Chapter 13: National and Sub-national Policies and Institutions

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Executive Summary

I. Improved institutions and governance enable ambitious climate action and help bridge implementation gaps

- **Climate laws and national strategies are equally prevalent, and targets are more widely prevalent than reported in AR5** (*medium evidence, high agreement)***.** Climate laws that explicitly aim at GHG mitigation had been passed in 46 countries (of 194 studied) covering 44% of emissions in 2017. Climate laws enable mitigation by providing directional signals to actors through targets; creating law-backed implementation mechanisms and institutions; enabling coordination; creating the basis for transparency and accountability; mainstreaming mitigation into development processes; and creating focal points for collective action *(medium evidence, high agreement).* {13.2}

- **The scope of climate governance includes both direct efforts to target greenhouse gas emissions and mitigation resulting from efforts at achieving multiple mitigation and development objectives** (*robust evidence, high agreement*). {13.2, 13.3, 13.4, 13.6, 13.8, 13.9} As a result, climate laws, organisations and policies are best defined broadly to include both direct mitigation efforts and those embedded in multiple objectives (*robust evidence, high agreement)*. {13.2, 13.6}

- **Enhanced climate governance can help bridge the ambition gap by setting strategic direction and narrow the implementation gap by ensuring coordination across ministries and levels of governance, and by providing forms of engagement and mediation with stakeholders and actors with divergent interests.** Climate governance includes formal laws, strategies and governmental organisations, but also private governance such as partnerships and voluntary associations (*robust evidence, high agreement)*. {13.2, 13.3, 13.4}

- **National climate institutions are more likely to emerge, persist and be effective when they are consistent with a framing of climate change that has broad national political support.** While mitigation focused institutions may win political support in some countries, in other cases sector focused or institutions oriented to multiple-objectives may be effective and stable (*robust evidence, high agreement)*. {13.2, 13.8}

- **Governance for climate mitigation and shifting development pathways is enhanced when it is tailored to national contexts and circumstance – there is no single template across countries.** Material endowments and level of economic development; domestic political systems; and cultural understandings shape domestic climate governance, and their effects can be addressed by appropriate policies, changing public perception and explicitly seeking co-benefits. The context-specific roles played by different actors such as regulators, business, civil society, indigenous communities and politicians are also salient to the design and functioning of climate governance (*robust evidence, medium agreement)*. {13.2, 13.4}

- **Sub-national and urban actors are playing a growing role in climate governance, ensuring that local concerns are factored into decision-making and that implementation is attentive to local context**. The extent of impact of these outcomes varies widely, and the scope is uneven, with fewer initiatives in developing countries. In addition to direct impacts, there are indirect benefits such as policy innovation and establishment of new norms of action (*robust evidence, high agreement)*. {13.3}

- **Explicit attention to equity and justice is salient to fair and effective climate policymaking.** Distributional implications of alternative climate policy choices are usefully evaluated at city, local and national scales as an input to policymaking. Institutions and governance frameworks that address equity implications and creation of narratives that allow for promotion of just transitions are likely to build broader support for climate policymaking) (*robust evidence, high agreement).* {13.2, 13.3, 13,6, 13.8, 13.9}

II. Because climate change is a multiscale, dynamic phenomenon, climate policymaking is a process that involves multiple actors, multiple objectives, cultural factors and citizen engagement.

- **Climate policymaking is mobilised, influenced and adopted by a number of actors including corporate actors, politicians, international organisations, environmental organisations, and civil society.** Governments are key decision-makers and adopters of climate policies. Civic, economic and political actors are to varying degrees mobilized in climate governance processes and their roles and importance vary across countries, across sectors; and issues (*medium agreement, medium evidence*). {13.4}
- **Cultural institutions, such as norms, worldviews, and traditions, shape policy measures and their perception.** Although they change slowly, cultural factors are malleable and therefore cultural change can create shifts in the attractiveness of different policy options *(robust evidence, high agreement)*. {13.4, 13.5}
- **Citizen engagement can enable accelerated mitigation action and stimulate individual behaviour change toward low-emissions futures.** Citizen action, operating through lobbying, litigation, shareholder activism, and voting, as well as boycotting, striking, protesting, and other direct actions can influence policymakers, regulators and businesses to accelerate their efforts, including the adoption of more ambitious policies. Citizen action can also spur behavioural change and local organisational initiatives, such as energy cooperatives *(medium evidence, medium agreement)*. {13.5}
- **Media, including social media, influence public support for and engagement with mitigation action, but media have also been used to spread misinformation about the causes and consequences of climate change** (*robust evidence; high agreement*). Media coverage of climate change increased notably and influenced public discussion, but such increases were not evenly distributed among countries *(robust evidence, high agreement)*. {13.4}
- **Climate litigation has been used as an instrument to debate, enforce, augment, or challenge climate legislation.** The majority of climate change litigation cases are brought against governments by citizens, corporations, NGOs and political parties, and occasionally across levels of government. The effectiveness of litigation actions is not established but they potentially contribute to mitigation actions directly via court decisions and indirectly by building narratives to fight climate change *(robust evidence, medium agreement)*. {13.5}
- **Building broader public support for action is shaped by individual and collective voices in the public sphere, the role of the media, the potential for organised civic engagement, and the opportunities to utilise other institutional channels like courts for civil action.** Citizens in developed nations report higher awareness of climate change than in developing nations and acknowledge a considerable link between lifestyle and climate change. Attitudes to climate policy measures are also influenced by values, political orientation, and social norms. Policies that bring benefits to individuals, such as subsidies and earmarking, usually receive greater support. The awareness of co-benefits for the public increases support of climate policies *(robust evidence, high agreement)*. {13.4, 13.5}

III. Policy instruments enable mitigation when they have wide coverage, are stringent and well-designed, but vary in their economic effects, their potential to achieve transformative change, their distributional impacts, and whether and how they achieve other policy objectives.

- **The share of global GHG emissions subject to mitigation policies has increased over time (*robust evidence, high agreement*), yet a substantial share of global GHG emissions is not yet addressed by specific mitigation policies (*robust evidence, medium agreement*).** The prevalence of mitigation policies that use compulsory instruments, in particular emissions pricing and regulatory instruments, has increased relative to voluntary action and information programs *(robust evidence, high agreement)*. However, important categories of GHG emissions not yet covered by mitigation policies are CH_4, N_2O and CO_2 from production of basic materials and feedstocks, as well as combustion of fossil fuel in many developing and some developed countries *(robust evidence, medium agreement)*. {13.6}

- **Policy instruments can be evaluated according to multiple criteria including environmental effectiveness, economic effectiveness and efficiency, distributional effects, feasibility, co-benefits and adverse side-effects, institutional feasibility, and their transformative potential**. The transformative potential of policy instruments depends predominantly on the stringency of their implementation *(medium evidence, medium agreement)*. {13.6}

- **Market-based instruments are increasingly prevalent, with carbon pricing covering about 20%of global CO_2 emissions** *(robust evidence, high agreement)***.** Design choices shape outcomes, including sources covered, allowance distribution/tax exemptions, adjustments to the cap/tax, and use of the revenue generated. Deliberate use of revenue, including through distribution to consumers or taxpayers, can increase the social acceptance of market-based instruments *(robust evidence, high agreement).* {13.6}

- **Regulatory instruments play an important role in mitigation as a complement or alternative to emissions pricing.** Financial incentives and regulations for renewable energy have contributed to major cost reductions and large increases in installed capacity *(robust evidence, high agreement).* Other, voluntary approaches, such as information programs and voluntary agreements can reduce GHG emissions and support transformation towards low emissions systems *(robust evidence, high agreement).* {13.6}

- **Price and regulatory policies have distributional consequences for businesses and consumers which can be addressed through policy.** Regulations generally address distributional impacts through implementation provisions and sometimes by allowing compliance by trading between emissions sources. {13.6}

- **Most jurisdictions have multiple mitigation policies that interact and often overlap, as well as other policies that directly or indirectly affect GHG emissions.** These interactions tend to affect the effectiveness and costs as well as distributional effects, co-benefits and institutional aspects of emission reduction efforts *(robust evidence, high agreement)*. {13.6, 13.8}

- **The impact of international interactions of national mitigation policies can both negatively affect and benefit other countries.** For example, reductions in quantities and prices of fossil fuels produced and exported and the value of fossil fuel resources tend to negatively affect other countries (*medium evidence, high agreement*), while creation of markets for emission reduction credits, technology development and diffusion (spill-overs), tend to benefit other countries *(medium evidence, high agreement)*. {13.7}

IV. Accelerating climate mitigation and shifting sustainable development pathways is enabled when attention is given to integrated policy and cross-society responses, the presence of enabling conditions, inequality and exclusion, the overcoming of lock-ins, and mitigation and adaptation synergies.

- **Accelerated action on climate mitigation and shifting development pathways is enabled by integrating policy and cross-society responses to meet multiple and simultaneous objectives, including adaptation, equity and justice.** Policy integration requires attention to the overarching frame through which different policy objectives are integrated, to mechanisms to bring about that integration, and to supportive governance conditions. Well-designed policy mixes can support addressing multiple objectives and enabling transition but to do so they need to be comprehensive across approaches, have balance across objectives, and ensure consistency between design and objectives *(robust evidence, high agreement)*. {13.8, 13.9, 13.10, Figure 13.6, Cross-Chapter Box 4 in Chapter 4}
- **Developing countries are more likely to suffer from an "adaptation deficit" -- when a country is unable to respond to the current impacts of climate variability -- and will likely face more impacts of extreme events than developed countries.** Those countries usually produce marginal impact of emissions, and therefore climate adaptation and mitigation need to be considered in the context of broader political, economic and development goals. Adequate attention to adaptation is required because no level of mitigation erases the need for adaptation, although addressing mitigation and adaptation together provide particular challenges of integration. {13.8.2}
- **Transitioning to low carbon systems is helped by simultaneously weakening the multiple cultural, political and behavioural lock-ins which reinforce high carbon systems whilst encouraging low carbon systems.** Deliberate policy attention to phasing out subsidies for fossil fuels and appropriately deploying subsidies for a clean energy transition are important policy tools *(medium evidence, high agreement)*. {13.6, 13.8, 13.9}
- **Incremental climate action has been insufficient to deliver the necessary emission reductions.** Incremental changes can help accelerate mitigation actions by triggering cost reduction, technological innovation, and build support among a wide variety of actors. There continue to be gaps in these actions, including gaps in prevalence and stringency of policy, and existence and capacity of institutions *(robust evidence, high agreement)*. {13.9}
- **Accelerating mitigation action may be aided by alignment of a range of enabling conditions.** Ensuring enabling conditions (identified in SR1.5 as multi-level governance, institutional capacities, behavioural and lifestyles, technological innovation, policy, and financial systems) are in place is an essential complementary dimension of transforming systems and acceleration of GHG reduction. These conditions will differ in different countries and contexts *(robust evidence, high agreement)*. {13.9}
- **Cross-economy structural change provides opportunities for a comprehensive, coordinated approach to accelerate mitigation and shift development paths.** Lessons learned from the 2008-9 Global Recession are that policies for a sustained economic recovery go beyond short-term fiscal stimulus to include long-term commitments of public spending; parallel carbon pricing reform; and attention to distributional impacts. Simultaneous environmental and industrial objectives were achieved at no extra cost. COVID-19 has created the possibility of stimulus packages, multi-objective recovery policies and other strategies, which both meet short-term economic goals whilst also enabling longer-term, broader sustainability goals *(robust evidence; high agreement)*. {13.9}

13.1 Introduction

Chapter 13 addresses national and sub-national policies and institutions. New institutional forms, policy experiments and actions continually emerge in different national and sub-national jurisdictions, allowing analysis of trends and a degree of ex-post analysis of observed practice and performance.

Several important developments since AR5 motivate this chapter and have shaped its structure and contents:

This chapter examines institutions in addition to policy, recognising that institutional development is an important component of effective mitigation action. The scope of both institutions and policy are understood broadly, to include not only those that are not framed solely or primarily as mitigation-focused institutions and policies, but also those that have the effect of impacting climate outcomes. This is an expansion from AR5, as a great deal of relevant policy and climate action is formulated in the context of multiple policy objectives such as energy security, energy access, and urban development.

The chapter also examines the processes through which societies build agreement for enhanced action. It assesses different interests and actors that make, influence and implement policy, including attention to the role of media and the courts.

While the chapter focuses on possible incentives for economic actors through policy formulation, it also assesses the importance of behavioural and other social change (see also Chapter 5) as a necessary component of climate action.

The chapter lays out a range of assessment criteria to assess policies and their empirical outcomes, including environmental and economic effectiveness and distributional consequences, but also examining transformational potential, co-benefits and institutional requirements.

Different aspects of climate policy and different approaches to institutions are prevalent in different regions of the world, based on social, political and economic context and underlying priorities. Our assessment aims to be sensitive to these contextual variations and their underlying reasons.

The chapter takes close account of a literature arguing that just outcomes are a prerequisite for sustainable development, which in turn is a prerequisite for effective global climate change mitigation (see also Chapter 4). In particular, the chapter explores the distributional impacts of a policy, which can affect its acceptance, and notes that distributional impact in policy design can be an enabling condition for successful and accelerated climate mitigation.

Since mitigation policy is frequently pursued in the context of multiple objectives, the chapter pays close attention to efforts at policy integration to shift development pathways, address multiple objectives and explore mitigation and adaptation synergies. This assessment discusses the broad context, including governance enables and disablers, within which efforts at policy integration occur, and factors that go into successful development of policy mixes for multiple objectives and shifting development pathways.

Economic recovery and stimulus packages are a significant part of the context for this Assessment Report. This chapter assesses national policy packages for economic recovery and their implications for climate policymaking.

Since AR5, an emergent literature focuses on the prospects for accelerating mitigation action, beyond incremental change. This chapter assesses this emergent literature, including the prospects for a deeper socio-economic and technological transformation; the importance of aligning enabling conditions; and a strategic focus on breaking multiple lock-ins that reinforce high-carbon systems.

The chapter is arranged as follows:

Section 13.2 examines the spread of climate institutions, including enabling laws, coordinating formal governance institutions and their associated tasks. Section 13.3 explores subnational – including urban –

climate actions, policies and stakeholders. Section 13.4 examines the structural conditions through which national climate policies emerge, while Section 13.5 examines policy processes through the lens of various actors, or players, in the policy process, who influence, adopt and implement policy. Section 13.6 provides assessment of policy instruments and their interaction effects, including empirical evaluations of policy application. International interactions of policies are assessed in Section 13.7. Section 13.8 explores the linkages between multiple objectives of policy, and the role of policy integration for sustainable development, shifting development pathways, and addressing mitigation and adaptation linkages. Section 13.9 assesses conditions for system transformation; limits to incremental mitigation approaches; and how economy wide restructuring, sometimes in relation to COVID-19, interacts with the potential for acceleration of climate mitigation.

