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Joint implementation of the Sustainable Development Goals, climate change mitigation and biosphere protection: **Policy options for tackling multiple crises simultaneously**

Bjoern Soergel, Elmar Kriegler, Christoph Bertram, Michael Crawford, Laura Delsa, Max Franks, Florian Humpenöder, Debbora Leip, Kai Lessmann, Alexander Popp, Nicolas Taconet, Isabelle Weindl, and Ottmar Edenhofer

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Contact:

Dr. Bjoern Soergel
soergel@pik-potsdam.de

Executive Summary

Humanity faces the enormous challenge of **ensuring a decent living for all global citizens while simultaneously averting dangerous climate change and biodiversity loss**. The **UN Sustainable Development Goals** (SDGs), the **Paris Agreement** and the prospective **Global Biodiversity Framework** set ambitious targets, but reviewing the current situation and the progress towards these targets is sobering: **A continuation of current policy ambition and implementation speed will fail to deliver on these international agreements**, leaving many people in poverty and hunger by 2030 and beyond, while at the same time the planet continues to heat up and biodiversity loss proceeds.

Against this background, this report discusses the interdependencies and especially the **mutual benefits of jointly implementing the Sustainable Development Goals (SDGs), ambitious climate change mitigation and biodiversity protection. Progress towards the SDGs**, such as encouraging healthy nutrition, energy efficiency and more sustainable lifestyles, eradicating poverty and reducing inequality, improving institutional quality and promoting better education and gender equality, **plays an important role as an enabling factor for climate change mitigation and biodiversity protection**. Vice versa, **averting dangerous climate change and protecting ecosystems is indispensable for the whole SDG agenda**, not least because of the risk of climate impacts and biodiversity loss jeopardizing many other SDGs.

We identify the **policy interventions required to simultaneously meet the Paris climate target, push forward the implementation of the SDG agenda, and halt and subsequently revert biodiversity loss**. These interventions include:

- **Supporting human development** (e.g. education and gender equality)
- **Fostering healthy nutrition** and **sustainable and biodiversity-friendly land use**
- **Carbon pricing** and national **redistribution of revenues**
- **International climate and development finance** to support poverty alleviation and infrastructure buildup
- **Enhancing energy access** in the Global South**, reducing energy consumption** in the Global North
- **Technology policies** for a sustainable energy system

We integrate these interventions into a *sustainable development pathway* that exploits synergies and manages trade-offs between different policy objectives (Section 1). Using results from an integrated energy-economy-land-climate model, we contrast this holistic policy approach with a continuation of current trends, as well as with a narrow approach focusing only on climate policy. **This highlights the potential but also the large challenges for SDG implementation until 2030** and beyond. For example, the number of people remaining in extreme poverty in 2030 can be halved compared to the trends-continued scenario, but the target to eradicate extreme poverty by 2030 (SDG 1) is nonetheless missed.

We also include more **in-depth analyses in three focal areas: i) nature-based solutions and a sustainable land and food system, ii) just transition, and iii) investment needs and fiscal space for the SDGs**. A summary of specific policy recommendations in these three focal areas is given in the final section of this report.

Concerning **sustainable land use (Section 2),** we highlight the potential of **nature-based solutions such as avoiding deforestation, re/afforestation and peatland protection for climate change mitigation while simultaneously protecting and enhancing biodiversity**. These options need to be embedded in a broader sustainable transformation of the agricultural system, including for example a **preservation of natural habitats within working landscapes**, as well as the **removal of counterproductive incentives driving environmental degradation in agricultural policies**. **Encouraging a shift towards healthier and less meat-intensive diets plays an important enabling role in this transformation**, as it frees up large areas of land currently used for livestock, and also has substantial co-benefits for several other SDGs.

In the context of a **just transition (Section 3)**, we present options for equitably managing the cost of the energy transition while simultaneously supporting other targets of the SD agenda. **At the national level, we recommend a comprehensive carbon pricing together with an equal-per-capita redistribution of its revenues**. This simple but effective tool compensates households for higher energy and food prices; additionally, employment effects need to be carefully managed. **At the international level, a carbon pricing scheme differentiated by the income level of countries, alongside international climate and development finance and investment support are promising strategies**. Additionally, **just energy transition partnerships could support the transition** especially in countries with a high dependence on coal. Taken together, these policies would contribute to reducing the global prevalence of poverty and inequality. This **link between environmental and social targets creates an additional entry point for ambitious climate policies**.

In addition, **investments into SDG-related infrastructure (Section 4) such as healthcare, education, energy and water and sanitation** play an important role. However, we identify a **large investment gap in low- and middle-income countries**, much larger than the funds currently available domestically or through international initiatives. **The removal of fossil fuel subsidies and carbon pricing are promising options to expand the fiscal space for SDG implementation in low- and middle-income countries, while at the same time reducing CO_2 emissions**. SDG-related investments indirectly contribute also to poverty reduction, and can thus be seen as an alternative policy option to direct redistributive policies. However, for many countries carbon pricing revenues cover only a fraction of the SDG-related investment needs, such that a **ramp-up of public and private international investments is also needed**.

The policy interventions discussed in this report are mutually supportive: together they enable **rapid progress towards the SDGs and meeting climate and biodiversity targets**, working towards the vision of **decent living and human well-being within planetary boundaries**. Policymakers, businesses and societies as a whole can work together to turn this vision into reality.

1 Sustainable development, climate change mitigation and biodiversity protection

1.1 Sustainable development - a global challenge

The UN Agenda 2030 for Sustainable Development and the Paris Agreement together form an ambitious agenda for fostering human well-being within the planetary boundaries (TWI2050, 2018; Sachs *et al.*, 2019; *Global Sustainable Development Report*, 2019). These two landmark agreements could soon be joined by an international agreement on the post-2020 Global Biodiversity Framework. However, the world is far off track compared to the ambition of these global goals. Progress towards many SDGs has been slow and patchy already prior to the COVID-19 pandemic. The economic and social fallout of the pandemic have exacerbated the situation further - for example by pushing over 100 million people globally back into extreme poverty (*The Sustainable Development Goals Report*, 2021) - and thus an increasing number of SDGs are becoming more and more difficult to reach by 2030 (Hughes *et al.*, 2021). While CO_2 emissions shortly fell during the pandemic, they have since rebounded to a record high (IEA, 2022), rapidly closing the small remaining window towards reaching the 1.5°C target from the Paris Agreement. Further, none of the 20 Aichi Biodiversity targets – the precursors to the post-2020 Global Biodiversity Framework currently being negotiated – have been fully achieved (*Global Biodiversity Outlook 5*, 2020), with potentially catastrophic consequences for our ability to accomplish the other SDGs (Steffen *et al.*, 2015; Blicharska *et al.*, 2019; IPBES, 2019a).

Against this backdrop, any possible pathway towards meeting these targets requires strong, coordinated and collaborative global action. This is most obvious for targets related to preserving global common goods or global planetary boundaries (Steffen *et al.*, 2015), such as an intact climate system, ocean and biosphere (SDGs 13, 14 and 15). However, it is also the case for many development targets like poverty eradication, zero hunger and access to clean energy (SDGs 1, 2, and 7) - not least because of the repercussions that price increases on the international markets for food and energy can have for meeting these goals. But also beyond that, implementing the SDGs is a global challenge that individual countries – especially in the Global South – cannot deliver upon on their own. In this context, a special role is played by SDGs 16 (Peace, justice and strong institutions) and 17 (Partnership for the goals). Besides being targets in their own right, they are also enablers and necessary preconditions for many of the other goals (Tosun and Leininger, 2017), and remain important despite the current geopolitical crisis. While the implementation of the climate and sustainable development agenda will have to take the changed geopolitical context into account, it nevertheless holds that the SDGs are highly synergistic (Roy *et al.*, 2018; van Soest *et al.*, 2019) and global in scope (van Vuuren *et al.*, 2022), and hence can only be achieved collectively rather than by isolated actions of individual countries on individual SDGs. Recent assessments have shown that the number of synergies between different SDGs substantially exceeds the number of trade-offs (e.g. *Global Sustainable Development Report*, 2019). Therefore, an integrated and coherent set of policy interventions that leverages the many synergies, while also carefully managing trade-offs, is instrumental for advancing the implementation of the SDG agenda. This key insight - the need for a holistic policy approach - is underpinned by a wealth of scientific literature (e.g. TWI2050, 2018; Sachs *et al.*, 2019; *Global Sustainable Development Report*, 2019; *Science Platform Sustainability 2030*, 2021).

1.2 The link between sustainable development and climate and biosphere protection

Historical development pathways based on extensive land conversion and fossil fuel use have led to a situation where all countries in which basic needs of the population are fully met also exceed one or several environmental boundaries (O'Neill *et al.*, 2018; *Global Sustainable Development Re-*

port, 2019). As future development pathways determine the magnitude of the challenges associated with meeting environmental targets, it is urgently required to shift development pathways towards a decent living within planetary boundaries (Pathak *et al.*, 2022).

The SDGs can play a pivotal role in this context, as many policies that primarily target individual SDGs also facilitate climate change mitigation and/or biodiversity protection. For example, policies encouraging healthier nutrition (SDGs 2 & 3) lead to large co-benefits for climate and ecosystem protection, thereby facilitating both mitigation and adaptation efforts (Section 2). Similarly, a reduction of energy demand through efficiency measures and encouraging more sustainable housing, mobility, consumption and production patterns (SDGs 7, 9, 11, 12) facilitates the decarbonization of energy supply and resolves trade-offs between climate policy and other SDGs (Bertram *et al.*, 2018; Soergel, Kriegler, Weindl, *et al.*, 2021). In this context, it is important to note that the majority of such demand-side interventions also have positive effects on human well-being and quality of life, among them improved health and life expectancy and enhanced social cohesion (Creutzig *et al.*, 2022a; 2022b).

