has an intermediate effect

(which partly runs through migration), and trade has a more modest role to play. Overall, their results imply that the promotion of migration should be seen as a promising strategy for climate change adaptation.

Second, accommodating large flows of climate migrants will generate a set of policy challenges. The literature on the local labour market effects of large migration flows has failed to find systematic evidence of negative impacts. Results are generally mixed. Several studies that have analysed large inflows of refugees into Jordan, Turkey and Colombia failed to document substantial negative impacts on local workers (Altındağ et al., 2020; Fallah et al., 2019; Rozo and Sviatschi, 2021). However, Kleemans and Magruder (2018) find negative local employment impacts in Indonesia. In general, animosity against migrants has emerged in several settings. Migrants from Mozambique self-report discrimination in South Africa, consistent with the literature on social strife and the perception of resource scarcity by indigenous groups (Moagi et al., 2018). Identifying policies to foster the social integration of immigrants and displaced people in host communities remains an important open avenue for future research.

5 Effective states[13]

5.1 Introduction

Climate change and environmental degradation are headwinds against economic growth. Facing these headwinds requires innovations by states along various dimensions. Climate change will, in the short-run, increase the incidence of shocks, and in the long-run change the future conditions of the environment and economy, through rise in global temperature. The state is responsible for protecting citizens against these new environmental risks. It also plays a large part in the investments needed to decarbonise the economy.

Innovation in regulations and taxes to address environmental degradation were examined in Sections 2.3, 3.2, and 4.2. The regulatory environment needs to focus on supporting the development and diffusion of innovations. Because developing countries are, in general, hotter, more agriculturally dependent, have fewer resources and less resilient existing infrastructure, the state has a major role to play in building the resilience necessary for sustainable growth. Lastly, as argued in Sections 2, 3, and 4, innovation in energy and transportation infrastructure has opened up pathways towards decarbonisation in low- and middle-income countries.

States will need to overcome various political gridlocks to enact adaptation and mitigation polices. In particular, to the extent that there are trade-offs between adaptation and resilience on the one hand, and pursuing traditional development objectives on the other, politicians will need to engage and understand constituents whose first priority may be neither climate mitigation or adaptation. In this chapter we focus on how governance and accountability can be improved, how the state can be (re)organised, how additional revenue can be raised, and how international cooperation needs to be designed to implement effective climate policies.

In short, the focus of this section is how the functioning and organisation of the state needs to change in order to achieve sustainable growth. We emphasise specific and actionable new challenges that a rapidly-changing climate presents for the already very challenging task of making states both effective and accountable.

13 Please refer to the IGC Evidence Paper: State Effectiveness (Bandiera, Callen, Casey, La Ferrara, Landais and Teachout, 2021a) and the IGC Evidence Paper: State Effectiveness (forthcoming, 2023) for a fuller treatment of the issues covered in this chapter.

5.2 Governance and accountability

The fundamental purpose of accountability and good governance is ensuring that citizens' preferences are represented in government policy. This is crucial to ensure both the quality and the political feasibility of climate policies. Since fragile states will be most affected by climate damages and least able to deal with their impacts, this concern is particularly pertinent for them. However, fragile polities often do not fulfil the primary functions of states: establishing a monopoly on power and generating legitimacy among their citizens. Coups, clashes, and conflicts are common in developing countries and there is growing evidence that state fragility is exacerbated by climate change and other environmental damages (Peters et al., 2020; Sharifi et al., 2021).

A recent meta-analysis suggests that a one standard deviation increase in temperature causes a 11.3% increase in contemporaneous inter-group conflict (Burke et al., 2015a). Income shocks are one mechanism through which climate affects conflict. For labour-intensive commodities, like smallholder agriculture, spells of bad weather translate into poor yields. Miguel et al. (2004) find evidence that ensuing lower growth increases conflict in African countries. Related income shocks have also raised violence in Colombia (Dube and Vargas, 2013).