13.2 National institutions and governance

While there is considerable attention to an 'ambition gap' in climate action (Chapter 4, Section 4.2) (UNEP 2020; Höhne et al. 2020), effective action requires that the mechanisms are in place to also address a possible 'implementation gap' between aspiration and action. Institutions and governance arrangements are important because they help address the challenges of implementation in climate mitigation. While the need for institutions and governance is common, countries have followed different approaches in developing institutions and governance for climate mitigation, based on national approaches and national circumstances. This section discusses the forms of institutions, including legislation and governance arrangements for climate mitigation at the national level and coordination with the sub-national level.

Consistent with usage in this assessment, institutions are rules, norms and conventions that guide, constrain or enable behaviours and practices, while governance is the structure, processes and actions public and private actors use to address societal goals (see Annex A: Glossary for complete definitions). This section begins with a discussion of national legal frameworks for climate action, which set the overarching governance context in a specific country. It then turns to a brief discussion of national strategies, which typically are not legally binding but set guidance for action. The third section discusses institutions, including organisations that are established to govern climate actions, and the governance roles they perform.

13.2.1 Climate laws

Understanding national laws that governs climate action are an important starting point because they set the legal basis for climate action (Averchenkova et al. 2020). However, developing this understanding is challenging because there are both narrow and broad definitions of what counts as 'climate laws'. The literature distinguishes direct climate laws that explicitly considers climate change causes or impacts – for example through mention of greenhouse gas reductions in its objectives or title (Dubash et al. 2013) – from indirect laws that have "the capacity to affect mitigation or adaptation" through the subjects they regulate, for example, through promotion of co-benefits, or creation of reporting protocols (Scotford and Minas 2019). Some direct climate laws may serve as 'flagship' (Townshend et al. 2013) or 'framework' (Averchenkova et al. 2017; Rumble 2019) laws that sets an overarching legal context within which other legislation and policies operate.

Laws can serve several functions that enable climate action. They provide a signal to actors by indicating intent to harness state authority behind climate action (Scotford and Minas 2019); promise enhanced regulatory certainty (Scotford et al. 2017); facilitate action by creating law-backed agencies for coordination, compliance and accountability (Scotford and Minas 2019); establish a platform for transparent target setting and implementation (Bennett 2018); provide a basis for mainstreaming mitigation into sector action, and create focal points around which social mobilisation for mitigation can occur (Dubash et al. 2013). For small developing countries, in particular, the existence of a law may also attract international finance by serving as a signal of credibility (Fisher et al. 2017). The realisation of these potential governance gains depends on local context, legal design, successful implementation, and complementary action at different scales.

The prevalence of both direct and indirect climate laws has increased considerably since 2007, although definitional differences across studies complicate this assessment *(medium evidence, high agreement)*. Direct climate laws – with greenhouse gas reduction a direct objective -- had been passed in 46 countries (of 194 studied) covering 44% of emissions in 2017, an increase from 32 countries in 2007 accounting for 16% of emissions from those 194 countries (Iacobuta et al. 2018) (See Figure 13.1). When national climate strategies -- executive decisions focused specifically on climate change but are not passed by parliament -- are included, 69% of global emissions were covered by legislation or strategies in 2017 (See Figure 13.1). While few laws or strategies were added after 2012, emission targets became more prevalent between 2012 and 2017. Indirect laws - those that have an effect on mitigation even if this is not the primary outcome – is most closely captured by the "Climate Change Laws of the World" database, which illustrates the same trend of growing prevalence, documenting 1500 entries by 2018 versus 500 in 2013 (Nachmany and Setzer 2018).

Climate laws spreads through multiple mechanisms, including the impetus provided by international negotiation events, diffusion by example across countries, and factors that shape domestic context *(medium evidence, medium agreement)*. Landmark UNFCCC negotiation events are associated with increases in national legislation (Iacobuta et al. 2018), with a stronger effect in countries where international commitments are binding (Fankhauser et al. 2016). Diffusion through example of legislation from other countries has been documented (Fankhauser et al. 2016; Fleig et al. 2017; Torney 2017; Inderberg 2019; Torney 2019). For example, the UK Climate Change Act was an important influence in pursuing similar acts in Finland and Ireland (Torney 2019) and was also considered in the formulation of Mexico's General Law on Climate Change (Averchenkova and Guzman Luna 2018). The presence of a flagship climate law that creates a framework for policy is positively associated with creation of additional supportive legislation (Fankhauser et al. 2015). Domestic contextual factors can also affect the likelihood of legislation such as a weak business cycle that can deter legislation (Fankhauser et al. 2015). In several cases, civil society groups play a role as advocates for legislation (Lockwood 2013; Lorenzoni and Benson 2014; Carter and Childs 2018; Wagner and Ylä-Anttila 2018; Torney 2019).

The most common approach to climate legislation is creation of a framework law intended to provide a coherent legal basis for action, to integrate past legislation in related areas, set clear directions for future policy, and create necessary processes and institutions (Townshend et al. 2013; Averchenkova et al. 2017; Fankhauser et al. 2018; Rumble 2019; Averchenkova et al. 2020) *(medium evidence, medium agreement)*. Another approach is the layering of climate considerations into existing frameworks in the absence of an overarching framework law, which has been described as a distinct 'sectoral' approach to climate law (Rumble 2019). The proliferation of indirect legislation suggests that this is an approach that is widely practiced. For example, a study of Commonwealth countries finds that a majority of these countries have not taken the route of a single overarching law, but rather an array of laws across different areas (Scotford et al. 2017).

The lessons from examination of framework laws, and particularly the UK law which has a long track record, includes the need for statutory targets with a long-term direction, shorter term instruments such as carbon budgets to induce action toward targets, a clear assignment of duties and responsibilities including identification of policies and responsibility for their implementation, an independent body to support evidence-based decision making and rules to govern information collection and provision (Barton and Campion 2018; Fankhauser et al. 2018; Averchenkova et al. 2020). However, there are diverse approaches even among framework laws. Korea's Framework Act on Low Carbon, Green Growth seeks to shift Korean business and society toward green growth through a process of strategy setting and action plans (Jang et al. 2010). Kenya's framework Climate Change Act focuses on creation of institutional structure to mainstream climate considerations into sectoral decisions, one of several examples across Africa of efforts to create framework legislation to promote mainstreaming (Rumble 2019). Sectoral emission targets are included in

Mexico's General Law on Climate Change, along with the creation of coordinating institutions across ministries and sub-national authorities (Averchenkova and Guzman Luna 2018). Consequently, different countries have placed emphasis on different aspects of framework laws, although the most widely prevalent approach is that exemplified by the UK.

The empirical evidence on performance of framework laws suggests a mixed picture. While the structure of the UK Act successfully sets a direction of travel and has resulted in a credible independent body, it performs less well in fostering integration across sectoral areas and providing an enforcement mechanism (Averchenkova et al. 2020). A review of seven European climate change acts concludes that overall targets may not be entirely aligned with planning, reporting and evaluation mechanisms, and that sanction mechanisms are lacking across the board (Nash and Steurer 2019), which limit the scope for legislation to perform its integrative task.

There is extremely limited evidence on the aggregate effects of climate laws on climate outcomes. A single study of direct and indirect climate laws as well as relevant executive action finds that existing laws have a measurable and positive effect, reducing global annual emissions by about 5.9 $GtCO_2$ (Eskander and Fankhauser 2020). This preliminary analysis suggests the need for further research on the robustness of this finding, the relative impact of framework versus sectoral approaches, and the weight of the various mechanisms through which laws act –target setting, creating institutional structures, mainstreaming and ensuring compliance.

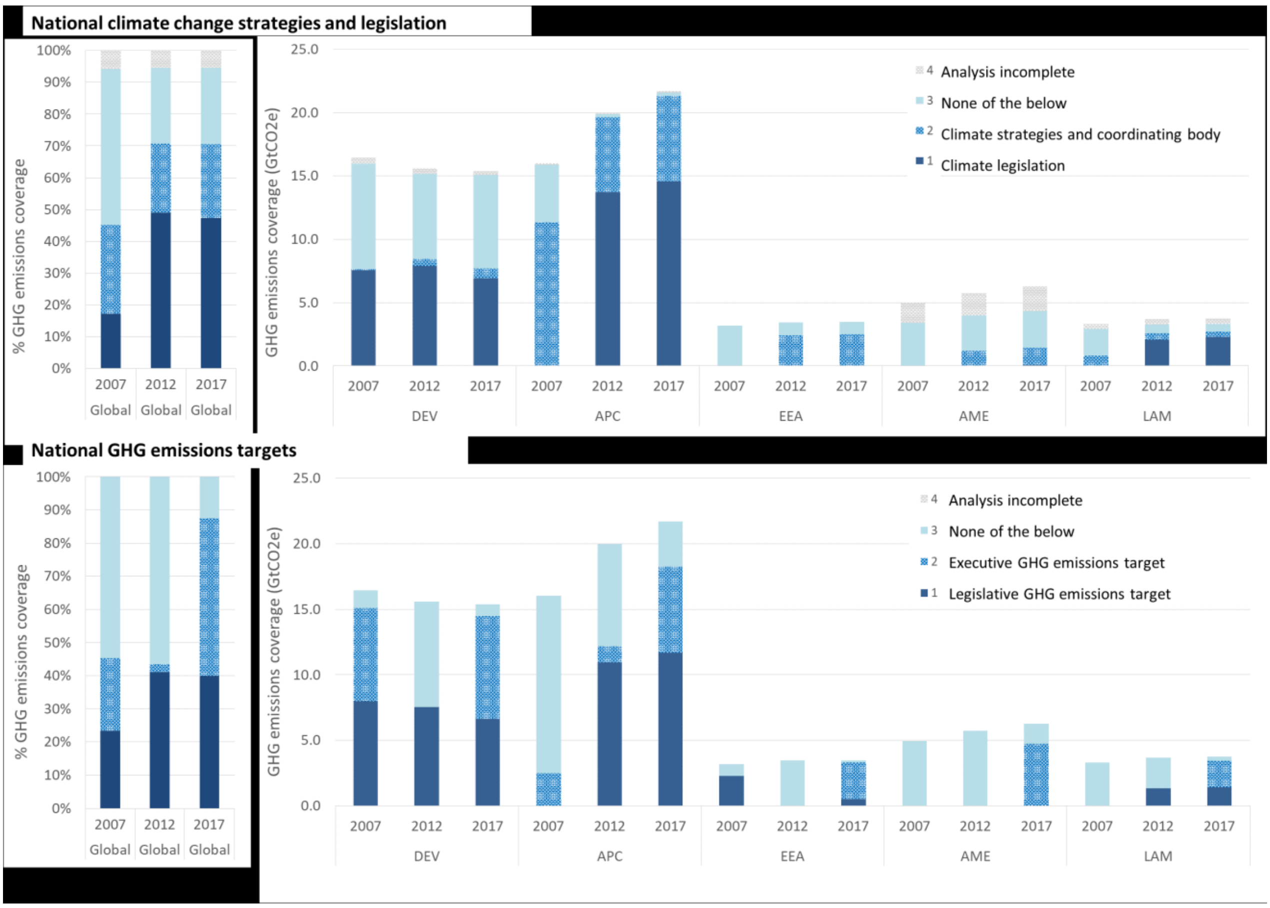

Figure 13.1 Prevalence of Legislation or Strategy and Emission Targets by Region

[Top: Shares of global GHG emissions under national climate change legislations and strategies; Bottom: Shares of global GHG emissions under executive or legislative national GHG emissions reduction targets – in 2007, 2012 and 2017. Adapted from (Iacobuta et al. 2018) *to reflect AR6 regional aggregation.*

Climate legislation is defined as an act passed by a parliament that includes in its title or objectives reductions in GHGs. Climate strategy is defined as a non-legislative plan or statement aimed at mitigation and that includes a coordinating body charged with implementation. International pledges are not included, nor are sub-national plans and strategies. Targets (GHG, renewables and energy efficiency) were included whenever they were defined in a policy or law, or in NDCs.

AR6 regions: DEV = Developed countries; EEA = Eastern Europe and West-Central Asia; LAM = Latin America and Caribbean; AME = Africa and Middle East; APC= Asia and developing Pacific.]

13.2.2 National strategies and Nationally Determined Contributions

Climate strategies formulated through executive action are an important part of the national governance context. National climate strategies and their regular revision can support long-term structural change by stimulating deliberation and learning (Voß et al. 2009). They enable discussion of low-emissions pathways while accounting for uncertainty, national circumstances and socio-economic objectives (Falduto and Rocha 2020). National climate strategies frequently set out long term goals and possible trajectories over time for emissions, with analysis of technological and economic factors (Levin et al. 2018; WRI 2020). This can include quantitative modelling of low-emissions transitions and their economic effects to inform policymakers and stakeholders of potential outcomes (Waisman et al. 2019; Weitzel et al. 2019). Scenario analysis can be used to explore how to make their strategies more robust in the face of uncertainty (Sato and Altamirano 2019). National climate strategies can also be used to make the link between mitigation and adaptation objectives and actions (Watkiss and Klein 2019; Hans et al. 2020). As part of the Paris Agreement process, several countries have prepared and submitted long-term low-emissions development strategies (Levin et al. 2018), while others have different forms of national climate change strategies independently of the UNFCCC process. The strategy setting process undertaken over time by the European Union is discussed in Box 3.1.

National Determined Contributions (NDCs) prepared under the Paris Agreement may be informed by national strategies (Rocha and Falduto 2019). But the preparation of NDCs can themselves raise political awareness on climate change, encourage institutional innovation and coordination, and provide a process to engage stakeholders (Röser et al. 2020). NDCs illustrate a diversity of approaches, with plans in the form of either mitigation targets, strategies, plans and actions for low GHG emission development, or mitigation co-benefits resulting from their adaptation actions and/or economic diversification plans (UNFCCC Secretariat 2016). Fig 13.1 shows that the prevalence of emission targets increased across all regions between 2012 and 2017, the period during which the Paris Agreement was reached.