Infrastructure design can also play an important enabling role in this context. For the example of cities (SDG 11), a more compact urban design and the availability of high-quality infrastructure for both public transport and active transport modes such as cycling facilitate climate-friendly mobility. Besides directly reducing emissions, this also leads to reduced air pollution and encourages physical activity, both of which are beneficial for human health. A reduced urban sprawl also spares land from being built on, with associated positive effects for ecosystem protection and biodiversity (Denton *et al.*, 2022; Riahi *et al.*, 2022).

The SDG agenda is also instrumental for enabling the societal and systems transformations required to meet ambitious climate and biodiversity targets. A reduction of poverty and inequality (SDGs 1 & 10) can facilitate the implementation of ambitious measures to protect climate and biodiversity while simultaneously ensuring that no one is left behind (Section 3, Roy *et al.*, 2018; IPBES, 2019b). This also applies to a broader perspective on decent living standards (including also food, energy, housing, clothing, healthcare, mobility and education), all of which can be achieved without a substantial increase in global emissions (IPCC, 2022b). Institutional quality and good governance (SDG 16), inclusive and high quality education (SDG 4), and gender equality (SDG 5) are also important determinants of the capacity of countries to pursue ambitious mitigation and biodiversity protection; the same applies for the capacity to adapt to current and future climate impacts (Andrijevic *et al.*, 2019, 2020). Global cooperation (SDG 17) is critical for collective action to achieve global goals. All of these aspects of the SDG agenda are therefore crucial requirements for shifting towards climate-friendly, climate-resilient and biodiversity-friendly development pathways.

Vice versa, ambitious climate change mitigation is also an important prerequisite for the whole SDG agenda, as already today climate impacts fall disproportionately on vulnerable populations in the Global South and thus jeopardize progress on poverty eradication and many other SDGs (Hallegatte *et al.*, 2016; Byers *et al.*, 2018; IPCC, 2022a). Mitigation policies also interact with the SDGs, with the exact synergy and risk profile being determined by the choice of mitigation strategies. There are clear synergies like a reduction of disease burden and mortality from air pollution, but also risks for trade-offs, for example concerning bioenergy and food production. However, these tradeoffs can be managed and avoided through appropriately designed supplementary policies (Bertram *et al.*, 2018; Humpenöder *et al.*, 2018; Rogelj *et al.*, 2018; Soergel, Kriegler, Weindl, *et al.*, 2021). Similar strong interconnections also exist between ecosystem protection and biodiversity and multiple other SDGs (IPBES, 2019b).

1.3 A sustainable development pathway for climate, biodiversity and SDGs

Given the interconnections between protecting climate and biodiversity on the one hand, and fostering human development on the other hand, a holistic policy approach is required (Fuso Nerini *et al.*, 2019; Zhenmin and Espinosa, 2019; *Global Sustainable Development Report*, 2019; Iacobuţă *et al.*, 2021; IPCC, 2022b). A *sustainable development pathway* (*SDP)* integrates these considerations and thus enables more rapid progress towards the SDGs and climate and biodiversity targets. This report takes the SDP scenario from Soergel, Kriegler, Weindl, et al. (2021) - which also features as Illustrative Mitigation Pathway "Shifting Pathways" in the IPCC AR6 WG III report - as an entry point to provide a high-level overview. The subsequent sections will then zoom in on individual focal areas to provide more detailed analysis in the areas of sustainable land management and nature-based solutions (Section 2), just transition (Section 3), and fiscal options to cover SDG financing needs (Section 4).

This SDP scenario integrates climate policy with a push towards the SDGs into an integrated strategy that rests on the following pillars:

- Supporting human development (e.g. improved education and gender equality), economic development and institutional quality[1], as well as improving infrastructure in low-income countries (see also Section 4)
- Enabling sufficient, healthy and sustainable food consumption and agricultural best practices (e.g. nitrogen and irrigation efficiency) as a precondition for a sustainable land use system that fosters biodiversity and strengthens natural carbon sinks (Section 2)
- Pricing CO_2 and other greenhouse gasses at a level sufficient to reach the 1.5°C target and in a globally equitable way. This implies carbon prices of 150-300 \$/tCO_2 in high-income countries by 2030, but initially much lower prices in low-income countries.
- Redistributing the carbon pricing revenues at national level as a "climate dividend" to support especially low-income households, while reserving part of the revenues from high-income countries to fund international climate and development finance (Section 3)
- Improving energy access in the Global South; reducing energy consumption in the Global North through efficiency measures and more sustainable lifestyles; enhancing resource efficiency
- Implementing technology policies for a rapid transition to a sustainable energy system and reduced air pollution (e.g. a rapid coal phase-out)

Figure 1 shows the projected SDG achievements and gaps for a selection of indicators[2], both in the SDP scenario and in a scenario continuing current socio-economic trends and policy actions. A continuation of current trends is clearly insufficient to meet the SDGs by 2030 and even by 2050, and exacerbates the current situation in a number of areas (relative poverty rate, food waste, biodiversity intactness, nitrogen fixation). On the other hand, the integrated sustainable development strategy substantially improves climate and SD outcomes. However, due to the short time horizon and the inertia in existing systems, a number of targets have moved out of reach for 2030 even in the case of strong policy interventions, a situation that is likely exacerbated further by the COVID-

[1] Note that these factors are not modelled explicitly, but represented through scenario assumptions.
[2] Indicators were selected according to relevance for the focal areas of this paper; see Soergel, Kriegler, Weindl, *et al.* (2021) for a more comprehensive set of indicators, as well as for indicator definitions and quantitative targets used.

19 pandemic.[3] Both of these points highlight the need to pursue sustainable development policies beyond 2030, and indeed many of the gaps can (partially) be closed by 2050.

The additional SD policies counteract trade-offs of narrowly designed climate policy and enable rapid progress towards other sustainability objectives (Figure 2). Through national redistribution of carbon pricing revenues and a ramp-up of international climate finance, both inequality (relative poverty) and extreme poverty[4] can be reduced substantially. Furthermore, a gradual shift to healthy and sustainable diets and lower food waste alongside agricultural best practices counteracts food price increases that would otherwise be caused by climate policies. Such shifts in food consumption and production would also have profound environmental benefits by i) allowing agricultural land to be repurposed to simultaneously address climate change and biodiversity loss (e.g. forest protection and ecosystem restoration), and ii) reducing agricultural nitrogen pollution to levels close to the planetary boundary target. They also substantially reduce agricultural emissions of methane and nitrous oxide, which facilitates reaching the 1.5°C target[5].

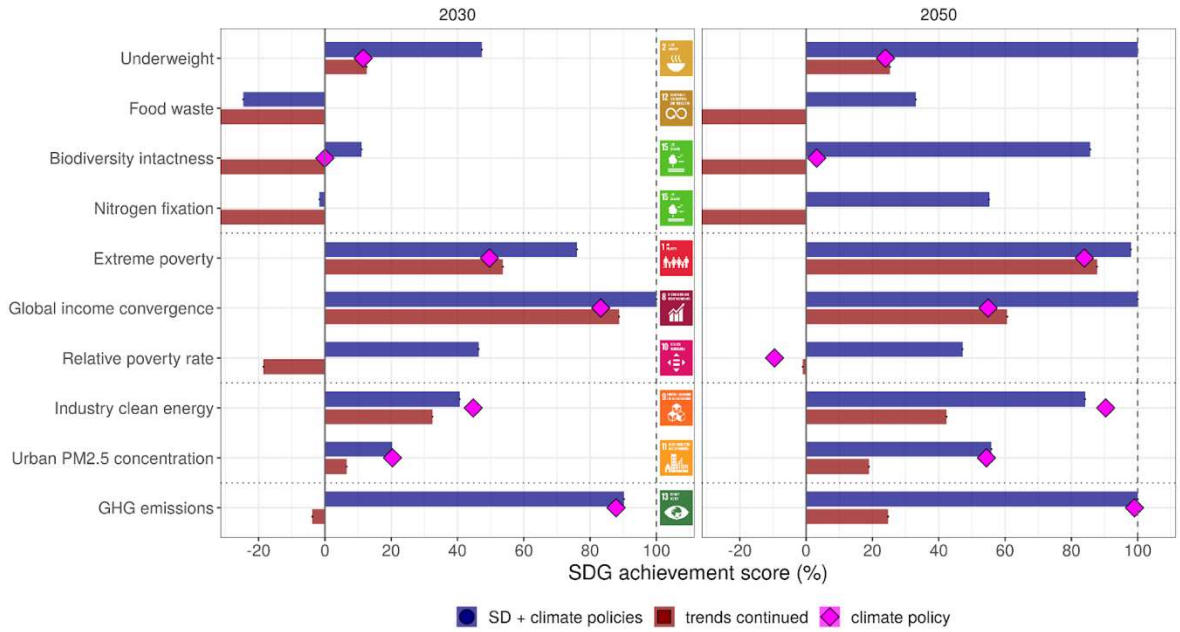

Figure 1: The integrated SD policy approach drastically improves climate and SDG outcomes both in 2030 (left) and 2050 (right)*: We contrast the SDP scenario (blue bars) with i) a trends-continued pathway (red bars) where socio-economic development follows historic trends (Riahi et al., 2017) and climate policy remains at the level of ambition of nationally determined contributions (NDC) submitted until October 2020, and ii) a narrow "climate policy only" pathway that reaches the 1.5°C target without consideration of sustainability or development implications (magenta diamonds). Indicators are selected and grouped according to the focal areas of Sections 2, 3 and 4. A value of zero represents the value of the indicator in 2015, whereas 100% indicates that the target is fully met or even exceeded. Negative values represent a worsening of the situation (scale cut at -30%). [Figure abridged from Soergel, Kriegler, Weindl, et al. (2021)]*

[3] The scenario calculations were performed at a time when the long-term economic impact of the COVID-19 pandemic was still very uncertain. Therefore, it is not explicitly considered in these results, and as a consequence the gaps towards a number of SDGs could be larger than shown here.