The costs of conflict extend well beyond the loss of life. They are often so large that they can throw development into reverse (Collier et al., 2018). Furthermore, climate change may lead to unplanned and large scale displacements of human populations which, in turn, can lead to conditions of fragility (Clement et al., 2021; Kleemans and Magruder, 2018). These shocks can also generate economic strain and exacerbate social cleavages. Greed and grievances, in turn, can result in the rise of anti-state groups (Berman et al., 2011; Blattman and Miguel, 2010).

Given growing concern over environmental devastation, environmental protection should be firmly in the mainstream of economic policy, especially since citizens in developing countries will be most affected.

State legitimacy emanates from adhering to the social contract with society. States must satisfy the principal needs of individuals to be safe, as well as socially and economically fulfilled. For many developing countries, demonstrable increases in standards of living are key for economic fulfilment. Indeed, legitimacy, economic fulfilment, and good governance are linked through a positive feedback loop. Spending funds on public goods, as opposed to distributing rents, can boost civic culture and tax payments, which in turn augments the provision of public goods (Besley, 2020). However, growth at all costs does not translate into legitimacy. Instead, states need to align environmental policy with citizens' preferences. The state's response to climate damages can

create legitimacy (Cohen and Werker, 2008; Neumayer and Barthel, 2014). Given growing concern over environmental devastation, environmental protection needs to be firmly in the mainstream of economic policy, especially since citizens in poorer countries will be most affected (Stern et al., 2022). For the most polluted cities and countries, aggressively tackling pollution may be one of the quickest ways to deliver legitimacy in the short-term (Greenstone et al., 2021a). Evidence that politicians clamp down on illegal forest fires during election years suggests that environmental damages matter to voters (Balboni et al., 2021).

Besides mitigation, effective adaptation and disaster relief will augment legitimacy in the climate crisis. Storms, droughts, and floods are all anticipated by-products of climate change. States which demonstrate responsiveness during times of crisis are rewarded (Besley and Burgess, 2002). Government accountability and responsiveness, in turn, depend on the availability of reliable information about the political process and politicians' performance (Pande, 2011).

Legitimacy further rests on talented and effective bureaucrats. If the functions of government are allocated by means of corruption or patronage, state effectiveness suffers (Xu, 2018). We discuss how the government can attract and adequately incentivise qualified workers in Section 5.3. Overall, more research is needed on how ambitious climate adaptation and mitigation policy can enhance government legitimacy.

Climate shocks are perceptibly increasing across developing countries. To deal with these challenges, climate action must be a political winner. This is not a given in states already facing substantial governance and growth challenges, and where the basic science of climate change, and the rapidity with which new shocks materialise are not fully understood by citizens and voters. International actors and domestic politicians therefore have a key role to play in both assessing and communicating the new risks.

The discussion above provides a few examples of how climate action can yield political dividends for state actors. In addition, because the shocks and challenges created by a changing climate create new policy complexities, there is a need for politicians to understand how the instruments available to them can help to address shocks and deliver sustainable growth. This paper and the supporting state effectiveness evidence paper is meant to provide a road map.

5.3 Organisation of the state

Effective and equitable implementation of government policy is essential for sustainable growth. Here, the manner in which the state is organised is paramount. The new and complex challenges posed by global warming will require institutional innovations. As exemplified by the floods in

A woman carrying a child walks near a flooded area at the 12 de Octubre elementary school in Beira, Mozambique. Photo by ALFREDO ZUNIGA/AFP via Getty Images.

Pakistan in 2022, extreme weather shocks may occur more frequently, with more intensity and in areas not previously exposed to shocks (Pörtner et al., 2022).

The state needs effective early warning systems to protect households, industry and agriculture. Disaster preparedness plans and tools are also essential to lower the extraordinarily high costs of high-impact climate events, such as cyclones, hurricanes, monsoons or floods. Moreover, a range of interventions from the choice of building materials to zoning requirements can strongly reduce damage and loss of life. Taking appropriate precautions will require a high degree of coordination across government departments, with the private sector, and the international community. Institutional innovations, such as climate change or heatwave commissions can aid in these efforts.

Thus, the effective organisation of bureaucracies requires urgent attention. While central for development, bureaucratic effectiveness is highly heterogeneous across countries (Besley et al., 2022). A range of factors, such as career concerns, financial incentives and mission orientation influence how well bureaucracies implement policy (Besley et al., 2022). Here, we highlight two of these: human and management capital.