The NDCs vary in their scope, content and length, reflecting different national circumstances, and are widely heterogeneous in both stringency and coverage of mitigation efforts (UNFCCC Secretariat 2016; Pauw et al. 2018; Campagnolo and Davide 2019; Pauw et al. 2019). Promoting renewable energy is the most common mitigation strategy included in the NDCs (a priority in 87 INDCs) with many countries specifying the kinds of renewable energy sources they aim to expand, including solar (59 times) and wind (38 times) (Pauw et al. 2018). The transport and agriculture sectors, while they are among the largest contributors to greenhouse gas emissions along with energy and industry (Blanco et al. 2014), while mentioned as areas for undertaking climate action, were not highlighted as focus areas for mitigation in many NDCs assessed; neither was carbon capture and storage (CCS) (Pauw et al. 2018). The agriculture sector, while mentioned in most NDCs (Strohmaier et al. 2016), is considered a priority in only five NDCs; 15 NDCs listed the transport sector as a priority; and 11 NDCs mentioned CCS (Pauw et al. 2018).

Case studies of NDCs illustrate that some countries approach NDCs as an opportunity to integrate mitigation objectives and broader economic shifts or sectoral transformations *(medium evidence, medium agreement)*. For example, Brazil's NDC focusses on emissions from land use change, including agricultural intensification to align mitigation with a national development strategy of halting deforestation in the

Amazon, and increasing livestock production (De Oliveira Silva et al. 2018). Ethiopia, Kenya and the Democratic Republic of Congo (DRC) have incorporated electrification targets into their INDCs, thus linking climate change mitigation with electricity access goals. Each of the three countries have set a target of 75% electricity access in 2030 which has been communicated in their NDCs and supporting development plans (Selvakkumaran and Silveira 2019). While the forest sector accounts for the bulk of Madagascar's mitigation potential, its NDC promotes GHG mitigation in both AFOLU and energy sectors to maximise co-benefits, and achieve a higher number of sustainable development goals (SDGs) (Nogueira et al. 2020). Realising the objectives in plans and strategies, however, requires adequate institutional capacity, which is the subject of the next section.

Box 13.1 EU climate policy portfolio and the European Green Deal

The European Union (EU) carries the international climate obligations of all EU member states, and has developed an encompassing climate governance framework (Kulovesi and Oberthür 2020). In the early 2000s, the EU adopted an Emissions Trading Scheme (ETS) for sectors with large GHG emitters, a burden sharing of EUs emissions reductions in sectors not covered by the ETS and policies for promotion of renewable energy and energy efficiency. From 2007 to 2009, the EU revised its climate policies, adopted targets for GHG emissions reductions, renewable energy shares and energy efficiency improvements for 2020 and the 'burden sharing' where relabelled 'effort sharing' rules (Boasson and Wettestad 2013). Subsequently, the ETS has been improved multiple times (Wettestad and Jevnaker 2019). In 2010, the European Commission created a directorate-general (equal to a ministry at the domestic level) for Climate Action. Between 2014 and 2018, the EU agreed on climate targets for 2030 and again revised its climate policy portfolio (Fitch-Roy et al. 2019; Oberthür 2019). From then on, domestic climate planning was regulated by the EUs Governance Regulation, requiring member states to develop detailed and strategic national energy and climate plans. In 2020, the European Commission, backed by the European Council (heads of states in the EU) and the European Parliament, launched a new broad climate and environment initiative; the 'European Green Deal', implying the revision of all EU climate polices. This roadmap develops a 'new growth strategy for the EU' and spans multiple sectors. In 2020, the EU replaced its governance regulation with a climate law, and upgraded its GHG emission reduction target to 55% by 2030 (European Commission 2020a).

13.2.3 Approaches to national institutions and governance

In order to operationalise climate action, national climate legislation and strategies require specific institutions, including rules, norms, conventions and organisations. This section assesses the forms of institutional solutions observed across countries and their functioning.

13.2.3.1 The forms of climate institutions

National climate institutions take diverse forms, as they are shaped by national politics, different framings of climate change, domestic political institutions, and national bureaucratic practices (Dubash, under review). In only very few cases are new, dedicated and legally-mandated bodies created specifically for climate mitigation; examples include the UK (Averchenkova et al. 2018), China (Teng and Wang, under review), and New Zealand (Timperley 2020). These cases indicate that dedicated and lasting institutions with a strategic long-term focus on mitigation emerge only under conditions of political agreement around a mitigation-centric framing of climate politics (Dubash, under review). However, the specific forms of those institutions differ, as illustrated by the case of the UK's Climate Change Committee established as an independent agency (See Box 13.2) and China, which is built around a top-down planning structure (See Box 13.3).

Box 13.2 Climate change institutions in the UK

The central institutional arrangements of climate governance in the UK were established by the 2008 Climate Change Act (CCA): statutory five-year carbon budgets; an independent advisory body, the Committee on Climate Change (CCC); mandatory progress monitoring and reporting to Parliament, and a continuous adaptation planning following a five-yearly cycle. The CCC is noteworthy as an innovative institution that has also been emulated by other countries.

The design of the CCC was influenced by the concept of independent central banking (Helm et al. 2003). It has established a reputation for independent high quality analysis and information dissemination, is frequently referred to in Parliament and widely used by other actors in policy debates, all of which suggest a high degree of legitimacy (Averchenkova et al. 2018) . However, since the CCC only recommends rather than sets budgets (McGregor et al. 2012), accountability for meeting the carbon budgets works primarily through reputational and political effects rather than legal enforcement. This has not always led to complete compliance; for example in the government's 2017 response to the fourth and fifth budgets (CCC 2019).

Box 13.3 China's climate change institutions

Climate governance in China features a combination of top-down planning and vertical accountability (Sims Gallagher and Xuan 2019; Teng and Wang, under review). An overarching coordination role is performed by the National Leading Group on Climate Change Response, Energy Conservation, and Emissions Reduction (NLGCCR), headed by the Premier and consisting of more than 30 ministers (Wang et al. 2018a). The Department of Climate Change (DCC) under the Ministry of Environment and Ecology (MEE) is the primary agency in charge of climate issues, with a corresponding local Bureau of Ecology and Environment in each province or city. While MEE is the leading agency in climate policy, the National Development and Reform Commission (NDRC) is the leading agency in setting overall and industry-specific targets in five-year plans, and thus has a key role in coordinating the absolute and per-GDP unit carbon emissions targets with energy and industrial development targets (Wang et al. 2019). Involvements of ministries related to transportation, construction, and manufacturing industries are also needed to push forward sector-specific climate initiatives. At subsidiary levels of government carbon intensity targets are enforced through a "targets and responsibilities" system that is directly linked to the evaluation of governments' performances (Lin 2012a; Li et al. 2016).

Where new dedicated organisations have not emerged, countries more commonly seek to convert existing bodies to address climate change, or layer climate responsibilities on existing institutions. In countries where there remains political contestation around climate change – such as Australia and the United States -- mitigation institutions do emerge but have been unstable, such as the short-lived Australian Clean Energy Act (Macneil, under review). As a result, institutional conversion is more common, for example the addition of mitigation to the responsibilities of the US Environmental Protection Agency (Mildenberger, under review).

In yet other countries, climate change is embedded within consideration of multiple objectives of policy or specific high-profile sectoral issues. In these cases, climate institutions tend to be layered on sectoral institutions for the pursuit of co-benefits or broader development concerns. Examples include India, where energy security was an important objective of renewable energy promotion policy (Pillai and Dubash, under review), Brazil's mitigation approach focused on sectoral forest policy (Hochstetler, under review) and South Africa's emphasis on job creation as a necessary factor in mitigation policy (Chandrashekeran et al. 2017; Rennkamp 2019).

Domestic administrative practices and bureaucratic traditions are also salient to building climate institutions. Existing governance approaches can also shape design of climate institutions – the prevailing UK practices of delegating authority to technical regulators influenced the establishment of the CCC (Lockwood, under review). In China, climate governance was elevated in importance over time through well-established organisational patterns such as a Coordination Group and a 'National Leading Group' (Teng and Wang, under review). At a basic level, questions of governmental capacity – the numbers and training of personnel – can shape the choices available for climate institutions and their ability to be strategic (Richerzhagen and Scholz 2008; Harrison and Kostka 2014; Kim 2016).

New rules and organisations are not only created, they are also dismantled or allowed to wither away. Cases of institutional rollback include the Australian Greenhouse Office and the Clean Energy Act (Crowley 2017; Macneil, under review), the Indian Prime Minister's Council on Climate Change, which, while formally functional, effectively does not meet (Pillai and Dubash, under review), and the weakening of climate units inside sectoral ministries in Brazil (Hochstetler, under review). While there is limited literature on the robustness of climate institutions, case studies suggest institutions are more likely to emerge, persist and be effective when institutions map to a framing of climate change that has broad political support *(limited evidence, medium agreement)*. Thus while mitigation focused framings and institutions may win political support in some countries, in other cases sectorally focused or multiple objectives oriented institutions may be most useful and resilient (Dubash, under review). Moreover, an expansive definition of climate institutions, which include processes of layering and conversion of existing institutions, is more representative of empirical complexity than a narrower definition of dedicated climate institutions focused only on mitigation outcomes.

13.2.3.2 Addressing Climate Governance Challenges

Climate institutions have a mixed record in addressing climate governance challenges. Institutions that provide coordination, integration across policy areas and mainstreaming are particularly important given the scope and scale of climate change (See Section 13.8) (Candel and Biesbroek 2016; Tosun and Lang 2017). Ministries of environment have often been appointed as *de facto* agents of coordination, but have been limited in this task by their limited regulative authority and limited ability to engage in intra-governmental bargaining with other ministries with larger budgets and economic heft (Aamodt 2018). Creation of a high-level coordinating body to coordinate across departments and mainstream climate into sectoral actions is another common approach (Oulu 2015). Zhou and Mori (2011) suggest that well-functioning inter-agency coordination mechanisms require political support from heads of government, that industry and environment agencies both need to be involved in coordinating action; and all sectoral agencies need to be engaged. However, coordination mechanisms without a clear authority and basis for setting directions run the risk of 'negative coordination', a process through which ministries comment on each other's proposals, removing any ideas that run counter to the interests of their own ministry, leading to even weaker decisions (Flachsland, under review). Countries with dedicated, new climate institutions tend to have a more explicit and authorised body for climate coordination, such as China's National Leading Group' (See Box 13.3).

Coordination with finance ministries, which have responsibility for allocating funds for mitigation actions, is particularly salient. Without explicit coordination, there is a risk of parallel and non-complementary approaches. For example, the South African Treasury pursued a carbon tax without clear indication of how it interfaced with a quantitative sectoral budget approach espoused by the environment ministry (Tyler and Hochstetler, under review). Skovgaard (2012) suggests that there is an important distinction between finance ministries that bring a limiting 'budget frame' to climate action, versus a 'market failure frame' that encourages broader engagement by relevant ministries.

Coordination within federal systems poses additional complexities, such as overlapping authority across jurisdictions, multiple norms in place, and approaches to coordination across scales (Brown 2012) . Multilevel governance systems such as the EU can influence the design and functioning of climate policies and institutions in member states, such as Germany (Skjærseth 2017; Jänicke and Wurzel 2019; Flachsland, under review) and the UK (Lockwood, under review). Within countries, policy coordination can occur through institutional platforms that allow federal and subnational governments to negotiate divergent interests and agree on policy trajectories (Gordon 2015). Some countries rely on explicit mechanisms of coordination, such as in Australia, where a council of governments has intermittently coordinated climate policy, and Germany, where cooperation is channelled through long-standing formalised mechanisms of cooperation such as periodic meetings of environment ministers and centre-state working groups (Weidner and Mez 2008; Brown 2012). Coordination may also take the form of bilateral negotiations and side-payments between scales of government, as seen in Canada (Rabe 2007; Gordon 2015). In situations of entrenched oppositional politics, the federal structure might leave room for sub-national institutions and policies that promote climate action despite constraints at the federal level, as has occurred in Australia (Gordon 2015; Macneil, under review) and the United States (Rabe 2011; Jordaan et al. 2019; Bromley-Trujillo and Holman 2020; Thompson et al. 2020). Coordination in states where agenda-setting powers on climate policy have traditionally rested with the central government may operate through targets, as with China (Qi and Wu 2013), or frameworks for policy action, as in India (Vihma 2011; Jogesh and Dubash 2015).

Managing the politics of mitigation is complex because transition to a low-carbon future is likely to create winners and losers over different time scales; institutions help mediate these interests in a number of ways (Section 13.4, 13.5) (Kuzemko et al. 2016; Lockwood et al. 2017; Finnegan 2019; Mildenberger 2020). Institutions that provide credible knowledge can help support ambition and prevent backsliding. For example, the analysis of the UK Climate Change committee has been harnessed, including by non-state actors, to prevent backsliding on decisions and to encourage more ambitious action (Lockwood, under review).

Institutions can also help create a positive feedback loop in favour of low carbon transition, by providing spaces in decision making for low carbon interests, such as renewable energy industries (Aklin and Urpelainen 2013; Lockwood et al. 2017; Roberts et al. 2018; Finnegan 2019). For example, a renewable energy policy community emerged in China through key agenda setting meetings, (Shen 2017), and in India, a National Solar Mission provided a platform for India's embryonic renewable energy industry (Pillai and Dubash, under review). Institutions can also create spaces to accommodate concerns of other actors (Upadhyaya et al. 2020). Deliberative bodies, such as Germany's Enquete Commission (Weidner and Mez 2008; Flachsland, under review) or the Brazilian Forum on Climate Change (Tyler and Hochstetler, under review) provide a space for reconciling competing visions and approaches to climate change. Many countries are creating deliberative bodies to forge 'Just Transition' strategies (Box 13.17). Conversely, institutions can also exert a drag on change through 'regulatory inertia,' as in the case of the UK energy regulator Ofgem, the creation of which preceded the political importance of a sustainability agenda, resulting in its exercise of veto powers in ways that may limit a low carbon transition (Lockwood et al. 2017).

Since addressing climate change requires transformative intent and shifting development pathways (Section 13.9, Chapter 1 Section 1.4, Chapter 4 Section 4.3, Cross-Chapter Box 4 in Chapter 4), institutions that can devise strategies and set trajectories are useful enablers of transformation. A strategic approach to climate mitigation can include high level target setting, including through framework laws (Averchenkova et al. 2017), but also identifying and signalling key sectors and opportunities for low-carbon transition (Hochstetler and Kostka 2015) and innovation (Mazzucato and Semieniuk 2018). Few countries have built deliberate and lasting institutions that provide strategic intent, and those that have, have pursued different approaches. The UK uses five-yearly target setting by an independent body followed by soft enforcement through reputational and legal effects; Germany introduced a law requiring sectoral budgets enforced through the Bundestag (Flachsland, under review); and China (Box 13.3) has an apex decision-body with the ability to set and delegate implementation of targets to ministries and provinces (Teng and Wang, under review).