[4] Relative poverty is defined as an income below 50% of the national median income. Extreme poverty is an income below the international poverty line of $ 1.90/day in purchasing power parity.

[5] A rapid reduction of non-CO_2 emissions allows for slightly higher CO_2 emissions during a transition phase while still meeting the 1.5°C target. This in turn gives slightly more time to transform energy use, which contributes to meeting growing demand for modern energy in developing countries and keeping energy price increases at bay.

Finally, ambitious energy efficiency measures, a rapid electrification of the energy demand sectors (Luderer *et al.*, 2022), and a shift towards less energy-intensive lifestyles can reduce energy demand in high-income countries. This facilitates the decarbonisation of the energy supply, and thereby reduces the dependence on fossil fuel imports and dampens energy price increases in the medium to long term. While narrowly designed climate policies could for example increase average European final energy prices by over 30% by 2030, the integrated SD policy approach already avoids around two thirds of this increase. This dampening of energy prices becomes even more pronounced over time as the impact of efficiency measures and lifestyle changes unfolds. In the global average, however, the dampening of prices is less pronounced, largely because of enhanced energy consumption in low-income countries in line with energy access and material needs targets (Kikstra *et al.*, 2021).

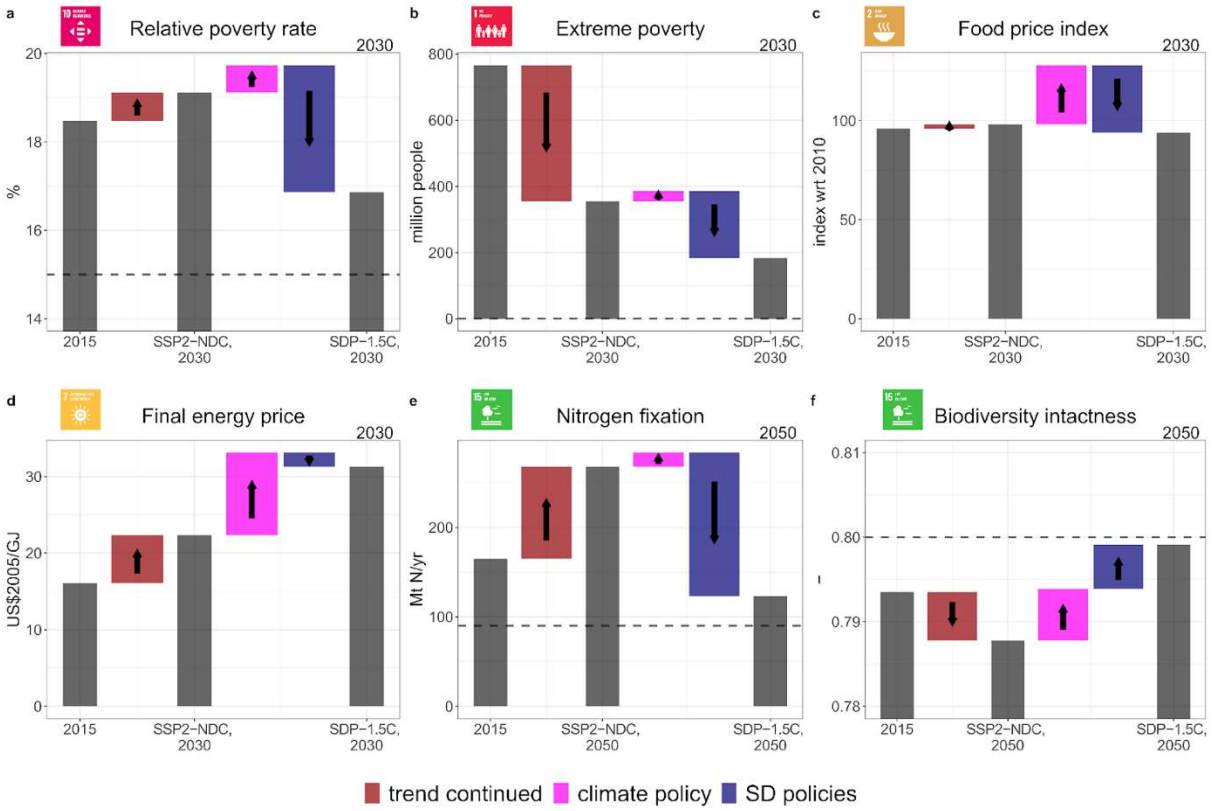

Figure 2: Targeted SD policies resolve trade-offs and create synergies between climate protection and SDGs: *The first step (dark red) denotes a continuation of current trends from 2015 to 2030 (2050 for panels e,f) including an implementation of NDCs submitted until October 2020 (SSP2-NDC). The second step (magenta) illustrates the effects of a narrow "climate-only" policy consistent with the 1.5°C target but without regard to other sustainability or development objectives. The third step (blue) illustrates the added value of additional sustainable development policies for resolving or softening trade-offs of climate policies (panels a-e) or creating synergies (panel f). For example, pairing climate policies with a shift to healthier diets, reduced food waste and agricultural best practices enables reaching both climate and food security objectives, as the combined policy avoids the increases in food prices that narrowly designed "climate-only" policies without these extra SD policies would otherwise cause (panel c). Target values for 2030 (2050) are indicated by the dashed lines. [Figure abridged from Soergel, Kriegler, Weindl, et al. (2021)]*

2 Nature-based solutions and a sustainable land and food system

2.1 Multiple pressures on the land system

Humanity places numerous, often competing pressures on the land system. While we rely on land to feed our growing population, it is vital for the mitigation of climate change – with measures being discussed ranging from the application of climate-friendly agricultural practices, to the substitution of fossil fuel-based energy and productions with those derived from organic resources, as well as the storage of carbon in terrestrial soils and biomass (Grassi *et al.*, 2017; IPCC, 2019; Roe *et al.*, 2019; Clark *et al.*, 2020). However, the preservation of land is also of paramount importance for the protection of biodiversity (Leclère *et al.*, 2020; Smith *et al.*, 2021). This is the central tension of the land-use system: How do we prioritize land use when we seem to need simply more land than we have? In this section, we review if climate mitigation measures in the land system represent viable nature-based solutions[6]. While these interventions are necessary to achieve the Paris Agreement, they may be insufficient or even detrimental to achieving many other SDGs. However, a growing number of studies are demonstrating that we can achieve a sustainable land and food system by embedding measures that mitigate climate change (SDG 13) into a comprehensive portfolio with other SD measures and targets, which include halting – or even reversing – biodiversity loss (SDG 15; Blicharska *et al.*, 2019; Roe *et al.*, 2019; Soergel, Kriegler, Weindl, *et al.*, 2021). In particular, these measures must be united with those ensuring food security (SDG 2) and improving public health (SDG 3).

2.2 Land-based climate change mitigation and biodiversity protection

Because the nature of climate and biodiversity protection are tightly intertwined, land-based climate change mitigation – with its three pillars of protection, management, and restoration – must be designed and implemented with its potential impacts on ecosystems in mind, and also with consideration of local conditions. When financing land-based adaptation and mitigation measures, policymakers should prioritize those that enhance biodiversity (IPBES, 2019b). Indigenous and local knowledge is a rich source of information on specific landscapes, ecosystems and their sustainable use. It can therefore facilitate interventions within a local context and increase their likelihood of success, as well as their durability over time (IPCC, 2019). Thus, these communities' expertise should be leveraged to find climate solutions that benefit people and ecosystems.

The foremost priority must be reducing and ultimately halting deforestation, as well as protecting intact ecosystems such as peatlands and biodiversity hotspots. These interventions not only have a high mitigation potential but also safeguard biodiversity (Figure 2-f; Smith *et al.*, 2020). These measures are also some of the most cost-effective. Reducing deforestation alone would mitigate about 3.6 $GtCO_2\ yr^{-1}$ (1.5 – 5.6 $GtCO_2\ yr^{-1}$) at a carbon price of only $\$100/tCO_2$ (Roe *et al.*, 2021) and should therefore be a central focus for a sustainable land-use agenda. However, if implemented without accounting for local context, these interventions may undermine food security, especially in low-income countries (Figure 2-c), which would disqualify them as nature-based solutions.

Improving the management of existing forests is also necessary, and will considerably contribute to CO_2 emission reduction and carbon sequestration, cost-effectively mitigating 0.9 $GtCO_2\ yr^{-1}$ (0.4

[6] The UNEA 5-Resolution "Nature-based Solutions for supporting sustainable development" adopts in OP1 the following definition: "[...] nature-based solutions are actions to protect, conserve, restore, sustainably use and manage natural or modified terrestrial, freshwater, coastal and marine ecosystems, which address social, economic and environmental challenges effectively and adaptively, while simultaneously providing human well-being, ecosystem services and resilience and biodiversity benefits [...]".