Human capital in bureaucrats encompasses skill, personality and motivation. Recent evidence shows that monetary and career benefits help to attract all of these qualities in public sector workers (Ashraf et al., 2020; Dal Bó et al., 2013). Once hired, an ample economic literature sheds light on how to best monitor and incentivise civil servants. Successful mechanisms include career incentives (Bertrand et al., 2020),

performance-based pay (Khan et al., 2016), performance-based postings (Khan et al., 2019), as well as enhancing employer recognition and visibility (Ashraf et al., 2014). The bulk of this research focuses on performance in the health, education, and taxation sectors. We urgently need further insights into how we can make bureaucrats more effective in confronting the climate crisis.

Well-designed institutions are particularly important to constrain externalities from industrial processes, deforestation, and land use change. Low- and middle-income countries typically see a divergence between *de jure* regulation and *de facto* outcomes. The emerging literature on environmental regulation in developing countries attributes this gap to failures of implementation which are, in turn, rooted in political constraints (Balboni et al., 2021; Burgess et al., 2012; Duflo et al., 2018; Lipscomb and Mobarak, 2017). In the current equilibrium, small numbers of politically powerful firms benefit from flouting environmental regulations. The ensuing benefits are often small relative to the social cost of pollution (Balboni et al., 2023a). Therefore, designing institutions and identifying politically feasible policies conducive to curbing environmental degradation is of the utmost importance. While the literature on political selection (Dal Bó and Finan, 2018) and on the hiring and incentivisation of bureaucrats (discussed above) are promising starting points, more evidence is needed.

A final critically important area of research regarding state organisation is how to coordinate across tiers of the government to address the challenges of a changing climate. A vast political economy literature (Bardhan, 2002; Faguet and Pal, eds, 2023) discusses the trade-offs involved in tasking different tiers of government with policy action. Climate disasters, such as floods, landslides, and droughts, can affect many jurisdictions or even countries simultaneously. Federal coordination is therefore critical. At the same time, these same disasters often have highly localised consequences and require localised solutions, creating a role for local governments.

Three particular examples stand out. Preventing flooding in the plains of South Asia requires effective water management in the mountains that feed the flood plain; early warning flood systems require upstream communities to inform downstream communities; and reforming natural disaster (flooding) insurance markets (Wagner, 2022).

Similar issues also affect the adoption of green technologies for renewable electricity generation. Countries or sub-national units with substantial renewable generation capacity will want to sell their power to areas with less renewable capacity. The state has a fundamental role to play in making these markets work, given that renewable energy is inherently cyclical.

5.4 Rethinking social protection

Social protection is the key tool used by governments to combat poverty and protect individuals against shocks, and there is a large body of evidence documenting its benefits. Programmes such as cash transfers, ultra-poor-graduation and work-guarantees have been shown to boost consumption, psychological wellbeing, and productivity among the poor (Balboni et al., 2022; Bandiera et al., 2017; Banerjee et al., 2021, 2015; Bertrand et al., 2021; Haushofer and Shapiro, 2016; Imbert and Papp, 2015). Furthermore, social insurance interventions – protecting individuals against agricultural output loss or job displacement – can help smooth consumption in the face of shocks (Gerard and Naritomi, 2021; Karlan et al., 2014). These programmes have been expanding in recent years – today they cover an estimated 2.5 billion people worldwide (Banerjee et al., 2022). In lower-middle-income countries, 46% of the population receives some form of social assistance. However, coverage remains limited in low-income countries, where only 15% of the population receive social protection (UN Statistics Division, 2020; Parekh and Bandiera, 2020). The difference between rich and poor countries in the share of GDP devoted to social protection is also large; 15% on average among the top quintile of countries as compared to around 3% for the bottom quintile. (Loshkin, et al., 2022).

A key challenge will be to develop social protection interventions that complement rather than substitute individual and community efforts to adapt to climate change and that work to enhance productivity.