Addressing all of these governance concerns – coordination, mediating interests, and strategy setting – require attention to institutional capacity. These include the capacity to address 'upstream' policy issues of agenda setting, framing, analysis and policy design ; pursue goals even while mediating interests (Upadhyaya et al. 2020); identify and manage synergies and trade-offs across climate and development objectives (Ürge-Vorsatz et al. 2014; von Stechow et al. 2015; McCollum et al. 2018); identify areas for transformation and the means to induce innovation (Patt 2017; Mazzucato and Semieniuk 2018); and developing the ability to monitor and evaluate to support accountability (See Box 13.4). The need for attention to institutional capacity is highlighted by the fact that the NDCs of 113 developing countries out of 169 countries studied list capacity building as a condition of NDC implementation (Pauw et al. 2020).

Box 13.4 South Africa's Monitoring and Evaluation System

South Africa's National Climate Change Response M&E System Framework provides high-level guidance on information requirements and assessment methodologies (DEA 2015). The country is developing a comprehensive, integrated M&E system including climate change responses and emissions inventory, which will enable the country to assess, analyse and understand progress made in tracking the transition to a climate-resilient and lower-carbon society. South Africa's approach to climate change M&E is premised upon continuous learning and improvement of the system implemented in phased manner with full-implementation of this system envisaged in 2020 (DEA 2019).

13.3 Sub-national institutions, governance and partnerships

13.3.1 Introduction

Subnational actors and institutions are a crucial component of climate mitigation as they have remit over land use planning, waste management, infrastructure, and community development, and their jurisdictions are often where the impacts of climate change are felt. Depending on the level of institutional constraints, subnational actors play crucial roles in developing, delivering and contesting decarbonisation visions and pathways (Schroeder et al. 2013; Ryan 2015; Amundsen et al. 2018) (Section 13.3.3).

Climate mitigation is not only a government concern. It challenges a range of actors across sectors and jurisdictions to create coalitions for climate governance. An actor is defined by its capacity and power to act. Sub-national actors include individuals, sectors, jurisdictions, and networks (e.g., a coalition of city or state authorities). These are either formal or informal, profit or non-profit and public or private (Avelino and Wittmayer 2016). For example, corporations are formal, private and for-profit, the state is formal, public, and non-profit, and communities are private, informal and non-profit. There is also an intermediary sector, which includes actors such as energy cooperatives, not-for-profit energy enterprises and the scientific community, crossing the boundaries between private and public, for profit and non-profit (Avelino and Wittmayer 2016). It is fundamental to evaluate how the multiscale interplay of subnational actors and institutions shapes mitigation policies. For example, these policies may be particularly effective if they are integrated with co-benefits related to adaptation and development priorities such as health, biodiversity, and poverty reduction (Romero-Lankao et al. 2018a).

13.3.2 Actors, networks and policies

The influence of subnational actors was formalised in the text of the Paris Agreement. They engage in climate relevant mechanisms, such as the Sustainable Development Goals and the New Urban Agenda. Subnational actors participate in transnational and subnational climate governance networks and facilitate learning and exchange among governmental and private organisations at multiple levels, gathering knowledge and best practices such as emission inventories and risk management tools that can be applied in multiple contexts (Kona et al. 2016; Sharifi and Yamagata 2016; Michaelowa and Michaelowa 2017; Warbroek and Hoppe

2017; Amundsen et al. 2018; Bai et al. 2018; Busch et al. 2018; Hsu et al. 2018; Lee and Jung 2018; Marvin et al. 2018; Romero-Lankao et al. 2018b; Ürge-Vorsatz and Seto 2018; Heikkinen et al. 2019). Subnational climate change policies exist in more than 120 countries (NewClimate Institute et al. 2019). A coalition of 120 subnational (i.e., state and regional) governments, representing 21% of the global economy and 672 million people, has pledged about 9% emissions reduction compared to a base year (The Climate Group with CDP 2018). More than 300 U.S. subnational actors are committed to maintaining momentum for climate action as part of the We Are Still In coalition (We Are Still In coalition 2020). More than 10,000 cities, representing more than 10% of the global population, participate in the Global Covenant of Mayors, C40 Cities (2018), and ICLEI's - Local Governments for Sustainability carbon registry (Hsu et al. 2018).

However, estimations of the number of subnational actors pledging voluntary climate action are challenging and underreporting is a concern (Hsu et al. 2018; Chan and Morrow 2019). As can be seen in Figure 13.2, the bulk of subnational climate action is located in Europe and North America (Bansard et al. 2017; Hsu et al. 2018; NewClimate Institute et al. 2019).

Subnational mitigation policies are further developed than adaptation policies, with at least 6,000 subnational governments setting mitigation targets (Kuramochi et al. 2020). In 2016, commitments to the UN's Global Climate Action portal tended to target economy-wide mitigation (45% of regions and 85% of cities), followed by renewable energy (19% of regions and 9% of cities) and energy efficiency (18% of regions and 4% of cities) (Hsu et al. 2016). Although local governments often have few formal competencies in energy (Rutherford and Coutard 2014), state and local governments are increasingly engaged in strategies targeting buildings, lighting, and transportation as well as green infrastructure interventions addressing both mitigation and vulnerabilities to climate change (Benedict and McMahon 2006; Bulkeley and Castán Broto 2013; The Climate Group with CDP 2018; Reckien et al. 2018; Romero-Lankao and Gnatz 2019; REN21 2019).

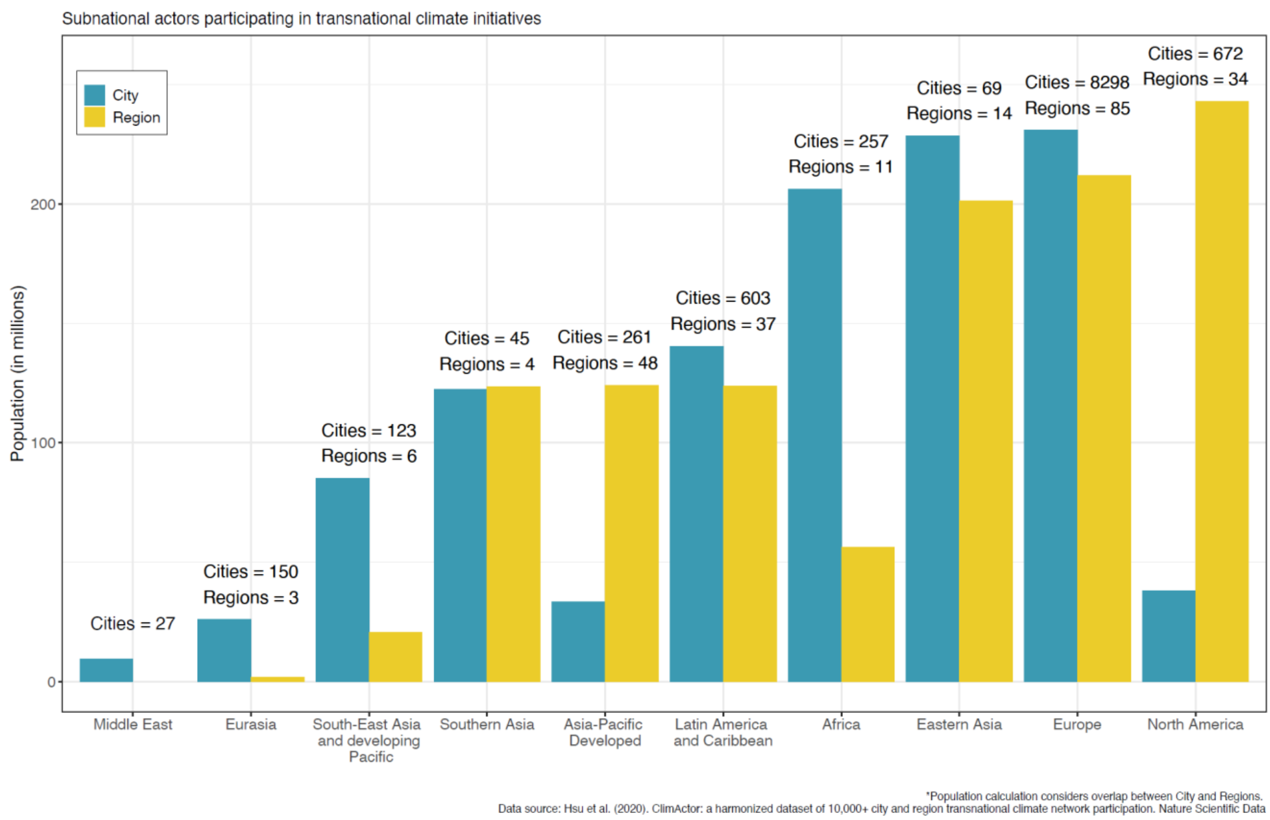

Figure 13.2 Sub-national GHG mitigation commitments: Total population by IPCC region

[Note: Adapted from (Hsu et al. 2020a) *to reflect IPCC AR6 aggregation. Population of subnational actors (cities and regions) recording climate action commitments as captured in the ClimActor dataset. Population calculation considers overlap between City and Regions]*

Sub-national mitigation policies are highlighted below, based on the taxonomy of policies in 13.6.1:

a) Economic instruments are in use worldwide for GHG mitigation, including carbon taxes, emission-permit trading, offset systems and subsidies. As of 2020, there were carbon pricing initiatives (ETS, carbon tax or both) in 32 subnational jurisdictions with additional initiatives under consideration (World Bank 2019). Examples include emission trading systems within the U.S. Regional Greenhouse Gas and Western initiatives, tax rebates for the purchase of EVs, a carbon tax in British Columbia, and a cap-and-trade scheme in Metropolitan Tokyo (Houle et al. 2015; Murray and Rivers 2015; Hibbard et al. 2018; Bernard and Kichian 2019; Chan and Morrow 2019; Raymond 2019; Xiang and Lawley 2019).

b) Regulatory instruments also exist such as land use and transportation planning, performance standards for buildings, utilities, transport electrification, and energy use by public utilities, buildings and fleets (Bulkeley 2013; Jones 2013; C40 and ARUP 2015; Martinez et al. 2015; Hewitt and Coakley 2019; Palermo et al. 2020). Policies such as regulatory restrictions, low emission zones, parking controls, delivery planning and freight routes, focus on traffic management and reduction of local air pollution but also have a mitigation impact (Slovic et al. 2016; Khreis et al. 2017; Letnik et al. 2018). For instance, in coordination with national governments, subnational actors in China, Europe and US have introduced access to priority lanes, free parking and other strategies fostering the roll-out of EVs (Creutzig 2016; Zhang and Bai 2017; Teske et al. 2018; Zhang and Qin 2018; Romero Lankao et al. 2019).

   Land-use planning addresses building form, density and transport, which are relevant for decarbonisation (Creutzig et al. 2015; Torabi Moghadam et al. 2017; Teske et al. 2018). Its effectiveness is limited by absent or fragmented jurisdiction, financial resources and powers, and national policies that restrict local governments' ability to enact more ambitious policies (Fudge et al. 2016; Gouldson et al. 2016; Petersen 2016). Most rapidly growing smaller cities in Latin America, Asia and Africa lack capacity for urban planning and enforcement (Romero-Lankao et al. 2015; Creutzig 2016).

c) Other policies include information and capacity building, such as carbon labelling aimed at providing carbon footprint information to consumers (Liu et al. 2016); mandatory building performance, disclosure and benchmarking policies to increase awareness of energy issues and track mitigation progress (Hsu et al. 2017; Papadopoulos et al. 2018). For instance, a building retrofit program was initiated in New York and Melbourne to foster energy efficiency improvements through knowledge provision, training, and consultation (Trencher et al. 2016; Trencher and van der Heijden 2019).

   Also significant is government provision of public good, services, and infrastructure (Romero Lankao et al. 2019), which include provision of electric buses or buses on renewable fuels for public transportation (Kamiya and Teter 2019) and zero emission urban freight transport (Quak et al. 2019), sustainable food procurement for public organisations in cities (Smith et al. 2016), green electricity purchase via community choice aggregation programs and franchise agreements (Armstrong 2019).

13.3.3 Institution building at the sub-national level

Institution building is a key requirement to address the political and institutional challenges posed by climate change. For instance, mitigation policies may demand coordination between administrative units that historically have not collaborated; they may demand that subnational actors confront issues that are politically sensitive such as carbon taxes or increases in utility rates; or they may demand a redistribution of resources to protect endangered ecosystems or vulnerable populations (Hughes and Romero-Lankao 2014).

Subnational actors have built climate institutions globally by creating new visions and narratives, by setting new entities or committing existing offices, providing them with funds, staff and legal authority, or experimenting with innovative solutions that could be transferred to other local governments or scaled nationally (Hoffmann 2011; Hoornweg et al. 2011; Hughes and Romero-Lankao 2014; Aylett 2015; Romero-Lankao et al. 2015; Hughes 2019). These actors have also created task forces, referendums, coordination of financial and human resources, technical assistance, awareness campaigns and funding (Castán Broto 2017; Romero-Lankao et al. 2018a; Hughes 2019)

Multi-jurisdictional and multi-sectoral sub-national networks in dozens of countries globally have helped climate institution building, facilitate social and institutional learning, and address gaps in national policy (Holden and Larsen 2015; Jordan et al. 2015; Setzer 2015; Haarstad 2016; Hermwille 2018; Kammerer and Namhata 2018; Lee and Jung 2018; Rashidi and Patt 2018; Westman and Castan Broto 2018; Lee 2019; Schwartz 2019).

Transnational networks such as the C40, the Covenant of Mayors for Climate and Energy, and ICLEI have disseminated information on best practices and promoted knowledge sharing between subnational governments (Lee 2013; Hakelberg 2014; Heidrich et al. 2016; Kona et al. 2016) (see also chapter 14.5.10). Transnational networks have opened opportunities for subnational actors to play a crucial mitigation role in political stalemates (Jones 2014; Schwartz 2019). Interagency organisations such as the US Carbon Cycle Interagency Working Group, the Australian Climate Action Network, and the Mexican Metropolitan Environmental Commission have helped facilitate coordination and learning across multiple jurisdictions and sectors, and connect ambiguous spaces between public, private and civil society actors (Romero-Lankao et al. 2015; Horne and Moloney 2019; Hughes 2019).