– 1.5 $GtCO_2$ yr^{-1}; Roe *et al.*, 2021). Finally, although re/afforestation has the highest technical mitigation potential (8.5 $GtCO_2$ yr^{-1}), its cost-effective potential is much less, though still substantial (1.2 $GtCO_2$ yr^{-1}, 0.9 – 1.5 $GtCO_2$ yr^{-1}; Roe *et al.*, 2021). If accomplished with native species, re/afforestation would benefit biodiversity and likely increase the resilience of terrestrial carbon sinks to climate change (Smith *et al.*, 2021). Timber from these re/afforested areas – if sustainably designed and constrained to ensure local ecosystem health – could be used to replace fossil-based building materials, providing a further carbon sink (Churkina *et al.*, 2020). However, large-scale re/afforestation (> 500 Mha globally) could intensify competition for land enough to tangibly impact food security (Fuss *et al.*, 2018). Food security concerns are also critical to setting sustainability limits for the deployment of bioenergy and bio-based products as substitutes for fossil resources, with careful consideration of ecosystem impacts in addition to mitigation potential. While large-scale cultivation of bioenergy crops poses sustainability risks, integrating woody or perennial grass bioenergy crops as non-dominant components of diverse agricultural landscapes can increase habitat diversity (Smith *et al.*, 2021). Following the cascading principle, priority should be given to the use of biomass in long-lasting products.

Soil carbon management is another promising nature-based solution for sequestering carbon in agricultural landscapes, potentially mitigating up to 0.7 – 11 $GtCO_2$ annually (Fuss *et al.*, 2018). The wide variance in mitigation potential owes to the fact that all current global estimates have focused on only single practices, which will not be appropriate for every context (e.g. croplands and dryland ecosystems will require different management strategies). This once again highlights the need for context-specific mitigation solutions and local knowledge.

Another important nature-based solution is peatland restoration. These biologically diverse ecosystems cover only ~3% of land area globally but store more carbon than any other terrestrial ecosystem (Joosten *et al.*, 2016). To date, roughly 500,000 km^2 have been drained for agriculture, peat extraction and forestry (Kreyling *et al.*, 2021). Drainage of intact peatlands threatens their biodiversity and impairs their provisioning of ecosystem services. Oxidation in drained peatlands is responsible for about 5% of the global anthropogenic greenhouse gas emissions (Kreyling *et al.*, 2021). Rewetting these drained peatlands can immediately strongly reduce – or even entirely halt – the net loss of carbon. Compliance with the Paris Agreement will require a large share of currently drained peatlands to be rewetted (Humpenöder *et al.*, 2020; Kreyling *et al.*, 2021). Fortunately, from an aggregate economic perspective, the trade-offs between peatland restoration and agricultural production have been estimated to be small (Humpenöder *et al.*, 2020). Within the European Union, peatland restoration could be facilitated by removing counterproductive incentives within the Common Agricultural Policy (Pe'er *et al.*, 2020). In particular, these incentives should be replaced with those rewarding the protection and restorative use of peatlands (Greifswald Mire Center, 2021). One example of this is paludiculture, or cultivating agricultural products in a peatland environment, which is a promising alternative to natural restoration that would enable the productive use of wet and rewetted peatlands (e.g. for building materials; Greifswald Mire Center, 2021).

Successful measures within the land system will not focus on maximizing carbon sequestration alone, but will also promote biodiversity and the provisioning of ecosystem services. Aside from the preservation of remaining intact natural ecosystems and biodiversity hotspots, policymakers should particularly focus on improving the health and resilience of agricultural landscapes, as the functioning of these landscapes is vital to the long-term integrity of the food system. Key levers for facilitating this transformation will be the diversification of agricultural practices and embedding natural or semi-natural habitats into these landscapes. The diversification of agricultural practices could include, for example, organic amendment, reducing tillage, or increasing the diversity of crop types. These practices have been conclusively shown to promote

the provisioning of ecosystem services (e.g. pollination, nutrient cycling, and water regulation) without compromising – and often increasing – agricultural yields (Tamburini *et al.*, 2020). Another method for safeguarding biodiversity and providing ecosystem services is to withhold and protect a certain share of natural or semi-natural habitats within working lands. These areas would be comprised of existing tracts of native habitat, but also include currently managed land with lower productivity, and ecologically sensitive areas like river margins, with a 20% target for protection and restoration considered effective in maintaining ecological functions with little or no trade-off with agricultural production at landscape level (Garibaldi *et al.*, 2021). Together, these interventions will be critical components towards halting and eventually reversing biodiversity loss.

2.3 The path towards a sustainable land and food system

Without effective land-based mitigation, we will fail to meet the Paris Agreement, as global food production alone could push the climate system beyond the 1.5 °C target (Clark *et al.*, 2020). However, too narrow a view on climate solutions in the land sector may fail to exploit synergies between the different SDGs and could even exacerbate societal and environmental challenges. To embed climate mitigation into a broader sustainable transformation, it is critical to improve resource efficiency and reduce ecosystem degradation (e.g. due to depletion of freshwater resources, nitrogen pollution, and pesticide use) across all stages of the food system. With a comprehensive approach, it is possible to substantially ease the pressure on the land system, ensuring food security while sparing land for conservation and land-based climate mitigation (Beintema, Pratt and Stads, 2020). Several priorities are foremost in ensuring this sustainable transformation.

First, reducing food losses and waste is effective in mitigating several food-related impacts simultaneously (Springmann *et al.*, 2018), e.g., decreasing reactive nitrogen requirements by up to 30 Mt yr^{-1} (Bodirsky et al., 2020; see also Figure 2-e above) and also lowering food prices (Stevanović *et al.*, 2017). Policies should target the whole food supply chain: in low-income countries investments in technological skills, storage, transport and agricultural infrastructure are required. In high-income countries, on the other hand, retailers, food service providers and consumers represent the highest potential to avoid food waste, for example by cultural shifts encouraged through education and rising awareness, and by technological solutions to extend shelf life as well as increasing economic incentives for their adoption (Parfitt, Barthel and Macnaughton, 2010; Cattaneo *et al.*, 2021).

Research and development (R&D) are also vital for reducing the amount of land needed for agriculture, as improved crop management and new technologies (e.g. breeding, pest management) enable to produce more food on less land by increasing crop productivity and the efficiency of livestock production (Wang *et al.*, 2020). Unfortunately, increasing yields may need higher nutrient and irrigation inputs, demanding that sustainability be embedded into R&D objectives (Gerten *et al.*, 2020). Further, the substitution of ruminant meat with plant-based or otherwise animal-free protein sources (e.g. microbial protein produced in bioreactors) could considerably reduce food-related environmental pressures, depending on how widely such alternative foods are adopted (Humpenöder *et al.*, 2022; Mazac *et al.*, 2022). To nurture technologies that increase yields and decrease pollution, or to potentially develop entirely new methods for food production, policymakers should strive to construct an environment with clearly communicated, predictable and consistent incentives (Herrero *et al.*, 2021). In particular, outcome-oriented market incentives that do not prescribe specific technologies are crucial and can be created by, for example, pricing externalities at the point of pollution.

On the demand side, a shift towards healthier diets, rich in plant-based proteins, fruits, vegetables, and nuts, e.g. according to the EAT-Lancet recommendations (Willett *et al.*, 2019), has been consistently found to be an especially impactful measure in reducing the pressure for land and water driven by the agricultural system (Figure 3; Springmann *et al.*, 2018; Soergel, Kriegler, Weindl, *et al.*, 2021; Doelman *et al.*, 2022). This effect emerges because the production of livestock dominates our current land use, with 80% of agricultural land being directly or indirectly driven by livestock production (Steinfeld *et al.*, 2006). Since these diets reduce – although do not necessarily eliminate – livestock products such as beef, they would free land that is currently devoted to livestock or feed crops for other purposes. This leads to substantial co-benefits. For example, as more land is available for the production of staple crops, food prices would be reduced and food security improved (Stevanović *et al.*, 2017).