Environmental externalities, most importantly climate hazards, make the expansion of social protection in low-income countries more urgent. Agricultural, health and job loss risks are all likely to become more pronounced due to climate change, and programmes that offer protection against those risks will thus become even more important (Lane, 2023; Narayan et al., 2023; Surminski, 2014). Additionally, climate change is likely to persistently slow down progress towards poverty elimination (Hallegatte, 2016). In the face of these challenges, an expanded social assistance system will be essential. Some promising evidence comes from a recent study in Nicaragua (Macours et al., 2012), which shows that augmenting a conditional cash transfer with either a business loan or a vocational training product enabled target households to diversify their income streams and to become more resilient to climate shocks. We need more evidence on the relative effectiveness of different programmes in reducing vulnerability to environmental externalities.

Climate change also calls for innovation of the design of social protection programmes. The key challenge will be to develop interventions that complement rather than substitute individual and community efforts to adapt to climate change and that work to enhance productivity.

For example, social protection programmes with non-portable benefits implicitly incentivise individuals to remain in areas affected by climate shocks.

Improving portability will unlock further benefits by allowing individuals to use social protection to fund migration towards less vulnerable areas (Gazeaud et al., 2023; Narayan et al., 2023). Additionally, it may be useful to design programmes that are conditional on certain behaviours that generate long-term adaptation gains (in the same way that conditional cash transfers have been used to promote human capital accumulation). Finally, the timing of assistance may be crucial: support ahead of a predicted shock may enable households to engage in a host of adaptive responses that would not be possible if support was only given after the shock (Lane, 2023; Pople, 2022).

Finally, additional research is needed on how climate change affects the main programme design issues that the social protection literature has explored so far. First, the literature has provided evidence on the effectiveness of specific targeting mechanisms such as proxy means testing, community targeting and self-selection methods (Alatas, 2011; Alatas et al., 2012, 2016b; Blattman and Ralston, 2015; Premand and Schnitzer, 2020). It will be important to understand whether these methods succeed in identifying those individuals that are most vulnerable to climate shocks.

Second, the literature has discussed extensively whether assistance is best delivered in cash or in kind. Cash has higher fungibility, but may generate inflation in communities not well integrated with outside markets (Cunha et al., 2019) and may expose households to considerable consumption risk determined by price volatility (Gadenne et al., 2022) – a point that will become more salient in the future due to climate change. Whether this affects the ultimate balance of costs of benefits of the different support modalities is currently not clear.

Finally, the literature has emphasised the importance of general equilibrium effects (for example, Egger et al. (2019); Imbert and Papp (2015); Muralidharan et al. (2017)) and climate hazards, which may have major negative equilibrium impacts on affected localities (Bustos et al., 2016; Jedwab et al., 2021). Whether social protection programmes, rolled out at scale, can counteract these negative equilibrium impacts remains a key open question.

5.5 Raising revenue

Limiting global warming to under 1.5 degrees will require extraordinarily high investments, on an order of magnitude of US$ 4–6 trillion per year globally until 2050 (Lenaerts et al., 2021; Naran et al., 2021). Investments are needed in everything from the electrification of transport vehicles to R&D on sustainable building materials (Lenaerts et al., 2021).

In 2020, sub-Saharan Africa received 70% of total climate finance, which amounted to only US$ 15.7 billion (Belianska et al., 2023). At the Paris Agreement in 2015, a collective goal of meeting a US$ 100 billion per year investment in climate projects was made. While climate finance is currently above this level and growing (Naran et al., 2021), there is still a significant gap relative to investment needs – particularly in developing countries and for adaptation projects. To face this gap, states need to boost tax revenue. This can be done through enhancing the state's institutional capacity to raise and manage revenue streams.

We begin by addressing tax capacity. In a state with lower enforcement capacity, tax avoidance occurs frequently (Gordon and Li, 2009) and the pool of taxable individuals is concentrated at high levels of the income distribution (Jensen, 2022). To create an effective tax base, low-cost enforcement mechanisms need to be implemented.