At the same time, these multilevel networks have limited influence in countries where national governments exert top-down control (e.g., in China), while private business controls the governance of innovation (Westman et al. 2019); where subnational actors face political fragmentation, lack regulations, and financial and human resources to separate their interests from those of national governments; or where vertically-integrated governance exists, as in State of São Paulo, Santiago de Chile, and Mexico City (Romero-Lankao et al. 2015; Setzer 2017).

The chances for climate institutions at the sub-national to be accepted by the public increase when climate policies are linked to existing issues such as travel congestion alleviation, air pollution control (Puppim de Oliveira 2013; Romero-Lankao et al. 2013, 2015; Ryan 2015; Simon Rosenthal et al. 2015); or when embedded in development priorities that receive support from the national government or citizens (Jörgensen et al. 2015b; Floater et al. 2016; Dubash et al. 2018). For example, Indian cities have engaged in international climate cooperation seeking innovative solutions to address energy, water and infrastructure problems, while a co-benefit approach has gained traction in India's National Action Plan for Climate Change (Beermann et al. 2016). In Brazil, a "win-win" discourse has secured support for mitigation policies justified through their provision of economic and public health co-benefits (Setzer 2017). In China, the government has aligned climate change and poverty reduction goals through the photovoltaics poverty alleviation initiative seeking to enable solar energy in poor areas (Lo and Castán Broto 2019).

Administrative structures, such as the presence of a professional city manager and staff assigned specifically to climate efforts can make an enormous difference (Simon Rosenthal et al. 2015) to subnational actors' capacity to develop mitigation policies such as targets and evaluation of progress. Also, the capacity to create knowledge and data on energy use and emissions is essential for GHG mitigation planning (Hughes and Romero-Lankao 2014; Ryan 2015). For example, the high technical competency of Tokyo's bureaucracy combined with availability of historical and current data enabled the city's unique cap-and-trade system on large building facilities (Roppongi et al. 2017).

Visions and narratives about the future benefits or risks of climate change are effectively advanced at the subnational level, drawing on local governmental abilities to bring together actors involved in place-based decarbonisation across sectors. (Hodson and Marvin 2009; Bush et al. 2016; Huang et al. 2018; Prendeville et al. 2018; Levenda et al. 2019). For example, in the plans of 43 C40 Cities, climate action is framed as part of a vision for the creation of vibrant, economically prosperous, and socially just cities, that are habitable, secure, resource-efficient, socially and economically inclusive, and competitive internationally (Romero-Lankao and Gnatz 2019).

However, institution building is often constrained by a series of governance challenges that will be assessed in this section. Subnational actors lack national support, funding, and capacity to mobilise financial and human resources, build coalitions, facilitate coordination, develop relationships across old and new organisations, and create new institutional competences (Valenzuela 2014; Jörgensen et al. 2015a; Ryan 2015; Anderton and Setzer 2018; Dubash et al. 2018; Romero-Lankao et al. 2018a; Cointe 2019; Di Gregorio et al. 2019; Hughes 2019; Jaccard et al. 2019).

Institutional arrangements also carry equity implications. For example, the institutional capacities, including resources, legal remit, knowledge, and political clout vary widely within and among subnational governments globally (Jörgensen et al. 2015b; Genus and Theobald 2016; Joffe and Smith 2016; Klinsky 2018; Reckien et al. 2018; Markkanen and Anger-Kraavi 2019). Moreover, studies covering several C40 member cities have found that dominant discourses tend to prioritise scientific and technical expertise and, thus, they focus on infrastructural and economic concerns over the concerns and needs of marginalised populations (Heikkinen et al. 2019; Romero-Lankao and Gnatz 2019).

Delivering climate justice through place-based strategies requires identifying forms of intervention that contribute to both advancing sustainable development objectives, addressing structural conditions of vulnerability and reducing carbon emissions (Romero-Lankao et al. 2018b). For example, in the implementation of nature-based solutions to address climate change in urban areas diverse questions of justice come together, which call for the integration of multiple perspectives through collaborative forms of planning (Kabisch et al. 2016). The principles of 'just sustainabilities,' in particular, connect environmental planning and management with the needs of citizens and communities (Agyeman 2013; Rydin 2013; UN Habitat 2016). However, the benefits of participatory planning in managing complex environmental problems in urban environments are not always recognised in practice, and often participatory planning is overlooked in favour of planning that seeks to deliver growth (Rydin 2013).

Another challenge is given by the fact that climate change mitigation depends on cultural (e.g., liberal or conservative, individualistic or collectivistic) norms and values of actors with varying levels of power, and shifting alliances (Lachapelle et al. 2012; Damsø et al. 2016; Romero-Lankao et al. 2018a; Giampieri et al. 2019). For instance, in countries such as the US, the UK, Canada and Australia, these different cultural values underpin the diverging framings, priorities, and blind spots enhancing mitigation policies by some subnational actors, and the counter-narratives, scepticism and denialism shaping inaction by other subnational actors (Unsworth and Fielding 2014; Trencher et al. 2016; Romero-Lankao et al. 2018b).

Subnational governments tend to emphasise expert driven, technical solutions such as infrastructural interventions and best practices that frequently undermine the knowledge of those who do not participate in the dominant knowledge order, such as lower income countries, communities or indigenous knowledge holders (Ford et al. 2016; Brattland and Mustonen 2018; Nagorny-Koring 2019). Indeed, the lower presence of mitigation action in the Global South has been attributed to factors such as the dominating role of Global North actors in the selection and diffusion of "best practices" (Bouteligier 2013). Ideas of energy and resource sovereignty have called for a broader inclusion of publics and communities in decisions about the future of energy and infrastructure systems, and in the design and implementation of new technologies (Laldjebaev et al. 2015; Menconi et al. 2016; Avila-Calero 2017; Broto 2017).

Case-based evidence shows that technological mitigation solutions, such as electric and automated vehicles, smart grids or smart controls rarely address the needs of the poor, particularly in Least Developed Countries (Mistry 2014). The implementation of best practices tends to be fragmented, because it is rearranged to suit the characteristics of specific contexts, and executed as pilot projects that rarely lead to structural change (Nagorny-Koring 2019). To move away from one-off recipes for action, scholars suggest considering context-specific conditions including values, cultures and governance that enable successful translation of best practices (Affolderbach and Schulz 2016; Urpelainen 2018) (See Box 13.5).

Box 13.5 Institutionalising Climate Change within Durban's Local Government

Durban is the largest port and city on the east coast of Africa and the third largest of South Africa's metropolitan areas. In terms of CO_2 emissions, its regional industry accounts for about 50% of Durban's emissions of 17.8m yearly tons and for associated high rates of respiratory problems, asthma, leukaemia and cancer (Aylett 2010). eThekwini Municipality, the local government structure responsible for managing Durban, has effectively linked climate change agendas with ongoing sustainability actions and goals.

Adaptation was considered a priority taking into account the developmental needs of the city, its high-risk socio-ecological profile and limited human resources. However, though broadening the concept of adaptation to include a just transition to a low carbon future to address development, energy security and GHG reduction pressures, mitigation was considered key in reducing vulnerability and risk in an unpredictable and climate-stressed future.

Durban has progressed in mainstreaming climate and justice concerns within local government through strong local leadership by key individuals and departments; mainstreaming climate concerns within various municipal short-term and long-term planning processes; civil society mobilisation (e.g., South Durban Community Environmental Alliance (SDCEA)); local and international networking; ad hoc (yet critical) funding opportunities; and institutional restructuring.

Diverse lessons can be drawn from Durban's experience. Embedding responses to climate change within local government activities requires that climate change is made relevant locally and framed within a broader environmental justice framework. Thus, ensuring that both the development and climate protection agendas are meaningfully linked. Not only collaboration and compromise but also conflict and mobilisation have had positive effects on climate change policy making. In particular, civil society has been key in balancing the influence of the private sector on Durban's dynamic political process. However, in Durban as many other cities worldwide, shifting to emission and development that are both more sustainable and equitable will require significant social, economic and political innovation.

13.3.4 Partnerships and experiments

Partnerships, such as those among private and public, or transnational and subnational entities, have been found to enable better mitigation results in areas outside direct government control such as residential energy use, emissions from local businesses, or private vehicles (Fenwick et al. 2012; Castán Broto and Bulkeley 2013; Aylett 2014; Hamilton et al. 2014; Bulkeley et al. 2016; Wakabayashi and Arimura 2016; Grandin et al. 2018). Partnerships take advantage of investments, such as local investors to match available grants or local investors to enable a local energy project to get going or enhance the scope or impact of mitigation. For example, the region of Metro Vancouver on the West Coast of Canada launched a partnership with seven municipalities and a selection of small and medium-sized enterprises to carry out GHG management training, employ a GHGs management tool and provide technical assistance for SMEs, the costs of which are shared equally amongst the initiative's partners (Burch et al. 2013).

The strategic positioning of subnational actors has led to a growing emphasis on other forms of action such as experiments and laboratories, which according to their promoters promise to achieve the radical change required to address the climate mitigation gap (Marvin et al. 2018; Smeds and Acuto 2018). Experiments span many domains, from smart technologies (e.g., in Malmö, Sweden (Parks 2019), to Eco-Art, Transformation-Labs and other approaches that question the cultural basis of current energy regimes and seek reimagined or reinvented futures (Castán Broto and Bulkeley 2013; Guy et al. 2015; Voytenko et al. 2016; Hodson et al. 2018; Peng and Bai 2018; Smeds and Acuto 2018; Culwick et al. 2019; Pereira et al. 2019; Sengers et al. 2019).

In dozens of countries, state and local authorities are central to initiating and implementing experiments and often use an incremental, 'learning by doing' governing approach (Bai et al. 2010; Castán Broto and Bulkeley 2013; Nevens et al. 2013; McGuirk et al. 2015; Hodson et al. 2018; Nagorny-Koring and Nochta 2018; Peng and Bai 2018; Smeds and Acuto 2018; Culwick et al. 2019; Sengers et al. 2019). Experiments relate to technological learning and changes in policies, practices, services, user behaviour, business models, institutions, and governance (Castán Broto and Bulkeley 2013; Wieczorek et al. 2015; Kivimaa et al. 2017; Laurent et al. 2018; Torrens et al. 2019).

Experiments, however, are often isolated and do not always result in longer-term, more widespread or transformative changes. Emerging research suggests that the transformative potential of experiments is constrained by uncertainty about locally relevant climate change solutions and effects; a lack of comprehensive, and sectorally inclusive national policy frameworks for decarbonisation; budgetary and staffing limitations; and a lack of institutional and political capacity to deliver integrated and planned approaches (Evans and Karvonen 2014; McGuirk et al. 2015; Bulkeley et al. 2016; Voytenko et al. 2016; Wittmayer et al. 2016; Webb et al. 2017; Grandin et al. 2018; Hölscher et al. 2018; Nagorny-Koring 2019; Sengers et al. 2019).

13.3.5 Performance, global mitigation impact and transformative potential

Performance has been measured using different methodologies developed by scholars and transnational organisations (Hsu et al. 2019). These range from small-scale studies assessing the mitigation potential of commitments by subnational regions, cities and companies in the U.S. or in ten high-emitting economies (Roelfsema 2017; Hsu et al. 2019), to larger studies finding that over 9,149 cities worldwide could mitigate 1,400 $MtCO_2$-eq in 2030 (Global Covenant of Mayors for Climate and Energy 2018; Hsu et al. 2018, 2019). Analyses of city performance are few in number, and found that the cities of New York, Berlin, London, Greater Toronto, Boston, and Seattle have achieved on average a 0.27 tCO_2-eq per capita y^{-1}reduction (Kennedy et al. 2012). Hsu et al. (2020a) found that 60%of more than 1,000 European cities, representing 6%of the EU's total emissions, are on track to achieving their targets, reducing more than 51 million tons $MtCO_2$-eq.

Whether participation in transnational climate initiatives impacts subnational governments' achievement on climate mitigation goals is uncertain. Some find that higher ambition in climate mitigation commitments did not translate into greater mitigation (Kona et al. 2016; Hsu et al. 2019). Other studies associate participation in networks with increased solar PV investment (Khan and Sovacool 2016; Steffen et al. 2019), and with potential to achieve carbon emissions per capita in line with a global 2°C scenario (Kona et al. 2016).

Reporting networks may attract high-performing actors, suggesting an artificially high level of cities interested in taking climate action or piloting solutions (self-selection bias) that may not be effective elsewhere (van der Heijden 2018). Many studies present a conservative view of potential mitigation impact because they draw upon publicly reported mitigation actions and exclude subnational actions that are not reported (Kuramochi et al. 2020).

Aside from direct mitigation contributions, which cannot be expected to fill the "mitigation gap" (Michaelowa and Michaelowa 2017), an alternative perspective on subnational actors' performance derives from indirect effects that, while difficult to quantify, ensure long-term change (Chan et al. 2015). Experimentation and policy innovation helps to establish best practices (Hoffmann 2011); set new norms for ambitious climate action that help build coalitions (Chan et al. 2015; Bernstein and Hoffmann 2018); and translate into knowledge sharing or capacity building (Lee and Koski 2012; Hakelberg 2014; Purdon 2015; Acuto and Rayner 2016)

A question receiving increased attention is the extent to which mitigation initiatives are (or can become) truly transformative not only in their mitigation potential but also by providing the resources, skills and networks that governments and other stakeholders currently use to deliver deep and radical change (Shaw et al. 2014; Wolfram 2016; Amundsen et al. 2018; Wiedenhofer et al. 2018; Heikkinen et al. 2019). Global level studies on urban mitigation have found that many measures support the status quo and only a few are transformational. There is still insufficient empirical evidence on how transformational capacity is created (Ziervogel 2019).

13.4 Structural factors conditioning climate governance

Climate governance changes over time, resulting from both slow-moving incremental changes and more rapid bursts of change due to, for example, general elections or global climate summits (Jordan and Moore 2020; Boasson et al. 2020; Aamodt and Stensdal 2017) (*medium evidence, high agreement).* Sometimes climate governance directly targets GHG emissions, other times mitigation is an outcome of governance measures that primarily aim to solve other issues, for instance relating to food production, forest management, energy markets, air pollution, transport systems or technology development, but with notable effects on climate mitigation or adaptation (Khreis et al. 2017; Sims Gallagher and Xuan 2019).