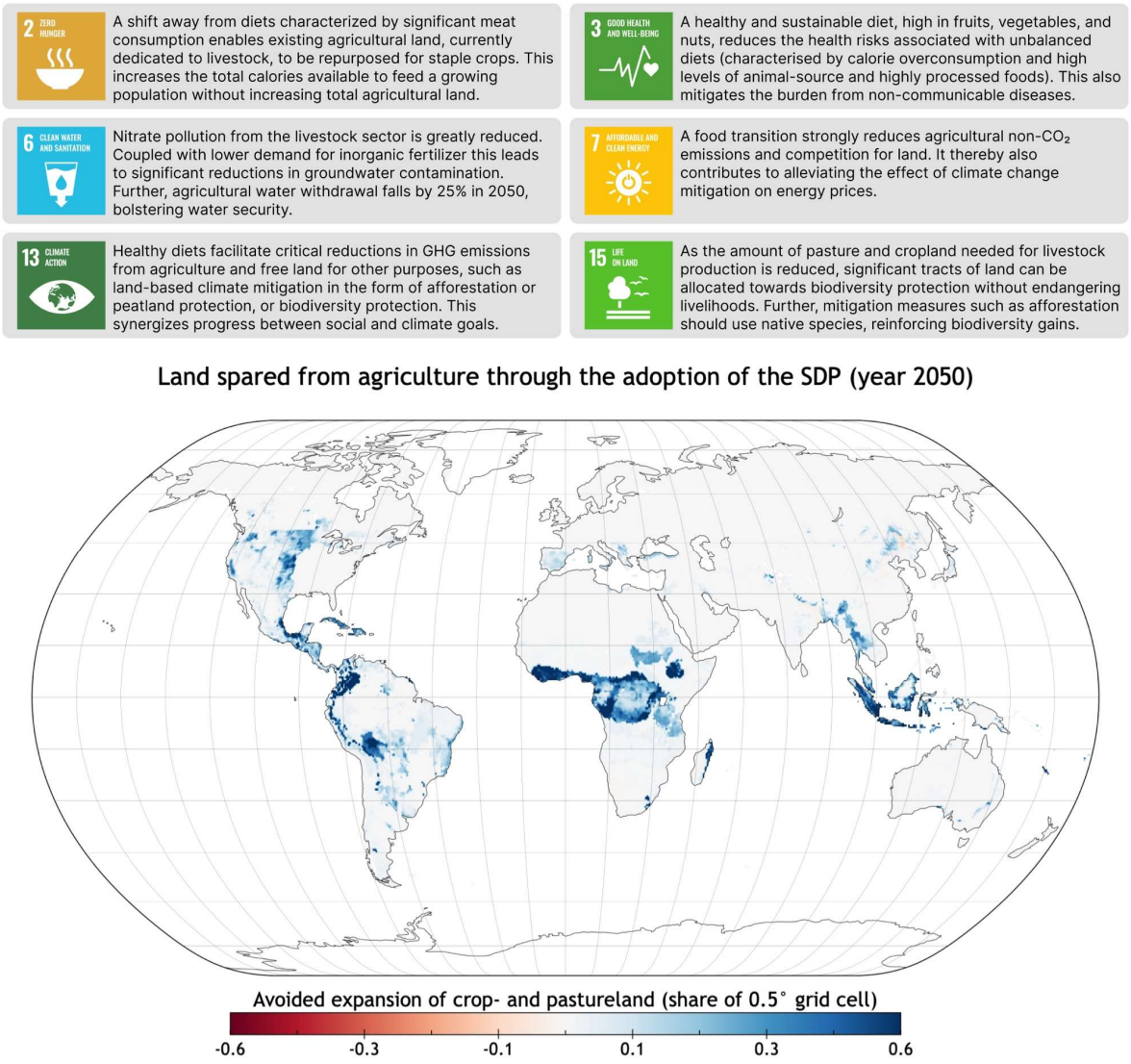

***Figure 3**: **Top:** The co-benefits of healthier diets for the SDGs: A transition towards healthy diets according to the EAT-Lancet recommendations, with a high share of plant-based proteins, fruits, vegetables and nuts, directly improves six SDGs. **Bottom:** Because healthy diets reduce the pressure of food production on the land system, they facilitate all SDGs that require land. In combination with other agricultural sustainability and efficiency measures, significant tracts of land, specifically in some of the most biodiverse areas in the world, could be spared from agricultural expansion by 2050 (comparison of SDP scenario to a reference scenario).*

Fewer livestock would also strongly reduce agricultural CH_4 and N_2O emissions, which in turn contributes to meeting the 1.5 °C target with up to 100 Gt more CO_2 emissions (Soergel, Kriegler, Weindl, *et al.*, 2021). The combination of policies adopted in the SDP scenario reduces agricultural CH_4 emissions from over 150 Mt CH_4 yr^{-1} in the year 2020 to roughly 35 Mt CH_4 yr^{-1} in 2050. As enteric fermentation and manure management contribute roughly 30% of the total anthropogenic CH_4 emissions (Reisinger *et al.*, 2021), healthier diets – combined with technological improvements – would be an important contribution to achieving the reductions required for 2030 by the Global Methane Pledge (GMP) signed at COP26.

Moreover, the adoption of healthier diets would also reduce the burden of non-communicable diseases, increasing quality of life globally (Kyu *et al.*, 2018; Willett *et al.*, 2019; Bodirsky *et al.*, 2020) and saving billions in health care costs per year (Springmann *et al.*, 2016). Less pressure for agricultural expansion would reduce and eventually halt deforestation, and significant tracks of land once used for agriculture could even be repurposed towards afforestation, biodiversity protection (Leclère *et al.*, 2020), and – in moderation – for raw materials in a sustainable bio-economy.

Thus, fostering the adoption of healthier diets is a clear target for policymakers seeking to ensure a sustainable land-use transformation, especially in countries with currently high meat and dairy consumption. A policy mix of market-based policies involving financial (dis)incentives, of administrative instruments targeting food standards and procurement in public areas such as schools, information policies including dietary guidelines, and behavioral instruments affecting the food environment is considered to be most effective in changing food consumption patterns, especially if guided by the twofold objective of human health and biosphere integrity (Temme *et al.*, 2020; Gaupp *et al.*, 2021). Such dietary shifts would be particularly impactful in view of multiple sustainability benefits when paired with measures promoting land-based mitigation and biodiversity protection.

3 Just transition

A just transition towards a sustainable and climate friendly economy has many aspects: an equitable sharing of climate mitigation costs across households (Section 3.1) and countries (Section 3.2) to buffer the impact on low-income households and the poor, as well as measures to absorb the impact on employment and investment in sectors that will shrink during the transition (Section 3.3). Combining sustainable development and climate mitigation policies with ancillary policies redirecting investments and employment, fostering structural change, and compensating income losses are key elements of establishing a just transition. Revenues from carbon pricing can be an important source of income to provide governments with the fiscal latitude that is needed for implementing such policies (see also Section 4). It is important to highlight that the transition is in itself a contribution to a more just society. Impacts from climate change and unsustainable development will fall disproportionately on the poor (Hallegatte *et al.*, 2016), and as such avoiding the worst of these impacts will help to avoid the associated worsening of poverty and inequality.

3.1 Domestic carbon pricing and redistribution policies in high-income countries

The design of climate policies is key to implementing them in an equitable way, and thus also matters for public acceptance of these policies. As they affect the prices of transportation, heating and electricity, as well as those of carbon-intensive goods, policies need to be designed in a way that especially low-income households can cope with these changes. A prime concern often voiced about carbon pricing is that its direct effects are regressive in many high-income countries, since on average low-income households spend a higher share of their income on energy (Ohlendorf *et al.*, 2021). Concerns about the impact of carbon pricing for households have led to public opposition, notably in France with the Yellow Vest movement following a planned raise in the level of carbon price. Indeed the carbon price applied to transportation and heating in France is regressive (Berry, 2019; Douenne, 2020). However, comprehensive carbon pricing across all sectors has been found to have a neutral incidence in many European countries, and even a mildly progressive incidence in some countries, including France. This is the case because, unlike direct energy use, indirect carbon use increases on average faster than proportional with income (Feindt *et al.*, 2021).

Household surveys also reveal that there is a large variation of policy costs within income groups due to heterogeneity in households' access to low-carbon technologies. Thus, hardship cases of poor households locked into high carbon technologies (e.g. retirees with oil heating, long distance commuters without access to public transport) require special attention (Hänsel *et al.*, 2021). However, in this context it is important to note that the effects even of an ambitious carbon price are smaller than the financial burden caused by the current increases in energy prices (which is mainly driven by the strong increase in gas prices, Kalkuhl et al. (2022)). In addition to effects on expenditures, distributional effects can also arise from carbon pricing affecting the income of households, and some studies focusing on the U.S. suggest that these effects on incomes are progressive (Rausch, Metcalf and Reilly, 2011; Goulder *et al.*, 2019).

Other policy instruments like bans, standards and subsidies can also lead to adverse distributional effects. For the example of France, subsidies to electric vehicles and thermal renovations have been found to reduce the discrepancy between urban and rural households, but to aggravate the regressivity of the overall policy (Ravigné, Ghersi and Nadaud, 2022). In addition, such alternative instruments do not generate revenues that can be used for compensating policies. In the case of carbon pricing, however, its revenues can play a central role for designing equitable climate policies. Revenues can be directly redistributed to households as an equal-per capita "climate dividend" to counterbalance the increase in energy prices. As lower-income households typically

emit less CO_2 than higher-income households, their payout exceeds their additional energy expenditures, which leads to net benefits for poor households (Figure 4; see also Kalkuhl, Knopf and Edenhofer, 2021; Strefler et al., 2021). This combination of climate protection and positive social outcomes could increase societal acceptance of climate policies, and would thus likely enable a more rapid and stringent implementation. A mechanism for such per-capita payments could also be used for compensating temporary price spikes unrelated to climate policy (Kalkuhl *et al.*, 2022), so its introduction could pay off even if initial transaction costs are higher than when using other compensating schemes (Färber and Wieland, 2022).

Revenues (or part of the revenues) can also be used for other purposes, such as green spending, subsidizing carbon-free electricity or low-carbon transport options, or reducing other taxes. These alternatives can in some cases contribute to lowering the burden of the policy on vulnerable households and increase policy support. For instance, in Germany, a reduction in the electricity price via the counter-financing of the Renewable Energy Sources Act (EEG) levy could offset some of the price increase. To a certain degree, subsidizing carbon-free energy can also alleviate the burden on vulnerable groups (Hänsel *et al.*, 2021). However, many suggested alternative schemes do not appropriately alleviate the burden on low-income households (Figure 4).