First, higher sanctions for tax evasion and audits can be deployed to dissuade potential offenders. In Ecuador, stronger sanctions against tax evasion have led to an estimated increase in corporate tax revenue of about 10% (Carrillo et al., 2011). Additionally, Best et al. (2015) demonstrate that using a turnover instead of a profit tax can reduce tax evasion significantly. Other options to improve enforcement include increasing the salience of audit threats via letters (Bergolo et al., 2023), emails (Mascagni and Nell, 2022), or text messages (Ortega and Scartascini, 2015). These enforcement options have proven to be a cheap strategy to generate meaningful gains in compliance.

The threat of audits may be insufficient where capacity is scarce. Mechanism design algorithms, such as Prioritised Iterative Enforcement, may help governments optimally allocate their scarce enforcement capacity, as shown in Peru (Chassang et al., 2022). Second, better technology is required. Dzansi et al. (2022) find that the use of database management software by tax collectors in Ghana improves the time efficiency of collecting and the targeting of households with higher propensity to pay. Similarly, the introduction of electronic billing machines raised VAT revenues in both Ethiopia (Ali et al., 2016) and Rwanda (Eissa et al., 2013).

Third, tax collection can be improved through well-designed personnel policies (Khan et al., 2016, 2019) and through better tax administration (Basri et al., 2021). Fourth, incentives for third parties – such as for buyers to request VAT receipts (Naritomi, 2019) – can effectively support policies that improve tax administration. Finally, tax morale and behavioural issues are likely to play an important role, as shown by recent experiments in which subjects received information on the tax compliance of others (Carpio, 2014; Slemrod, 2019).

Taxes on externalities – 'Pigouvian taxes' – are of particular interest for the sustainable development agenda. We first discussed Pigouvian taxation in Chapter 3 to explore how innovation subsidies combined with Pigouvian taxes can maximise welfare and reduce emissions. We now discuss (i) how compliance concerns affect the desirability of Pigouvian taxes

and (ii) whether this form of taxation is politically feasible in low- and middle-income countries. We will focus on one key Pigouvian tax at the core of climate change: carbon taxes.

A carbon tax becomes, if anything, more attractive once we consider tax compliance constraints. This is because a large amount of CO_2 emissions are generated by a few, formal energy producers, who will find it hard to evade the tax. Some of the tax will then pass through to other actors in the economy, including informal actors that rely on formal energy sources. This discourages the most CO_2-intensive forms of production and consumption (Timilsina, 2022). In a recent simulation exercise, the gains in tax compliance that can be obtained by replacing some of the existing taxes with a carbon tax are substantial (Bento et al., 2018). However, these gains will decrease to the extent that producers are able to substitute to informal sources of energy and if non-payment for electricity remains widespread (Burgess et al., 2020).

Our second point is a that a carbon tax will likely be politically unpopular unless the revenues from the tax are reinvested in a way that addresses citizens' key concerns. There are two distinct problems: (i) these taxes can reduce growth, and (ii) they can have negative distributional effects. A recent survey of high- and middle-income countries provides clear evidence: individuals are more favourable to green infrastructure and innovation subsidies (financed with a progressive wealth tax) than to a carbon tax (with revenues equally redistributed to households) (Dechezleprêtre et al., 2022).

Are these concerns well founded? The empirical literature suggests that, in the past, the effects of carbon taxes on growth have been modest (Metcalf, 2021). It is not entirely clear whether this would also be true for those developing countries that are most dependent on high-carbon sources of energy such as coal, for example, South Africa. While results on the distributional implications remain mixed, a recent meta-analysis finds that about 65% of the studies report evidence of regressive impacts (Ohlendorf et al., 2021).[14] But, losses due to the tax can be offset given the substantial contribution to state revenue (Ross, 2018). Carbon taxes therefore have the potential to both mitigate the global externality (which disproportionately impacts vulnerable households) and encourage emission reducing innovations. Recent modelling by Stiglitz (2019) suggests high carbon prices today in high-income countries will create production inefficiencies, but these are offset by induced green innovation and a declining carbon price trajectory.