This section assesses the literature on how structural features, such as material endowments, political systems, cultural-institutions and the media dynamics shape the development of domestic climate governance. All of these features are partly shaped by prior policy decision, and may either enable or constrain future climate governance choice, known as governance feedback effects (Skocpol 1992; Pierson 1993; Lockwood 2013; Jordan and Moore 2020). Policy makers can try to account for such long term effects of existing policies when preparing, making and implementing new policies, even though it is challenging to avoid unexpected effects (Bernstein and Hoffmann 2018; Boasson et al. 2020; Jordan and Moore 2020) (*limited evidence, medium agreement*).

In order to accelerate climate action, climate governance needs to both counteract existing policies that foster increasing GHG emissions while nurturing new policies that facilitate long-term deep emission reductions (Geels et al. 2017a; Roberts and Geels 2019; Rosenbloom et al. 2019) (*limited evidence, medium agreement*). Policy feedback effects may enable strengthening of climate governance by reducing the cost of mitigation over time (Schmidt and Sewerin 2017) and underpinning emergence of green industries and nurturing pro-climate coalitions (Meckling et al. 2015; Bernstein and Hoffmann 2018; Jordan and Moore 2020). On the other hand, policy feedback may also constrain, hamper, undermine, or create barriers to climate mitigation (Fleurbaey et al. 2014; Munck af Rosenschöld et al. 2014; Seto et al. 2016). For instance, well established policies such as industry taxations schemes, licensing systems for siting of energy plants or fossil fuel subsidies can lock-in and reinforce carbon-intensive modes of transportation and energy generation over time (Seto et al. 2016; van Asselt 2018; Kotilainen et al. 2019). In addition, prior political and corporate decisions that allowed for investments in fossil fuel based energy infrastructures and power plants may constrain future climate governance development, and such effects are often termed lock-in (See also Section 13.9; Roberts and Geels 2019).

Climate governance processes involve multiple actors, several decision-making arenas, multiple levels of decision-making and a variety of political goals. In the following sub-sections, we discuss how and to what extent various structural or systematic factors (material endowments; political systems; cultural-institutional understandings; and the media) contribute to shape and create climate governance, with a specific focus on explaining differences across countries. Although all of these factors are important, civic, corporate and/or political mobilisation may counteract their influence. Section 13.5 sheds more light on this by examining literature on the role and importance of various actors in policy and governance process.

13.4.1 Material endowments

Natural and economic resources, such as fossil fuels and renewable energy resources, forests and land, energy mixes and economic structure, tend to enable and constrain developments of domestic climate governance (*limited evidence, high agreement*) (Friedrichs and Inderwildi 2013; Hughes and Lipscy 2013; Lachapelle and Paterson 2013; Bang et al. 2015). Such effects can be altered by other factors, such as cultural-institutional change, skilled policy entrepreneurship or other factors that are further discussed in Section 13.5 (Boasson 2015; Aklin and Mildenberger 2018; Colgan et al. 2020) (*limited evidence, medium agreement*). As a result, countries with rather similar material endowments may differ in climate governance, and countries with differences in material endowments have similar policies. For instance, some countries with rich fossil fuel endowments, such as Australia, have weak domestic climate policies, while others, such as Norway, have adopted rather ambitious climate targets and measures (Eckersley 2013). On the other hand, countries with radically different electricity sectors and energy resource potentials may have quite similar renewables support schemes, such as France, Germany, Poland, and the United Kingdom (Boasson et al. 2020).

Carbon-intensive resources and infrastructure can hamper acceleration of climate action by increasing abatement costs and by influencing perceptions of climate mitigation efforts (Bertram et al. 2015a; Erickson et al. 2015), Successful climate policies can change material endowments in a way that underpin more forceful climate governance, for instance by decreasing the value of fossil fuels and increasing the value of renewable energy sources (Ürge-Vorsatz et al. 2018; Colgan et al. 2020).

Developed countries tend to have broader portfolios of climate measures (Schmidt & Fleig, 2018), while developing countries often design policies to tackle climate change in combination with other developmental challenges (von Stechow et al. 2015, 2016; Deng et al. 2017; Thornton and Comberti 2017; Campagnolo and Davide 2019), such as air pollution, urban transportation, energy access, and poverty alleviation (Viguié and Hallegatte 2012; Geng et al. 2013; Klausbruckner et al. 2016; Li et al. 2016; Melamed et al. 2016; Slovic et al. 2016; Khreis et al. 2017; Xie et al. 2018). However, combining climate and developmental policies for synergise benefits should not overlook potential trade-offs and challenges (Jakob et al. 2014; Jakob and Steckel 2014; Dagnachew et al. 2018; Ellis and Tschakert 2019).

13.4.2 Political systems

Political systems have developed over generations and constitute a set of formal institutions, such as laws and regulations, organisational structures of political executives, legislative assemblies and political parties (Pierson 2004). Different political systems create differing conditions for climate governance, and political systems are not likely to change because of climate mitigation efforts (DUIT and GALAZ 2008; Boasson et al. 2020) (*medium evidence, high agreement*).

Researchers have compared democratic and non-democratic political systems and found that freer political systems tend to develop more encompassing climate governance, with stronger commitments to international agreements (Li and Reuveny 2006; Bättig and Bernauer 2009; Böhmelt et al. 2016), lower deforestation rates (Buitenzorgy and P. J. Mol 2011) and more success in decoupling economic growth from CO_2 emissions (Lægreid and Povitkina 2018) (*medium evidence, medium agreement*). More authoritarian states started to develop climate governance since 2010, including Singapore, Vietnam, and China (Beeson 2010; Gilley 2012; Green and Stern 2015; Zimmer et al. 2015; Han 2017; Engels 2018), with various degree of participation from the civil societies (Simpson and Smits 2018).

Countries with electoral systems in which divisions in an electorate are reflected proportionately tend to do better on climate-related outcomes, than countries where candidates have to receive a majority of the votes to be elected (Fredriksson and Millimet 2004; Lachapelle and Paterson 2013; Finnegan 2019) (*medium evidence, high agreement).* Such systems enable more ambitious climate positions to influence policymaking (Harrison and Sundstrom 2010; Willis 2018) and create less political risk related to imposing climate related costs on voters (Finnegan 2018, 2019). However, the research on the role of electoral systems in climate action is still inconclusive.

Concerning party structure, similar parties (for instance social democratic or conservative parties) in varying countries may have different climate policy positions (Boasson et al. 2020). However, having green parties of significant size is associated with lower greenhouse gas emissions (Neumayer 2003; Jensen and Spoon 2011; Mourao 2019), and left-wing parties tend to adopt more pro-climate policy positions (Carter 2013; Tobin 2017; Farstad 2018). However, many conservative parties also support climate measures (Båtstrand 2015) and there may also be consensus on climate action across the political spectrum (Thonig et al. 2020). There remains a limited literature on green parties in developing countries (Haynes 1999; Kernecker and Wagner 2019).

In varying types of political systems, climate policies may be obstructed by actors that abuse entrusted power for private gain (Treisman 2000). (*medium evidence, high agreement*). CO_2 emissions increase with corruption, either through the direct effect of corruption on law enforcement or through the effect of corruption on countries' income (Welsch 2004). These findings are reinforced by study of a global sample (Cole 2007), in a sample of post-Soviet countries (Bae et al. 2017), in a sample of BRICS (Brazil, Russia, India, China, and South Africa) countries (Wang et al. 2018b), in the Middle-East and North Africa region (Sahli and Rejeb 2015), in Malaysia, Indonesia and the Philippines (Ridzuan et al. 2019), and in African countries that already have relatively low CO_2 emission levels, but not countries that have relatively high CO_2 emissions (Habib et al. 2020). Corruption can also undermine deforestation efforts (Sundström 2016). Povitkina (2018) further shows that democracies only emit less if their corruption levels are low. More research is required on the causal mechanisms that link corrupt practices to emissions.

13.4.3 Cultural understandings shaping climate governance

Cultural institutional understandings of climate governance may differ significantly across countries, societal sectors; corporate actors; ministries other social groups (Shwom et al. 2015; Boasson et al. 2020) *(medium evidence, medium agreement)*. Differences in cultural-institutional understandings can help explain differences in climate policy mixes across countries and why similar policy instruments have differing characteristics in differing countries, such as emission trading systems (Knox-Hayes 2016; Wettestad and Gulbrandsen 2017) and feed-in schemes for renewable energy (Boasson et al. 2020) (*medium evidence, medium agreement*). Cultural change can create shifts in how actors perceive their own interests (Boasson 2015; Boasson et al. 2020) and the attractiveness of differing policy measures, instruments and governance strategies (Schifeling and Hoffman 2019) (*medium agreement, limited evidence*).

Climate governance preferences may be influenced by several different cultural institutional factors, such as values (Ziegler 2017), norms (Bechtel et al., 2019; Rinscheid et al., 2020), discourses and frames (Brown and Sovacool 2017; Leipold et al. 2019), corporate climate imaginaries (Levy and Spicer 2013), traditional approaches to application of scientific information in policy making (Jasanoff 2011), and informal behaviour scripts, sometimes called institutional logics (Boasson 2015; Aamodt and Boasson 2020; Boasson et al. 2020) *(medium evidence, medium agreement)*.

Researchers have identified a broad range of cultural-institutional features that may shape which policy measures, strategies, targets, and public-private private collaborations are regarded as appropriate (Brulle and Norgaard 2019; Leipold et al. 2019). Three dominant culturally distinct understandings are identified. First, climate governance may be framed and understood as compatible with economic growth and minimising the short-term societal costs of climate mitigation; such understandings are termed ecological modernisation (Bäckstrand and Lövbrand 2006, 2019), climate capitalism (Newell and Paterson 2010), institutional market logics (Boasson et al. 2020; Boasson 2015) or the global commons approach (Bernstein and Hoffmann 2019). Second, others perceive climate governance as primarily relating to technological change, scholars have named this 'the institutional technology-development logic' (Boasson et al. 2020), or climate transformation (Geels et al. 2017a). Third, an increasing number of actors understand climate governance as primarily a justice issue (Bäckstrand and Lövbrand 2006, 2019; Fuller and McCauley 2016; Reckien et al. 2017; McCauley and Heffron 2018; Routledge et al. 2018), or even an existential issue that may reshape political alignments within and across countries (Colgan et al. 2020).

Cross-country examinations of cultural-institutional differences aim to identify similarities and differences in public perceptions of climate change and climate governance. In most developed countries, the general public largely agree that anthropogenic global warming is happening (Shwom et al. 2015) (*high evidence, high agreement*). Further, there are high levels of climate change concern across nations, and the concern is increasing (Shwom et al. 2015) (*high evidence, high agreement).* A few studies pool data across multiple cross- national surveys and find that citizens in developed nations report higher awareness of climate change than in developing nations but with mixed results regarding concern and risk perceptions (Kim and Wolinsky-Nahmias 2014; Lee et al. 2015; Knight 2016). Lee et al. (2015) report higher concern among those in developing countries who have heard about climate change, than those in developed countries who have heard about climate change. Kim and Wolinsky-Nahmias (2014) report similarly higher concern about climate change and support for mitigation policies in developing nations.

At the individual level, a range of factors are related to degree of climate concerns, including: differences in values (egalitarian values, self-transcending values, environmental values), political orientation/ideology (left-oriented), personal norms, social norms, climate concerns and beliefs, as well as the person's trust in politicians, the institutional system and trust in people in general (Drews and van den Bergh 2016; Harring et al. 2019). Differences in levels of concern, perceptions of risk and urgency may also be underpinned by variation in political orientation (left leaning more concerned), gender (female more concerned) and place of residence (urban residence more concerned) (Shwom et al. 2015; McCright et al. 2016; Ziegler 2017). We know less about whether class, income, race, religiosity, age and education affect perceptions (Shwom et al. 2015; Pearson et al. 2017). Lewis (2019) finds that in non-western countries, climate concern is only weakly correlated with gender, rises with age and religiosity, and is more strongly correlated with education. Bechtel and colleagues (2019) find that individuals working in polluting industries tend to adopt norms against forceful climate governance, but we do not know if differences in dominance of polluting industries underpin governance differences across countries (Bechtel et al. 2019).

Concerning social explanations to cultural-institutional differences across countries, researchers have given emphasis to differences in countries' colonial histories (Aamodt 2018; Aamodt and Boasson 2020); the ministry that takes the lead in climate and energy governance developments (Tosun 2018; Aamodt 2018); differences in countries' regulatory traditions (Boasson et al. 2020) and differences in domestic policy makers' educational background (Rickards et al., 2014:756). Brulle and Norgaard (2019) suggest that differences in unusual natural events linked to climate change, such as bush fires and floods, may result in tragic outcomes that disrupts and renews dominant domestic cultural understandings, but they also highlight that climate governance may be interpreted as a profound challenge to the existing social order, and this may strengthen climate denial frames. In order to better understand how varying cultural-institutional features shape climate governance more systematic comparative studies are required.

All cultural-institutional features are malleable, but the pace of change may vary substantially (Boasson 2015; Leipold et al. 2019; Boasson et al. 2020). Cultural-institutional changes may spur profound changes in climate governance (Boasson et al., 2020), but it may also result in less consistency between political talk, political-decisions and actual climate action (Geden 2016). Although the global targets in the Paris Agreement have changed the climate discourse, it may not equally change decisions and actions (Geden

2016). More research is needed on how adoption of ambitious and complex long-term targets influences domestic climate governance.

13.4.4 Multiple media platforms condition climate governance

Media present, interpret and condition climate governance debates (Tindall et al. 2018). The media coverage of climate change has grown steadily since 1980's (O'Neill et al. 2015; Boykoff et al. 2019), but the level and type of coverage differs over time and from country to country (Boykoff 2011; Schmidt et al. 2013; Schäfer and Schlichting 2014) (*robust evidence, high agreement*). A broad variety of media platforms cover climate, including traditional news media, such as newspapers and broadcasting, digital social media (Walter et al. 2018), creative narratives such as climate fiction and films (Svoboda 2016); humour and entertainment media (Brewer and McKnight 2015; Skurka et al. 2018; Boykoff and Osnes 2019); and strategic communications campaigns (Hansen and Machin 2008; Hoewe and Ahern 2017). Media coverage can have far-reaching consequences on policy processes, but we know less about its relative importance compared to other policy shaping factors (*medium evidence, medium agreement*) (Boykoff 2011; Xinsheng Liu et al. 2011; Hmielowski et al. 2014).