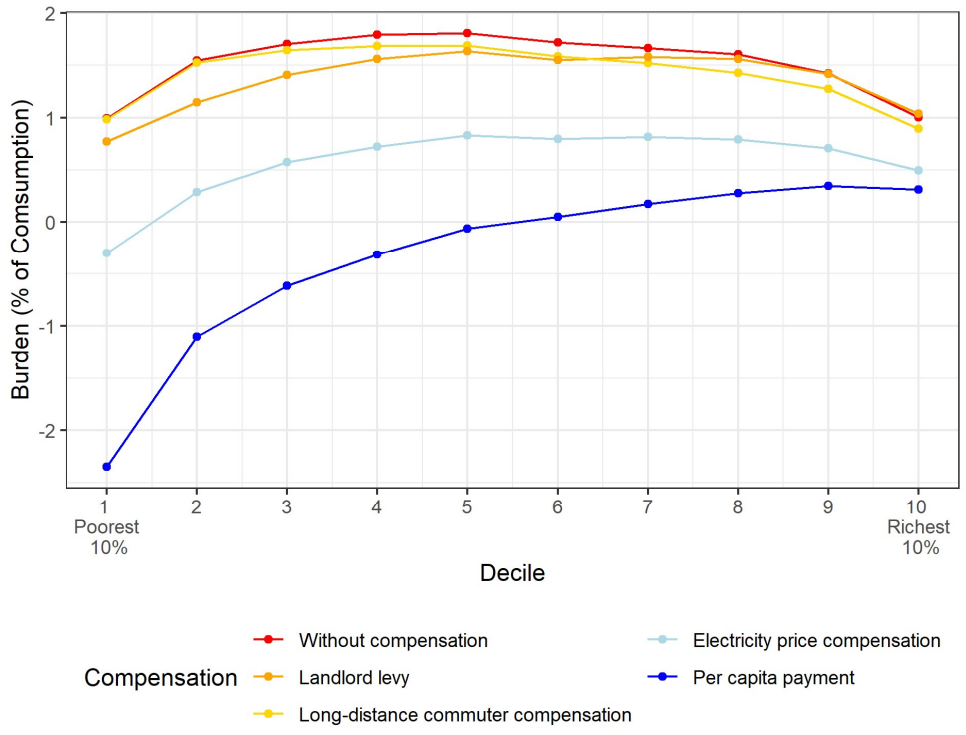

Figure 4: Incidence of a national CO_2 price of 100 EUR/tCO_2 on heating and transport fuels, without and with different compensation schemes in Germany*: Shown is the median value for each decile; values above zero are a net burden, values below zero a net gain. A carbon price without compensation (red) leads to a burden on all households, whereas a combination with an equal-per-capita payout of the revenues leads to a net gain for the poorer half of the population (blue). Most other suggested redistribution schemes fail to alleviate the burden on lower-income households. "Landlord levy" denotes a policy where only half of the CO_2 price burden on heating oil and gas is passed on to the tenant, whereas the other half is borne by the landlord. Data obtained from the MCC CO_2 price calculator[7] (Kalkuhl, Knopf and Edenhofer, 2021).*

[7] https://mcc-berlin.shinyapps.io/co2preisrechner/

Broadening beyond just carbon pricing, fiscal policy should generally better integrate environmental considerations. A substantial step into this direction could be taken by the removal of environmentally harmful subsidies. For the example of Germany, these subsidies amount to around 65 billion EUR per year (Stallmann, 2021); their removal could already lead to adjustments of consumer behavior and would free up money for green investments and/or additional redistribution policies. In a second step, taxation on environmental and/or health externalities beyond greenhouse gases (e.g. air pollution, eutrophication) could be introduced as part of a comprehensive environmental tax reform. These externalities are estimated to be at least 455 billion EUR annually in Germany (Kalkuhl *et al.*, 2021). Their taxation would lead to damages previously borne by the public being priced into market decisions, thereby reducing damaging activities and generating revenues for e.g. a reduction of other taxes.

3.2 International burden sharing and global poverty alleviation

A globally just transition in line with the Paris targets needs to recognize historical responsibility and current per-capita emissions, as well as the economic and technological capacity of countries. A widely shared perception of fairness will be critical to establish collective global action towards common goals. As a consequence, there is a requirement for high-income countries to lead the way, and to support the transition in low-income countries by means of international climate finance and technology transfers.

However, according to recent analysis (*Climate Action Tracker*, 2022) the NDCs of most high-income countries (including the EU and most other G7 countries) are currently rated as insufficient for reaching the 1.5°C target. Furthermore, the 2009 pledge by developed countries to provide 100 billion $ per year in international climate finance by 2020 (also recognized as SDG target 13.a) has so far not been fulfilled.[8] Therefore a further strengthening of the NDCs, as well as closing the gap on international climate finance should be a priority for international climate diplomacy. Simultaneously, the negotiations on a longer-term framework for international climate finance need to be advanced, recognising that the requirements for international finance for mitigation and adaptation investments and compensation for climate damages substantially exceed the currently pledged 100 billion $ annually.

In the sustainable development pathway scenario introduced in Section 1, we propose a globally just transition strategy consisting of the following pillars:

- All countries adopt a carbon price, but the price level is differentiated between countries based on per-capita income levels. Low-income countries initially face very low carbon prices, but gradually converge to the higher price level of high-income countries, leading to a globally uniform carbon price by 2050. This reflects not only the capacity of countries, but also takes into account a key trade-off in international climate policy between efficiency and sovereignty.[9] It furthermore results in a desirable sequence of rich countries taking the lead on new technologies and developing regions scaling new options up once they are more mature and cheaper. A first step into such a staged accession to international carbon pricing could be an open climate club where joining countries commit to a minimum carbon price, which however depends on their income level.

[8] The latest available figures from the OECD state a total of just below 80 billion $ for 2019, however its true value according to an Oxfam estimate (counting loans at reduced interest rate by their grant equivalent) is only around a third of the stated sum (Timperley, 2021, and references therein).

[9] International transfers required for a fair effort sharing are high in the efficient (lowest global costs) situation of uniform carbon prices, which can be perceived as infringing with countries' sovereignty. However, the requirement for international transfers can be substantially reduced by a moderate differentiation of carbon prices (Bauer *et al.*, 2020). Furthermore, while strong differentiation leads to strong asynchronicity of sectoral transformations across countries, and thus negative leakage effects, a moderate differentiation ameliorates this effect.

- A fraction of the carbon pricing revenues from high-income countries is earmarked for international climate and development finance. It could be used for direct cash transfers in order to improve the income situation of poor households in the Global South who are affected most strongly by energy and food price increases related to climate policies. Alternatively, part of the revenues could also be used for funding infrastructure investments towards the SDGs (see also Section 4).

Such a globally just transition strategy would contribute to the reduction of especially extreme poverty (Soergel, Kriegler, Bodirsky, *et al.*, 2021), and thereby creates a direct link between climate change mitigation and sustainable development policies. Such a link could be an important entry point to climate policy especially for low- and middle-income countries.

3.3 Employment and investment implications

Another key concern for a just transition is the livelihood of workers, both within and across countries. Fossil fuel related jobs, though not dominant in total numbers, play an important role in various regions, both in high-income countries and developing countries. Therefore, an energy transition that leads to a fast decrease of fossil fuel use will put a disproportionate burden on the livelihoods in such regions. Independent of climate policy, fossil fuel jobs will decrease in coming decades, while jobs related to renewable energies will increase strongly (Malik *et al.*, 2021; Pai *et al.*, 2021). Ambitious mitigation will accelerate both processes. Actively managing this transition, e.g. via early diversification of energy sector solutions where possible (Malik and Bertram, 2022) or alternative industries is important for improving the political feasibility of the energy transition (Kriegler *et al.*, 2020).

A just transition is also influenced by the redirection of investments needed to implement the transition. One area of particular importance is energy investment needs (McCollum *et al.*, 2018; Bertram *et al.*, 2021), which need to increase from an average of 1.6 trillion US$/yr from 2015-2020 to 2.2-4.6 trillion US$/yr in 2030 in order to limit warming to 1.5°C with low or no overshoot. 80% of those investments are in non-fossil technologies and roughly two thirds in non-OECD countries (Bertram *et al.*, 2021). Given that many low-carbon technologies are capital-intensive compared to fossil technologies, financing needs are a crucial hurdle especially in developing countries where interest rates are higher (Ondraczek, Komendantova and Patt, 2015). Therefore, de-risking solutions and the mobilisation of additional public and private investments (both domestic and external) play an important role in a comprehensive just transition strategy (see more detailed discussion in Section 4). Partnerships such as the recently announced Just Energy Transition Partnership[10] between various European countries, the EU, US and South Africa can play an important role in this context. It is important that such partnerships are extended to more countries with significant coal infrastructure soon, and that similar initiatives are also developed for countries that currently look into leapfrogging options to avoid coal lock-in in the first place.

[10] https://ec.europa.eu/commission/presscorner/detail/en/IP_21_5768

4 Investment needs and fiscal space for the SDGs

Achieving the SDGs will require substantial investments especially in low- and middle-income countries. This section reviews financing needs and discusses how they can be met by a combination of both public and private, and domestic and external funds. We highlight the potential of carbon pricing to expand the fiscal space for domestic investments into SDG-related infrastructure while simultaneously reducing emissions. This creates a synergy between development and climate policy.

4.1 Investment needs and sources of finance for sustainable development

An assessment by the World Bank (Rozenberg and Fay, 2019) estimates an annual total investment need of 1.5 trillion $/yr in low-and middle-income countries (4.5% of GDP) in order to achieve the infrastructure-related SDGs (electricity - including its decarbonization, transport, water & sanitation, flood protection and irrigation). Investment needs vary substantially with the ambition level of the goals, but also the assumed spending efficiency plays an important role (total range: 2 to 8% of GDP). Estimates of the global investment gap (the additional investments required above current trends) for meeting SDGs 2-4 (zero hunger, health and education) also span a broad range, but are likely in the range of up to a few hundred billion $ per year for each of these SDGs (Kulkarni *et al.*, 2022). Climate change mitigation (SDG 13) is likely the SDG with the largest investment gap, estimated at around 1-2 trillion $ annually, but again with a large range between different estimates (Section 3.3, Kreibiehl *et al.*, 2022; Kulkarni *et al.*, 2022; Pathak *et al.*, 2022).