The key question of how to spend carbon tax revenues is still being debated. The choice of revenue recycling – lump-sum to households, reduction in alternative taxes, or reinvestment in clean technologies – depends on whether governments prioritise efficiency, equity or mitigation

14 The literature is focused on high-income countries, though in the sample of Ohlendorf et al. (2021), developing countries, when included, tend to have less regressive tax outcomes.

goals (Timilsina, 2022). If they want to minimise the negative impacts of the tax on the economy, revenue is best spent on cutting distortionary taxes. But, if the objective is to neutralise the regressive impacts of the policy, revenue is best invested in cash transfers to poor households (Ross, 2018; Timilsina, 2022).

Timilsina (2022) simulates the introduction of a carbon tax in Ethiopia, and finds that its regressive impacts can be completely offset by cash transfers. However, this use of tax revenue does not maximise growth (Fried et al., 2021). Prioritising equity goals when deciding how to reinvest revenues will likely be essential to make a carbon tax politically viable. Dechezleprêtre et al. (2022) show that carbon tax support grows considerably when the revenue is used to fund a cash transfer to the poorest households.

Far from taxing it, many governments in developing countries subsidise fossil fuels through payments for electricity, cooking fuel, or diesel. The IEA (2023) identifies over 600 fuel subsidies globally, 80% of which are directed to fossil fuels.[15] Removing these subsidies and concurrently replacing them with a carbon tax is politically unpopular (Timilsina, 2022) as low-income households are perceived to bear the cost. Contrary to this sentiment, evidence suggests fossil fuel subsidies go disproportionately to wealthier households (Dar et al., 2013; Goulder et al., 2019).

Some progress on subsidy reform is being made – the government of Nigeria has managed to announce the removal of its fuel subsidies (Damania et al., 2023). Global coordination on the Glasgow Pact has prioritised the removal of harmful and often inefficient fossil fuel subsidies as a key policy goal (IISD, 2021). More research is needed to understand the ways governments may ease out fossil fuel subsidies, potentially in tandem with cash transfers or social norms marketing (Ryan and Barnwal, 2023).

The political feasibility of a carbon tax – and of other important forms of Pigouvian taxation, for example, a methane tax – remains an open area of investigation. We encourage more research on the impacts, the political feasibility, and the best use of revenues generated by carbon taxes in developing countries. Next, we look at how states can manage their resource rents for growth, and in turn, attract investment to further expand their revenue base.

A successful growth agenda guides re-investment of tax revenues into highly productive public goods or services to accrue wealth (Arrow et al., 2012). For this, many states rely not only on general taxation but also on the extraction of their natural wealth, including oil, gas, minerals and timber. Resource royalties can form a large part of government revenue, but over-reliance on resource windfalls can lead to state instability (Caselli and Tesei, 2014). Notably, fossil fuel price fluctuations have lead to investments in substitute technologies (Hassler et al., 2021). For example, Hassler et al.

15 For a more complete discussion on the measurement of fossil fuel subsidies and different estimates (including both pre- and post-tax subsidy estimates) please see Koplow (2018).

(2021) finds that the 1970s oil embargo encouraged progress in energy savings technologies, fossil fuel extraction, and long-term substitutability of renewable energy sources for exhaustible resources.

If revenues are effectively taxed and reinvested in productive public spending, such as education and infrastructure, the extraction of non-renewable resources in developing countries may contribute to sustainable growth (Birdsall et al., 2000; Caselli and Tesei, 2014; Collier and Hoeffler, 2005; Dietz and Rosa, 1997; Hamilton and Clemens, 1999).[16] Chile and Norway, which have created sovereign wealth funds to sustainably use their resource wealth, serve as positive examples.

To achieve the global targets for low-emissions energy and industrial infrastructure, a significant investment will need to be made in the extraction of critical minerals – where electric vehicles require lithium and cobalt is essential for wind turbines (IEA, 2021b). Currently, we find no evidence of the effect of increasing demand for low-emission technology on exhaustible resource rents in developing countries. Scenario modelling by the IEA (2021b) suggests developing countries hold large reserves of essential minerals. More information is needed on how low-income countries with mineral deposits can best manage the revenues from the resources, particularly in Africa (Siwale and Werker, 2023). Moreover, research on industrial policies in developing economies, such as local content requirements and the effect they have on local growth is not well developed (Harrison et al., 2017; Rodrik, 2014). Generally, we encourage future research in tax capacity, climate taxes, and exhaustible resource management to better understand how developing countries can finance sustainable growth.