More media coverage does not necessarily lead to more accurate coverage of climate change mitigation, as it can also spur diffusion of misinformation (Boykoff and Yulsman 2013; van der Linden et al. 2015; Whitmarsh and Corner 2017; Fahy 2018; Painter 2019). Because media professionals tend to follow the norm of representing both sides of a controversy, the representation of scepticism of anthropogenic climate change is disproportionate to their standing in climate science (Tindall et al. 2018), particularly in some countries like the US and the UK (Freudenburg and Muselli 2010; Boykoff 2013; Painter and Gavin 2016). This occurs despite increasing consensus among journalists regarding the basic scientific understanding of climate change (Brüggemann and Engesser 2017).

Misinformation can be disruptive by rapidly spreading through social media (Walter et al. 2018). Accurate transference of the climate science has been undermined significantly by climate change counter-movements, particularly in the US (McCright and Dunlap 2000, 2003; Jacques et al. 2008; Brulle et al. 2012; Boussalis and Coan 2016; Farrell 2016a; Carmichael et al. 2017; Carmichael and Brulle 2018; Almiron and Xifra 2019; Boykoff and Farrell 2019) in both legacy and new/social media environments with misinformation (van der Linden et al. 2017). Climate change counter-movements have utilised media as a conduit to spread misinformation about the causes and consequences of climate change (Brulle 2014; Farrell 2016a,b; Supran and Oreskes 2017). Together with the proliferation of suspicions of 'fake news' and 'post-truth', media representations have fuelled polarisation and partisan divides on climate change in contexts such as the United States (Feldman et al. 2017), Australia, Canada and Brazil (Hornsey et al. 2018). Polarised public opinions on climate change can deter development of new and ambitious climate policy (Tindall et al. 2018). Further, the ideological stance of media also influence the intensity and content of media coverage; in developed and developing countries alike (Dotson et al. 2012; Stoddart and Tindall 2015).

Whether and how climate governance is debated openly, and which actors that dominate, varies significantly across countries (Takahashi 2011; Poberezhskaya 2015). Open debates can underpin adoption of more ambitions climate policy (Lyytimäki 2011) and media coverage on energy saving, patriotism, and social justice in the countries like US and the UK have helped connect mitigation of climate change with what other concerns, thereby raising popular support to climate action (Leiserowitz 2006; Trope et al. 2007; Doyle 2016; Corner and Clarke 2017; Whitmarsh and Corner 2017; Markowitz and Guckian 2018). Further, media coverage of climate change mitigation has influenced public opinions through discussions on political, economic, scientific and cultural themes about climate change (Irwin and Wynne 1996; Smith 2000; Boykoff 2011; O'Neill et al. 2015) (*medium evidence, high agreement,*). Media can be a useful conduit to build public support to accelerate mitigation action, but may also be utilised to impede decarbonisation endeavours (Boykoff 2011; Farrell 2016b; Carmichael et al. 2017; Carmichael and Brulle 2018; O'Neill et al. 2015).

Common challenges in reporting climate change exist around the world (Schmidt et al. 2013; Schäfer and Painter 2021). Analyses of key differences in reporting have found lower capacities, lack of journalist training in complex climate subjects, and lack of access to clear, timely and understandable climate-related resources and images in newsrooms in the Global South (Harbinson 2006; Shanahan 2009; Broadbent et al. 2016; Lück et al. 2018). Ugandan journalist Patrick Luganda has said, "Those most at risk from the impacts of climate change typically have had access to the least information about it through mass media." (Boykoff 2011, p. 176).

13.5 Actors in climate governance

For many years, climate governance was primarily shaped through governmental policy processes, but over time public-private partnerships and corporate social responsibility initiatives have become more common (Jordan et al. 2018) (*medium evidence, high agreement*). From the mid-2000s and onwards, litigation became an aspect of climate governance processes, although it is still of relatively modest importance (Peel and Osofsky 2015; Wilensky 2015; Bouwer 2018; Setzer and Byrnes 2019) (*medium evidence, high agreement*). Section 13.4 shows that various structural factors conditions climate governance developments, but their weight also depend on whether and how they are mobilised by actors (Boasson, 2015; Hochstetler, 2020) *(limited evidence, medium agreement*). People may take part in climate governance as citizens, voters, employees, participants in social movements, political party members or consumers, and differing expectations, authority and impact are related to these roles. This section specifies the role of civic, corporate and political actors in climate governance processes, before we discuss courts and litigation.

13.5.1 Mobilisation of civic, corporate and political actors in climate governance

Civic, economic and political actors are to varying degrees mobilised in climate governance processes and their roles and importance vary across countries (Longhofer et al. 2016; Kukkonen et al. 2018), across sectors (Boasson, 2015) and issue areas (Boasson and Wettestad 2013) (*medium evidence, medium agreement*).

Civic engagement denotes the manifold ways that citizens participate in their societies with the intention of influencing communities, politics, and the economy (Skocpol and Fiorina 1999; Barrett and Zani 2014). Many civil society organisations play a role in climate governance, including human rights groups, development and social justice groups, religious communities; and indigenous peoples organisations (Gulbrandsen and Andresen 2004; Jamison 2010; Schroeder 2010; Cabré 2011; Jinnah 2011; Allan and Dauvergne 2013; Felli 2014; Wallbott 2014; Glaab et al. 2018). Among these, environmental and climate groups, climate change counter groups as well as indigenous organisations have gained significant attention in the scientific literature.

Non-governmental environmental and climate organisations aim to mitigate environmental problems and/or climate change, but they have differing origin stories (Longhofer et al. 2016), financial models (Bloodgood and Tremblay-Boire 2017) and positions on climate issues. After 2010, an increasing number of organisations have started to promote a deliberate decline in fossil fuel investments, production and dependence (Rosenbloom and Rinscheid 2020). Another set of organisations aims to undermine established climate science and oppose proposed climate action (Brulle 2014, 2019). These may be think-thanks, philanthropic foundations, or looser activist networks (Brulle 2019). While some are established with the purpose of countering climate mitigation action, others merely have this as one of their missions (Almiron and Xifra 2019). Many organisations countering climate change action in the US are financed by business and thus some argue they should be regarded as economic and not civic actors (Brulle 2014).

Economic organisations include corporate actors as well as labour unions. Corporate actors are for-profit enterprises—publicly traded, privately held or state-owned—and the business and industry associations that aggregate and represent their interests in politics, have been given particular attention in the literature (Meckling 2011; Mildenberger 2020). Because big corporate actors often have good access to political systems, control material resources and are favoured by domestic cultures and traditions, they often play key roles when it comes to influencing, adopting and implementing climate governance (Pulver and Benney 2013; Mildenberger 2020) (*limited evidence, medium agreement*). However, corporate actors' positions and roles in climate policy vary across differing groups of corporate actors, countries, sectors and climate issue-areas (Skjærseth and Skodvin 2010; Boasson and Wettestad 2013; Boasson 2015; Boasson et al. 2020) (*medium evidence, medium agreement*). Labour unions represent employers in private and public organisations and although there is far less research on their role in climate governance, their role are getting increasing attention (Mildenberger 2020).

Domestic civic, economic and political organisations play into climate governance in most, or maybe all, countries. In addition, a range of international organisations can be important and particularly in developing countries, for instance by assisting in framing of national climate governance and supporting the design of climate policies through technical assistance projects (Talaei et al. 2014; Kukkonen et al. 2018; Ortega Díaz and Gutiérrez 2018; Bhamidipati et al. 2019; Charlery and Trærup 2019).

13.5.2 Influencing climate governance

In the period before a policy idea or proposal is adopted or rejected, actors may aim to influence the policy agenda, how the issue is framed, how issues are linked and how a particular measure is designed (Knill and Tosun 2012). Whether, and how, civic mobilisation occurs in relation to climate governance relies on at least two factors: the belief that global warming generally can be mitigated is associated with increased public engagement on climate change (Bostrom et al. 2018; Schleich et al. 2018; Dubois et al. 2019; Marlon et al. 2019; Aasen and Vatn 2020); and whether people believe effective measures are being taken in other countries and on the international level (Aasen and Vatn 2020; Schleich et al. 2018).

There is expansive research on the ways citizens with less access to resources and power participate by challenging the political and economic system. These forms of engagement target nodes of power—policymakers, regulators, and businesses—to change their behaviours and/or accelerate their efforts. Tactics that work within the economic and political systems to achieve these goals include lobbying, legal challenges, shareholder activism, coop board stewardship, and voting (Clemens 1997; Gillan and Starks 2007; Schlozman 2012; Bratton and McCahery 2015; Yildiz et al. 2015; Olzak et al. 2016; Mildenberger et al. 2019)**.** They provide the labour and political will needed to pressure political and economic actors to enact emission-reducing policies, as well as providing resistance to them (Fox and Brown 1998; Boli and Thomas 1999; Oreskes and Conway 2012; McAdam 2017).

Other citizen engagement involves a range of more confrontational tactics, such as boycotting, striking, protesting, and direct action that target politics, policymakers, and businesses that employ data collected from specific types of engagement with the issue of climate change (Meyer and Tarrow 1997; Fisher et al. 2005; Tarrow 2005; Fisher 2010; Walgrave et al. 2012; Saunders et al. 2012; Wahlström et al. 2013; Hadden 2014, 2015; O'Brien 2018; Fisher et al. 2018a; Cock 2019; Fisher 2019; Hadden and Jasny 2019; Swim et al. 2019). Very few studies look specifically at the effect of these tactics on actual climate-related outcomes. This type of engagement has received attention recently as climate strikes and other confrontational forms of climate activism have become more common (O'Brien 2018; Evensen 2019; Fisher 2019; see Box 13.6).

Box 13.6 Civic Engagement: The School Strike Movement

Starting in August 20th 2018, a school-children led movement by Greta Thunberg adopted the novel tactic of skipping school on Fridays to protest against climate change. The movement has since spread around the world. In March 2019, the first *global* climate strike took place, turning out more than 1 million people around the world (Carrington 2019). Six months later in September 2019, young people and adults responded to a call by young activists to participate in climate strikes as part of the 'Global Week for Future' surrounding the UN Climate Action Summit (Thunberg 2019) and the number of participants globally jumped to at least an estimated 6 million people (Taylor et al. 2019). Research on this movement and its consequences in terms of political outcomes and emissions reductions have yet to be fully understood but has a vigorous literature (Evensen 2019; Fisher 2019; Marris 2019; Wahlström et al. 2019; Bevan et al. 2020; Fisher and Nasrin 2021; Han and Ahn 2020; Holmberg and Alvinius 2020; Jung et al. 2020; Martiskainen et al. 2020; de Moor et al. 2020; Thackeray et al. 2020; Trihartono et al. 2020). In their recent assessment of this cycle of climate activism internationally, de Moor and colleagues note that the pandemic "arguably marks the end of the first chapter of the recent climate protest cycle" (de Moor et al. 2020)**.**

Environmental groups tends to have marginal control of material endowments and limited access to the political system, but often take part in larger coalitions or networks to change cultural-institutional frames and understanding (Tjernshaugen 2011; Boasson and Wettestad 2013; Aamodt and Stensdal 2017). Sometimes the influence of environmental groups drops if they have contrasting agendas, but other times moderate organisations may profit if others call for more radical climate measures (Schifeling and Hoffman 2019). After 2010, an increasing number of groups have emerged that call for phase-out, divestments and destabilization of fossil fuel investments and structures (Rosenbloom and Rinscheid 2020). In addition to aiming to influence public policy, environmental groups also influence or initiate private climate governance initiatives, such as public-private partnerships or the investments of universities' funds (Dentoni et al. 2018; Rosenbloom and Rinscheid 2020).

A good deal of research has found that activism, including litigation, as well as the tactics of protest and strikes played a large role in pressuring governments to create environmental laws and environmental agencies tasked with enforcing environmental laws that aimed to maintain clean air and water in countries around the world (McCloskey 1991; Schreurs 1997; Rucht 1999; Brulle 2000; Steinhardt and Wu 2016; Longhofer et al. 2016; Wong 2018). In addition, there are a number of studies that compare across countries to understand the relationship between NGOs in country and the country's environmental impact (Frank et al. 2000; Schofer and Hironaka 2005; Jorgenson et al. 2011; Baxter et al. 2013; Longhofer and Jorgenson 2017; Grant et al. 2018; Mildenberger et al. 2019). Other studies focus specifically on the relationship between NGOs and environmental impact within nations (Shwom 2011; Dietz et al. 2015; Grant and Vasi 2017). In general, these studies conclude that environmental NGOs have a positive effect on reductions in carbon emissions.

At the same time, other research has documented various forms of backlash against climate policies, both in terms of voting behaviour, as well as other collective efforts (Hill et al. 2010; Williamson et al. 2011; McAdam and Boudet 2012; Wright and Boudet 2012; Walker et al. 2014; Boudet et al. 2016; Fast et al. 2016; Krause et al. 2016; Lyon 2016; Mayer 2016; Stokes 2016; Stokes and Warshaw 2017; Muradian and Pascual 2020; Stokes 2020). For instance, the French Yellow vests movement was sparked by a carbon tax proposal, and eventually the French government backtracked (Chamorel 2019). However, there is limited knowledge about the conditions that allow counter actors to succeed in shaping climate governance.

Indigenous peoples organisations represent the communities, peoples, and nations that 'have a historical continuity with pre-invasion and pre-colonial societies that developed on their territories and 'consider themselves distinct from other sectors of the societies now prevailing on those territories' (Schroeder 2010). Like environmental groups, indigenous peoples groups, tend to have limited structural power but often aim to shape cultural-institutional frames relating to broad variety of climate governance issues. These include opposing extraction and transportation of fossil fuels on their traditional lands (especially in the Americas) (Bebbington and Bury 2013; Hindery 2013; Coryat 2015; Claeys and Delgado Pugley 2017; Wood and Rossiter 2017) ; large-scale climate mitigation projects that may affect their traditional rights (Brannstrom et al. 2017; Moreira et al. 2019; Zárate-Toledo et al. 2019); supporting deployment of small-scale renewable energy initiatives (Thornton and Comberti 2017); seeking to influence the development of REDD+ policies through opposition (Reed 2011); and participation in consultation processes and multi-stakeholder bodies (Bushley 2014; Gebara et al. 2014; Astuti and McGregor 2015; Kashwan 2015; Jodoin 2017a). However, indigenous peoples have been excluded from REDD+ readiness processes in some countries (Pham et al. 2014; Jodoin 2017b). Indigenous groups have been reported to have had some influence on some climate discussions, particularly forest management and siting of renewable energy (Claeys and Delgado Pugley 2017; Jodoin 2017a; Thornton and Comberti 2017).