While these large numbers at first appear daunting, it is important to note that different types of funding sources can be designed to mutually reinforce each other. Funding sources can be differentiated along the dimensions of private vs. public, and domestic vs. external. Typically, roughly half of the investment gap could be covered by private investment, but countries differ with regard to the SDG areas that require the most financing, and also with regard to the expected availability of private finance. Figure 5 shows annual per capita costs of achieving the SDGs for selected developing countries, a breakdown by investment area, and the share that could be covered by private investments (Franks *et al.*, 2018). While private finance could make an important contribution towards reaching certain SDGs (e.g. certain types of infrastructure, Granoff, Hogarth and Miller, 2016), it is not equally suitable for all SDGs, and unlikely to fully cover the entire SDG agenda. Therefore, also public finance is needed to finance SDG-related investments.

Concerning external financing, high–income countries have repeatedly pledged to spend at least 0.7% of gross national income on official development assistance (ODA), however so far this pledge remains unfulfilled for all but a few countries. But even if it was fulfilled, the volume would still fall far short of the SDG financing needs (Adam *et al.*, 2015), and would likely not cover all SDG areas equally well. Further external sources of public finance include multilateral agencies, such as the World Bank, but also the European Global Gateway Strategy, the G7's Build Back Better Initiative or the Chinese Belt and Road Initiative. Those sources, however, also appear unlikely to fully finance the entire SDG agenda[11]. Thus, external public finance for financing SDGs should be directed to those countries with highest investment needs and lowest potential for domestic resource mobilization. Moreover, they should be used to help de-risk private investment (Steckel and Jakob, 2018).

[11] The Chinese Belt and Road Initiative, the largest of these programmes, provides resources that are, on average, equivalent to 13% (median 9%) of the national SDG investment needs compiled by Franks et al. (2018). However, only part of the resources of the BRI can be expected to directly fund SDG-related investments, so that the share of SDG investments covered is likely substantially lower. The funds mobilized by the European Global Gateway Strategy would cover only roughly 3% of those investment needs.

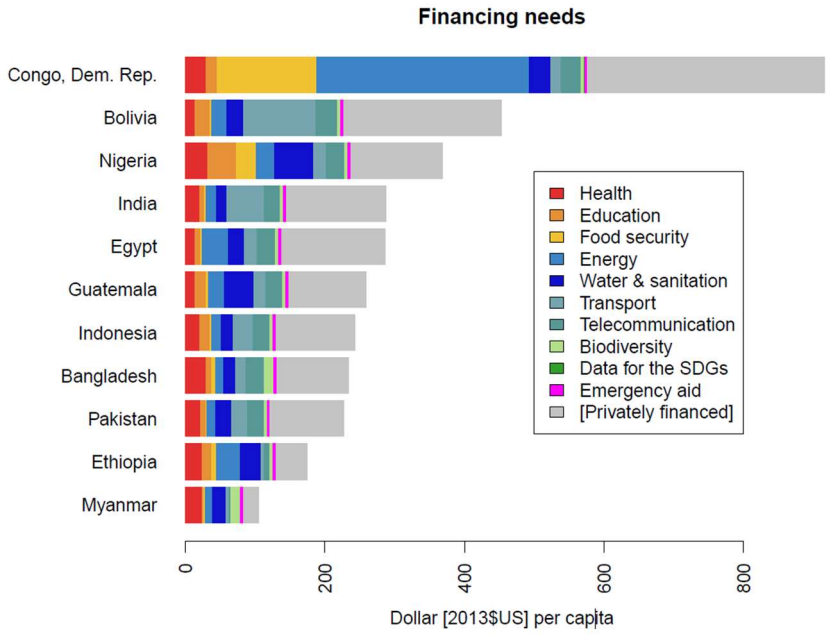

Figure 5: Per-capita annual costs of the respective SDG agenda of selected developing countries*. Financing needs of the different SDG investment areas that should be covered by public sources are distinguished using different colors. The needs that can be financed by private sources are aggregated and displayed in gray. The data set originates from Franks et al. (2018) and contains 68 countries. For illustration purpose we show only a subset here, focusing on countries with the highest population from each world region, as well as on those with the lowest and the highest investment needs.*

4.2 Expanding the fiscal space: Domestic public revenue potential of carbon pricing

Given the above, mobilizing domestic public finance can be expected to play an important role for sustainable development (Bhattacharya *et al.*, 2016). Developing countries frequently display low tax revenues, despite substantial public investment needs. In addition, due to low institutional and administrative capacities, public revenues are often generated through taxes that entail sizable economic distortions (Besley and Persson, 2014). Additional public revenues could be raised by improving administrative capacities to handle less distortionary taxes, such as corporate, income and value-added taxes, and to reduce tax evasion (Development Committee, 2015). Here, we want to emphasize the potential of carbon taxes as an efficient source of public finance. Carbon pricing can increase the efficiency of the tax system in countries with a large informal sector, as taxes on energy used in this sector are easier to collect than taxes on labor or capital (Liu, 2013; Markandya, González-Eguino and Escapa, 2013).

Carbon pricing and removal of fossil subsidies can create synergies between development and climate policy by raising public funds for SDG investments while at the same time reducing CO_2 emissions (SDG 13). However, many countries (including also high-income countries) not only lack a carbon price, but on the contrary, subsidize fossil fuel use, thus effectively putting a negative price on carbon emissions. Removing economically inefficient and environmentally harmful subsidies (in combination with appropriate adjustments of redistributive tax systems, see Section 3) is thus an important first step towards implementing positive carbon prices.

Here we take a country-specific look at both financing needs and sources of finance to show how governments can expand their fiscal space and make substantial contributions to sustainable development (Franks *et al.*, 2018). On the financing needs side, the costs of achieving the SDGs are calculated based on ten SDG investment areas for which individual cost estimates can be obtained

from country-level data.[12] As more recent global cost-estimates (Kulkarni *et al.*, 2022) tend to revise costs upwards, this should be considered a lower bound on investment needs. Note that here no direct transfers to vulnerable groups are included in these financing needs, i.e. poverty eradication is assumed to be achieved by the combination of investments in health, education and food security. Therefore, this section provides a complementary picture to the direct redistribution policies discussed in Section 3.1 (noting, of course, that the revenues can be spent only once).

On the financing sources side, we consider a removal of fossil fuel subsidies and the introduction of national carbon prices consistent with the 1.5°C target, with price levels differentiated between countries by income level as in the Sustainable Development Pathway scenario (see Sections 1 and 3.2).[13] This focuses on the domestic revenue raising potential; international transfer schemes such as the Green Climate Fund or the transfer scheme described in Section 3.2 (or any other form of international cooperation) can further increase the funding base. However, using such funds for SDG-related investments in low- and middle-income countries would likely require a broadening of the scope of international climate finance, aiming for a more integrated climate and development financing approach.

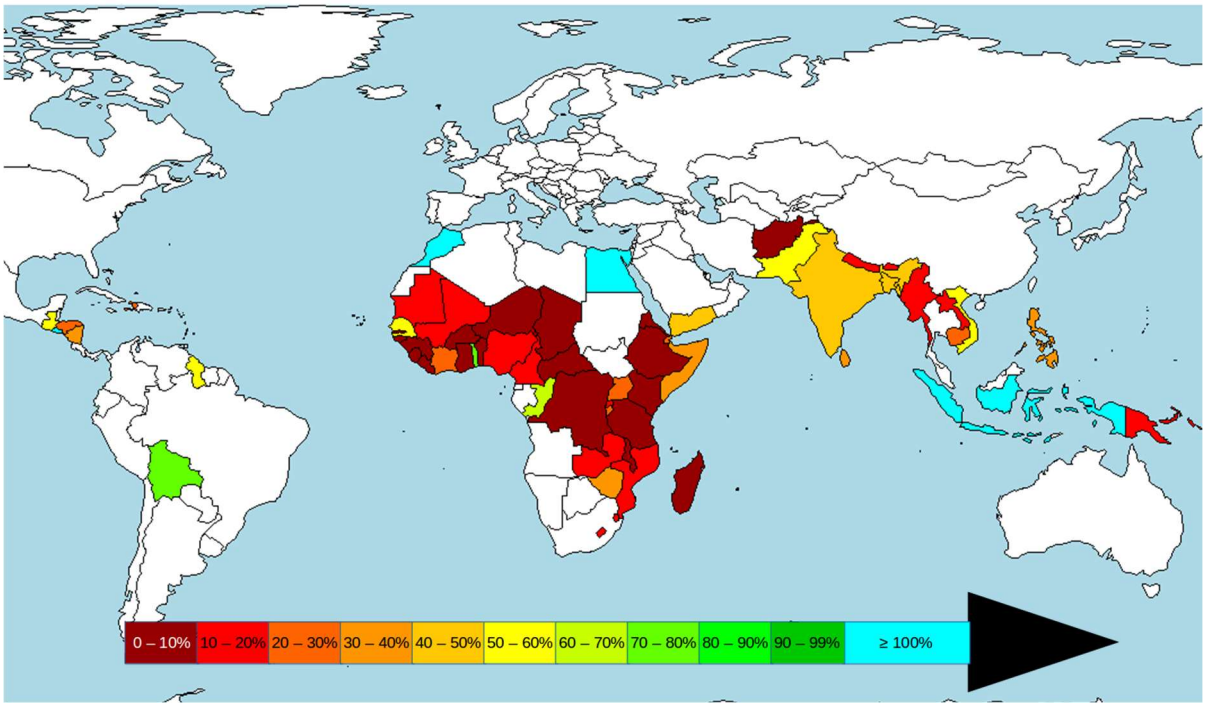

Figure 6: Fraction of public financing needs for the SDGs that could be financed by a removal of fossil-fuel subsidies and a carbon price consistent with the 1.5°C target *(calculated for the period 2020 to 2030). Note that as a result of the calculation method, variation between countries of the same world region is driven mostly by differences in financing needs. For countries colored in white, the available data was not sufficient to calculate the financing needs of the entire SDG agenda.*

[12] Health (Jamison *et al.*, 2013), education (UNESCO, 2015), food security (FAO, 2015), energy (Pachauri *et al.*, 2013), water and sanitation (Hutton and Varughese, 2016), transport, telecommunication (both from World Bank, 2013), biodiversity (CBD, 2012a, 2012b), data for the SDGs (Espey, 2015), and emergency aid.