Tax authorities, and federal finance ministries in particular, will also play a central role in obtaining in employing climate finance. This requires a few key investments. First, the state needs the essential capacity to access climate financing. The complexity of the matter is underscored by the fact that most poor countries are not fully utilising the UN Green Climate Fund. Second, governments need to develop the capabilities to track and to assess the impact of climate investments. This will be essential to convince donors of the value of continuing to support climate action in developing countries.

16 However, poor management of natural resource extraction has been well-documented, and has actually negatively impacted developing countries' overall economic health (Arrow et al., 2012; Collier and Hoeffler, 2005; Hamilton and Clemens, 1999). A vast literature explores this resource curse (Ross, 2015; Venables, 2016).

5.6 International policy and coordination

Finally, the international dimension of climate change mitigation and adaptation complicates policy and represents an important area of research. Here, we touch on two aspects of international cooperation: policy coordination and the design and governance of loss and damage funds.

Global warming affects all citizens of all countries regardless of where the underlying GHG emissions originate. These externalities govern not only private actors' incentives to pollute but also governments' incentives to regulate. Economists have examined various potential solutions to the collective action problem facing regulators. Hsiao (2023a) and Farrokhi and Lashkaripour (2022) examine whether trade policy can curb environmental degradation. Nordhaus (2015) investigates whether climate clubs can induce emission abatement by imposing trade penalties on non-members. Battaglini and Harstad (2016) consider the role of the contractability of green investments, while Harstad (2016) explores the role of intellectual property rights for green technologies, the duration and stringency of climate agreements in facilitating cooperation.

The strategy of instead implementing green policies unilaterally raises concerns about carbon leakage, an issue which has received much attention in the literature (Branger and Quirion, 2013; Fowlie and Reguant, 2018; Grubb et al., 2022; Weisbach et al., 2023). Empirical studies have not found significant evidence of leakage (Branger and Quirion, 2013; Grubb et al., 2022). However, this is partly because policymakers have so far shielded key industrial sectors (Grubb et al., 2022).

We encourage more research on the extent of and remedies to carbon leakage as governments implement more ambitious mitigation policies. We further need innovative approaches to breaking deadlocks in international climate diplomacy. International cooperation can further facilitate achieving emissions reductions as efficiently as possible. Both the Kyoto Protocol and the Paris Agreement provide frameworks to trade mitigation outcomes internationally. Since low- and middle-income countries offer particularly cost-effective opportunities to save GHG emissions, financing climate projects in developing countries could accelerate mitigation efforts at current spending levels (Glennerster and Jayachandran, 2023). More research on how this cooperation can be organised effectively as well as on how climate change mitigation projects can boost development is urgently needed.

A major equity concern in international climate cooperation is the uneven distribution of pollution and damages. While high-income countries are responsible for the majority of emissions to date, its damages are concentrated in low- and middle-income countries. Furthermore, developing countries are least able to prepare for and react to natural disasters. This creates an ethical imperative to redistribute resources from high-income to low- and middle-income

countries. Hence, transfers should target not only mitigation but also adaptation. They are justified not only by efficiency, but also by ethical considerations.

Important progress has recently been made in this area: COP27 mandated a transitional committee to design a loss and damage fund by the end of 2023. Research has an important role to play in providing evidence for an effective design of the fund, for example, by identifying effective mitigation measures for slow-onset events or by establishing the magnitude of climate damages (Serdeczny and Lissner, 2023). Economic research is already contributing, for example, by pointing out pitfalls of spending and adaptation policies in the face of rising sea levels (Balboni, 2019; Hsiao, 2023b). Similarly, estimates of the costs inflicted by natural disasters (Anttila-Hughes and Hsiang, 2013; Hsiang and Jina, 2014) can inform the timing and amount of funds to be disbursed.

Finally, an ample development literature investigates how public policy can effectively target poor and vulnerable populations (Alatas et al., 2016a, 2012; Alderman, 2002; Banerjee et al., 2018; Hanna and Olken, 2018). Numerous dimensions, from institutions, over geography to income, determine a community's exposure to climate change. Future research could hence build on the insights of the targeting literature to explore which mechanisms channel loss and damage funding to the most vulnerable communities.