[13] Carbon pricing revenues are calculated at the level of 12 world regions, and downscaled to country level by assuming the same ratio of revenues to GDP for all countries pertaining to the same world region. Variation of results within world regions are, thus, primarily driven by differences in SDG financing needs, and not by differences in revenue raising potential.

Figure 6 shows the fraction of the public financing needs for the SDG agenda that could be financed by such a national fiscal reform. In the median across countries, such a reform could create the fiscal space equivalent to 20% of the total SDG investment needs. However, the extent to which climate policy can contribute to financing the SDGs is highly country-specific. Countries differ with regard to the SDG areas that require the most financing and also with regard to the expected availability of private finance. Moreover, the potential to raise revenue via carbon pricing varies with the emission intensity and scale of economic activity.

Our analysis identifies many countries, predominantly in Asia, in which carbon pricing can cover a substantial share of the public revenues needed to finance SDG-related investments. For instance, the revenues in India could cover almost half of the entire public funds required to achieve the SDGs. Core infrastructure investments are typically the costliest component of the SDG financing needs, and these countries already have comparably high infrastructure stocks. Moreover, due to the high CO_2-intensity of their economies, carbon taxes have a relatively large tax base. In line with SDGs 16 and 17 (particularly target 17.1), international support for these countries should include a strengthening of local capacities in tax administration, in order to tap into this revenue raising potential. This should be embedded into a broader effort of capacity building for improving institutional quality and fostering good governance, which would also help with overcoming vested interests opposing such fiscal reforms.

On the other hand, for many other countries, mostly but not exclusively in Sub-Saharan Africa, national carbon pricing revenues would cover only a fraction of the required SDG investment needs. Nonetheless, carbon pricing could contribute to their national strategy to strengthen domestic revenue mobilization as called for by the Addis Ababa Action Agenda (*Addis Ababa Action Agenda of the Third International Conference on Financing for Development*, 2015) and the G20's Compact with Africa. It is, however, of special importance to strengthen international investments and support for countries where the domestic revenue raising potential is limited. In this context, the Green Climate Fund, but also international initiatives like the EU's Global Gateway Strategy or the G7's Build Back Better World Initiative can play an important role, but also delivering on the pledge to spend 0.7% of GNI on development assistance is a necessity.

5 Synthesis and policy recommendations

The current, at best incremental, policies are not sufficient to tackle the prevailing global social and environmental crises of poverty, hunger, climate change and biodiversity loss. In order to safeguard the global commons of an intact climate and biosphere, and to ensure a decent living for all global citizens, a sea change in policy is urgently required.

Delivering on the SDGs, meeting the Paris climate targets, and protecting the biosphere form a highly interconnected agenda. Many policies targeting individual SDGs simultaneously also facilitate or enable a more ambitious protection of climate and ecosystems. This holds, for example, for policies targeting healthier nutrition, energy efficiency and more sustainable lifestyles, as well as climate-friendly infrastructure design. Eradicating poverty and reducing inequality, as well as fostering high-quality education, gender equality and good governance are crucial enabling factors for the required societal and systems transformations. International collaboration and international support especially for countries of the Global South are also necessary enabling conditions.

Vice versa, mitigating climate change and protecting biodiversity are prerequisites for many other targets of the SDG agenda. A failure to protect climate and ecosystems would jeopardize progress towards many other SDGs, not least because of the impacts of climate change and ecosystem destruction on human livelihoods.

We integrate these considerations into a *sustainable development pathway* with the following main pillars: i) **supporting human development** ii) **healthy and sustainable nutrition** and a **sustainable and biodiversity-friendly land use** system, iii) **carbon pricing** and national **redistribution of revenues**, iv) **international climate and development finance** to support poverty alleviation and infrastructure buildup, v) **enhanced energy access in the Global South, reduced energy consumption in the Global North**, and vi) **technology policies** for a sustainable energy system.

Such an integrated strategy substantially enhances progress towards the SDGs, and ensures meeting the Paris climate target and halting and reverting biodiversity loss. Leveraging the substantial synergies between different targets, while also carefully managing the trade-offs, is of crucial importance for this integrated strategy. Its implementation requires overcoming silo approaches that treat different aspects of the SDG agenda as largely separate issues. The more detailed policy recommendations in the three focal areas of this report are therefore designed to integrate into a coherent policy approach.

Nature-based solutions and a sustainable land and food system

We recommend supporting and encouraging the emerging trends towards healthier, more sustainable, and more plant-based nutrition and diets, especially given their profound beneficial effects for climate, environment and human health. Public-sector consumption (e.g. in canteens of education institutions and government agencies) is one important policy lever, and should shift towards considerably lower meat consumption for health reasons alone.

The protection of remaining forests and other carbon-rich ecosystems (e.g. peatlands) is one of the most cost-effective measures to mitigate climate change from the perspective of land use. Reforestation and afforestation will also be necessary to meet the Paris climate targets, but should be accomplished with native species to respond to the biodiversity crisis and improve resilience to climate change impacts. It is vital for the implementation of these measures to consider local circumstances and repercussions on international food markets,

in order to avoid negative side-effects on livelihoods and food security. Leveraging indigenous and other forms of local experience will improve the likelihood of the success of these interventions.

In order to halt and reverse biodiversity loss, the conversion of remaining intact ecosystems, wilderness and biodiversity hotspots needs to be stopped. Furthermore, in working lands 20% of the area should remain as natural or semi-natural habitats in order to maintain their ecological function (pollination, pest control, soil formation, water quality, habitat for biodiversity and connectivity). These protected areas could be composed of e.g. riparian buffers and hedgerows, but will vary based on local context. Therefore, these policies should be designed in partnership with local communities.

Counterproductive incentives that encourage the degradation of ecosystems – especially those key to climate mitigation and biodiversity protection – should be replaced with incentives and financing mechanisms that align the provisioning of public goods with environmental and societal sustainability. For instance, drainage-based agriculture is still eligible for area-based payments under the EU Common Agricultural Policy. This needs to be corrected, shifting incentives towards peatland restoration and paludiculture.

Just transition

In order to enable a just energy transition, ambitious carbon pricing in combination with a redistribution of the revenues should be the leading national climate policy instrument. In high-income countries, an equal-per-capita "climate dividend" is a fairly simple option that leads to net benefits for most lower-income households. Depending on the national context, other compensation measures should also be considered, however with careful attention towards actually targeting redistribution towards low-income households. For low-income countries, both direct redistribution policies for poverty alleviation, and investing in SDG-related infrastructure, are promising options.

At the international level, an equitable sharing of the climate change mitigation effort is required. Especially high-income countries need to further strengthen their NDCs, as well as their contributions to international climate finance. We recommend working towards a staged accession into a global carbon pricing scheme; as a first step a climate club committing to a minimum carbon price could be established. Low-income countries could initially introduce lower carbon prices, but gradually converge to the higher price level of high-income countries. In addition, a strong ramp-up of international climate finance could be financed from part of the carbon pricing revenues from high-income countries.

Additionally, employment implications of, and investment requirements for the energy transition must be included as part of a just transition strategy. Negative effects on employment especially in fossil-fuel dependent regions should be ameliorated, for example by establishing alternative industries in such regions. In order to overcome investment barriers in low-income countries, international investment support and de-risking solutions are needed, for example by creating just energy transition partnerships that support rapid coal phase-out plans.

Investment needs and fiscal space for the SDGs

Investment needs for the full SDG agenda including climate change mitigation are likely in the range of several trillion $ per year, however with a considerable range between different estimates. The largest part of these investment needs are infrastructure investments (including clean energy infrastructure) in low- and middle-income countries. The required funding could come from a combination of domestic and external, and public and

private sources. However, both private and external funding are unlikely to cover the full investment needs, and also not all SDGs to the same extent. Therefore, also a strengthening of domestic public financing capabilities is needed.

A removal of fossil fuel subsidies and the introduction of a national carbon price can contribute to financing SDG investment needs while simultaneously reducing emissions. Such a fiscal reform could also contribute to improving the efficiency of tax systems, especially in countries with large informal sectors. However, the fraction of SDG investment needs that can be covered by carbon pricing revenues and fossil fuel subsidy removal varies substantially across countries.

International support should include a strengthening of local capacities in tax administration, **especially in countries where carbon pricing revenues can finance substantial parts of the SDG agenda.** This needs to be embedded into a broader effort of capacity building for improving institutional quality and fostering good governance.

International financing for the SDG agenda should especially support low-income countries, most notably in Sub-Saharan Africa, where SDG financing needs are high and expected revenues from carbon pricing are low. This could include financing from the Green Climate Fund, the EU's Global Gateway Strategy, the G20 Compact with Africa or the G7's Build Back Better World Initiative. But also fulfilling the pledge of high-income countries to spend at least 0.7% of GNI on official development assistance is required.

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Potsdam Institute for Climate Impact Research

Potsdam Institute for Climate Impact Research (PIK) e.V.
Telegrafenberg A 31 · 14473 Potsdam · www.pik-potsdam.de