To keep donors convinced of the utility of providing climate finance, governments will need to document effective implementation and clear impact of these funds. The last 25 years of development economics research have provided states with powerful tools to test the efficacy of government programmes – especially randomised controlled trials. Governments can pilot, refine, test and evaluate investments to make the case to donor countries that climate spending can support climate adaptation and mitigation.

Conclusion

Eradicating poverty has dominated the development agenda since 1990. Governments, donors and academics looked towards economic growth to lift people out of poverty. The challenge of growth boiled down to understanding the nature of economic activity and what actions governments could take, if any, to ignite it. Once one began to think about questions of growth, it was hard to think of anything else (Lucas Jr, 1988). Institutions like the International Growth Centre (IGC) were set up to work with policymakers in developing countries to promote growth through research.

Much like the mechanics of growth, it is now hard to think of anything but the challenge of climate change. Confronting climate change has become the major global development challenge alongside eradicating poverty. The two are intricately linked. Overlaying the distribution of the extreme poor in the world on a map of the most extreme climate damages yields a strong overlap (see Figure 1). These same low- and middle-income countries will also account for the bulk of future emissions. Climate change and poverty therefore cannot be thought of in isolation. The future of the planet depends on achieving sustainable growth in low- and middle-income countries.

This paper has focused on how innovations of different types can achieve a balance between growth and the externalities from growth. Thanks to innovation, the growth paths of today's developing countries have the opportunity to be vastly greener. Yet, technological innovation in a narrow sense will not be enough to achieve sustainable growth. Growth in low- and middle-income countries is built around technologies – for energy, transport, manufacturing, and the like – that rely on cheap and widespread fossil fuels. A swift transition to a low-emissions economy involves developing new low-emissions technologies, as a first step, but then reshaping the entire economy, from markets and regulation to taxation, redistribution, and international trade. The goal of this reshaping is to adopt new technologies quickly but also to ensure a politically feasible, economically viable and socially just transition.

With an appropriately broad view, it is not only solar photovoltaic panels that should be seen as technologies for climate change mitigation and adaptation. Our political, economic, and social institutions are themselves "technologies" that must innovate to drive a clean energy transition and help adapt to the effects of climate change that are already affecting us. This paper sets out a research agenda to understand how this re-design can be achieved while fostering inclusive economic growth across countries, regions, and social groups.

Despite their close connection, the challenge of eradicating poverty is fundamentally different from that of mitigating climate change. For poverty, we can more easily measure the size of the problem. Moreover, we now have some well-tested policy interventions to help tackle poverty. On several dimensions, the challenge of climate

Workers install solar panels on the roof of a house in South Africa. Photo by Getty Images.

change is greater. First, emissions do not respect political jurisdictions or boundaries. They affect us all irrespective of their origin. Second, those that are suffering the most from climate change are not the main polluters. Third, we do not yet have a well-evidenced policy toolkit to confront climate change, especially in low-income contexts.

The first two hurdles point to the need for international coordination and action. Climate change is a global problem: relying solely on domestic policy will be insufficient. Compensation through loss and damage funds is necessary for those already facing existential climate change. International policy coordination is necessary to progress to a net-zero economy as quickly and efficiently as possible. International climate finance can offer the essential capital to ensure the innovations laid out in this report can be rapidly diffused.

Widespread innovations in energy and environment, firms, cities, and effective states have make sustainable growth increasingly attainable. Instead of sacrificing an intact environment for economic growth, we now have the opportunity to attain both. To achieve the innovations outlined in the preceding chapters, researchers need to collaborate across disciplines and across all fields of economics. It is only by mainstreaming environmental issues into economics and economic policy and working across disciplines that we can realise the opportunity of sustainable growth. This is the best way for the academic community to support policymakers in striking a balance between generating the economic growth needed to confront poverty and curbing the externalities that lie behind climate change. This represents the central mission of the IGC going forward.

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Innovation, growth, and the environment

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Tim Dobermann, and Allegra Saggese

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