Corporate actors' positions and ability to influence climate policy vary across differing groups of corporate actors, countries and climate issue-areas (Skjærseth and Skodvin 2010; Boasson and Wettestad 2013; Boasson 2015; Boasson et al. 2020) (*medium evidence, medium agreement*). Corporations may gain influence through the material endowments they control (MoeSingh 2012), have superior access to the domestic political system (Mildenberger 2020) or greater success in shaping cultural-institutional features (Boasson 2015). The fossil fuel industries have been important agenda-setters, for instance in the USA (Dunlap and McRight 2015; Supran and Oreskes 2017; Downie 2018) in the EU (Skjærseth and Skodvin 2010; Boasson and Wettestad 2013), in Australia (Ayling 2017), China and India (Blondeel and Van de Graaf 2018), and in Mexico (Pulver 2007), but they have had differing positions across countries (Kim et al. 2016; Nasiritousi 2017). In the US, the oil industry has underpinned emergence of climate scepticism (Dunlap and McRight 2015; Farrell 2016a; Supran and Oreskes 2017), and its spread abroad (Dunlap and Jacques 2013; Engels et al. 2013; Painter and Gavin 2016). Smaller corporate actors providing climate solutions, such as renewable energy industries, have sometimes succeeded in influencing public policy more than large fossil fuel actors, for instance in the EU (Boasson, 2019), Germany (Leiren and Reimer 2018), the US (Stokes and Breetz 2018), the Nordic countries (Kooij et al. 2018) and Japan (Li et al. 2019). Corporate actors tend to change their climate policy preferences over time, particularly in Europe and in relation to energy issues (Boasson and Wettestad 2013; Boasson 2015).

We know far less about how labour unions influence climate governance, although many have developed positions and programmes on climate change (Snell and Fairbrother 2010; Stevins 2013; Räthzel et al. 2018) (Snell and Fairbrother 2010; Stevins 2013; Räthzel et al. 2018), formed alliances with other actors in the field of climate policy (Stevis 2018), and participated in domestic policy networks on climate change (Jost and Jacob 2004). In his in-depth comparative analysis of the role that unions have played in influencing climate mitigation policies in countries with significant fossil fuel resources, Australia, Norway, and the United States, Mildenberger (2020) concludes that labour unions, particularly industrial unions, tend to contribute to reducing the ambition of domestic climate policies. In contrast, (Glynn et al. 2017) find that the role of labour unions varies across countries.

Political actors are political party organisations, legislative assemblies and committees, governmental executives and the political leaders of the governmental ministries (Boasson, 2015, pp. 38–46). Citizens assemblies is a new type of political actor, that have played a role in climate governance development in a few countries, such as Ireland (Devaney et al. 2020). Politicians have limited control of material endowments, but in democracies the dominant political parties or coalitions have the formal authority in the political systems (Boasson et al. 2020). Moreover, politicians may frame debates on climate change and their cues can shape public opinion both positively and negatively (Guber 2013, 2018; Linde 2018). Some political leaders have been particularly successful in shaping how climate change is framed within their countries, for instance, Ethiopian Prime Ministers Zenawi and Desalegn largely succeeded in framing climate as a question of green industrialisation (Okereke et al. 2019), and President Lula and Minister for the Environment da Silva largely succeeded in framing deforestation in Brazil as a crucial climate measure (Hochstetler and Viola 2012; Nunes and Peña 2015). A key driver for political leaders to promote climate change is the prospect of portraying themselves as global climate leaders (Boasson and Wettestad 2013; Carter and Jacobs 2014; Schmitz 2017). However, political leaders have also several times contributed to strengthening sentiments against domestic climate actions (Ferrante and Fearnside 2019; Selby 2019). Politicians are more likely to pay attention to climate issues when polling indicates high political salience with the public (Carter 2006, 2014). In general policy-makers tend to underestimate people's willingness to support mitigation policies (Hurlstone et al. 2014; Mildenberger and Tingley 2019). Fluctuations in the public's interest underpin instability in politicians' engagement (Willis 2017, 2018).

13.5.3 Adopting climate governance

Climate governance adoption refers to actual decision-making, in relation to targets, strategies, measures, instruments and long-term strategies (Knill and Tosun 2012). Governments are key decision-makers and adopters of climate policies and measures (Iacobuta et al. 2018), but an increasing number of non-governmental actors perform climate governance through partnerships (Forsyth 2010), voluntary agreements (Krarup and Ramesohl 2002), GHG emissions disclosure (Hahn et al. 2015) and other voluntary initiatives (*medium evidence, medium agreement*).

Given the dominance of governments in climate governance, the politicians in legislators and executive governments tend to play the dominant role in actual decision-making, although there is variation in whether it is the legislative assembly, the executive government or the political leadership of certain ministries that have the last word (Bang et al. 2015; Aamodt and Stensdal 2017; Boasson et al. 2020). Although other governmental actors, such as independent advisory committees (Carter and Jacobs 2014), the courts (Vanhala 2013; Setzer and Vanhala 2019), and citizens assemblies (Devaney et al. 2020) may have some authority over climate governance, politicians tend to be the most important decision-makers as they often have the formal decision-making power.

Emissions disclosure is the most prevalent form of corporate self-governance (Hahn et al. 2015) but reporting practices vary across countries (Pulver and Benney 2013) and sectors (Backman et al. 2017), as well as between corporations within the same sector (Boasson 2009). Disclosure may be accompanied by target setting, ranging from pledges to source one hundred percent renewable energy to commitments to reduce carbon intensity per unit of product (Gouldson and Sullivan 2013; Walenta 2020).

Private climate governance initiatives can be collaborative partnerships between corporations, environmental organisations and other actors, for instance developing forest management projects (Forsyth 2010), climate certified products (Dentoni et al. 2018), or greening the supply chain (van Huijstee et al. 2011). Overall, environmental organisations' collaboration with large corporate actors that contribute to significant GHG-emissions have increased, but not all initiatives actually affect corporate practices (van Huijstee et al. 2011; Comi et al. 2015). With the exception of a few big international organisations (such as WWF), there is have limited literature on environmental organisations' role as adopters of climate policy (Forsyth 2010; Comi et al. 2015; Longhofer et al. 2016; Aamodt and Stensdal 2017; Dentoni et al. 2018). Moreover, there is little information on the overall performance of private governance initiatives (Pattberg 2010), and the importance of environmental organisations in the internal decision-making processes (Forsyth 2010; van Huijstee et al. 2011; Dentoni et al. 2018). Further, more scientific assessments are required on the role of indigenous groups with respect to adopting and implementing climate measures (Jodoin 2017a; Claeys and Delgado Pugley 2017; Thornton and Comberti 2017).

13.5.4 Implementing climate governance

Implementation is the carrying out of climate policy and governance decisions, denoting what happens after decisions are made (Hill and Hupe 2014).

Corporate actors are crucial to implementation of public and private policies; this follows from their control of material endowments, their crucial role in the causes of climate change (as prominent emitters of the greenhouse gases and owners of carbon-intensive technologies) and their contribution to offering solutions (owning, developing and performing low emission practices and technologies) (Perrow and Pulver 2015). Measures that imply mandatory requirements for corporations rely on their compliance in order to succeed, for instance this is the case with carbon pricing that cover 20%of global emissions (World Bank 2019). Measures creating economic advantages to corporate actors that perform certain practices rely on businesses voluntary stepping up to exploit the economic opportunities, such as investment support or feed-in support for renewable energy or energy efficiency measures and voluntary set of programs like the Clean Development Mechanism (CDM) (Olsen 2007). Since corporations have to actively choose to exploit these measures, they have much leeway to influence the success of the measures, but there is little systematic research on this.

Environmental organisations are less visible in the implementation stage, but they may engage in 'naming and shaming' activities aimed at increasing countries' compliance with climate obligations. The carbon tracker initiative is one example of is (Carbon Tracker 2019), but we have little systematic research on the effect of such initiatives.

There is an extensive literature (discussed in Chapter 7 of AR6) that concerns the role of Indigenous Peoples in the implementation of REDD+ through community-based REDD+ programs and projects and community involved in measurement, reporting, and verification of carbon emissions from forest-based sources (Jodoin 2017a). In some cases, REDD+ programs and projects have supported Indigenous-led community forestry as a strategy for reducing carbon emissions, and contributed to strengthening the forest tenure rights of Indigenous Peoples, while in other cases, Indigenous Peoples have been excluded and both their rights and their traditional knowledge have been neglected (Jodoin 2017a).

Politicians tend to play a less central role in implementation than they do in influencing and adopting public climate policies. However, when politicians intervene and change policies often, this may create uncertainty that hampers implementation of climate policies (Boasson et al. 2020).

13.5.5 Shaping climate governance through litigation

Climate litigation has become a more common aspect of domestic climate governance development since the mid-2000s, but there are major variations across countries (Peel and Osofsky 2015; Wilensky 2015; Bouwer 2018; Setzer and Byrnes 2019) *(medium evidence, high agreement)*. This is not surprising, given that courts play differing roles across varying political systems and law traditions (La Porta et al. 1998). Climate litigation is an attempt to control, order or influence the behaviour of others in relation to climate governance, and it has been used by a wide variety of litigants; governments, private actors, civil society and individuals, at multiple scales (local, regional, national and international) (Osofsky 2007; Lin 2012b; Keele 2017; McCormick et al. 2018; Peel and Osofsky 2018; Setzer and Vanhala 2019).

The vast majority of climate cases have emerged in United States, but it has also had importance in Australia and the United Kingdom, and more recently in developing countries (Humby 2018; Kotze and du Plessis 2019; Peel and Lin 2019; Setzer and Benjamin 2019; Zhao et al. 2019). Overall, courts have also played a more active role for climate governance in more democratic than in authoritarian countries (Peel and Osofsky 2015; Setzer and Byrnes 2019), but recent reforms to environmental public interest laws in authoritarian systems, such as those in China, allow individuals and groups to initiate environmental litigation (Zhao et al. 2019). Whether and to what extend differing law traditions and political systems influence the role and importance of climate litigation has, however, not been examined enough scientifically.

The majority of climate change litigation cases are brought by civic and non-governmental organisations and corporations against governments (Eisenstat 2011; Markell and Ruhl 2012; Wilensky 2015; Fisher et al. 2017). The Dutch Urgenda case has set a particularly important precedent, as the first in the world in which a highest level domestic court established a state's duty to reduce emissions by at least 25% by the end of 2020, in accordance with its human rights commitments and to the recommendations of IPCC's AR5 (Burgers and Staal 2019; Antonopoulos 2020). Since the first decision in the Urgenda case was issued in 2015, individuals and communities around the world have initiated proceedings against states seeking to achieve similar rulings (Roy and Woerdman 2016; Mayer 2019). Moreover, a number of regulatory challenges to permits authorising high-emitting projects are setting precedents that are also favourable to climate action (Bouwer 2018). For instance, the UK Court of Appeal concluded that the government needed to consider the Paris Agreement goals in its policy framework for the expansion of Heathrow Airport (Gordhan 2020; Mitchell 2020) and the High Court in Pretoria, South Africa, concluded that climate change is a relevant consideration for the environmental review of a coal-fired power plant (Humby 2018).

Climate change litigation has also been brought against corporations by regional and local governments as well as civic and non-governmental organisations (Wilensky 2015; Ganguly et al. 2018). One type of private climate change litigation alleges climate change-related damage and seeking compensation from major carbon polluters (Ganguly et al. 2018). The litigators claim that multinational corporations (the so-called 'Carbon Majors') are historically responsible for a significant portion of global greenhouse gas emissions (Heede 2014; Frumhoff et al. 2015; Ekwurzel et al. 2017). These cases rely on advancements in climate science, particularly climate attribution (Marjanac et al. 2017; Marjanac and Patton 2018; McCormick et al. 2018). It is alleged that major carbon emitters had knowledge and awareness of climate change and took actions to confound or mislead the public about climate science (Supran and Oreskes 2017). Strategic climate change litigation has also been used to argue against financial investments in the fossil fuel industry (Franta 2017) and to hold corporations to specific human rights responsibilities (Savaresi and Auz 2019). Claims have also been brought against banks, pension funds and investment funds for failing to incorporate climate risk into their decision-making, and for failing to disclose climate risk to their beneficiaries (Solana 2019).

But questions about the extent to which these cases help to address climate change in a meaningful way remain unanswered (Peel and Osofsky 2015; Setzer and Vanhala 2019). Climate litigation has been initiated to reduce as well as increase the stringency and ambitiousness of climate governance (McCormick et al. 2018). Individual cases may attract media attention, and that in turn can influence how climate policy is perceived (Nosek 2018; Hilson 2019), yet whether and how they actually result in new understandings of rules and policies (Peel and Osofsky 2018). In the United States, pro-regulation litigants more commonly win renewable energy and energy efficiency cases, and more frequently lose coal-fired power plant cases (McCormick et al. 2018). Outcomes tend to favour anti-regulatory litigants compared with pro-regulatory litigants, in the United States, while outcomes tend to favour pro-regulatory litigants compared with anti-regulatory litigants outside the United States (Setzer and Byrnes 2019).

13.6 Policy instruments and evaluation

This section provides a taxonomy of policy instruments, presents a set of criteria for policy evaluation, and synthesises the literature on the most common mitigation policies. The emphasis is on recent empirical evidence on the performance of different policy instruments and lessons that can be drawn from these experiences. AR5 provided a more theoretical treatment of policy instruments for mitigation.

13.6.1 Taxonomy and overview of mitigation policies

13.6.1.1 Taxonomy of mitigation policies

A large number of policies and policy instruments can affect GHG emissions and/or sequestration, whether their primary purpose is climate change mitigation or not.[1] There is no agreed operational definition of what constitutes a mitigation policy so this section adopts a broad interpretation. Policies and their instruments tend to overlap and interact.

Environmental policy instruments, including for climate change mitigation, have long been grouped into three main categories – (1) economic instruments, (2) regulatory instruments, and (3) other instruments – although the specific terms differ across disciplines and additional categories are common (Kneese and Schultze 1975; Jaffe and Stavins 1995; Nordhaus 2013). Common policies in each category are shown in Table 13.1. Principles of and empirical experience with the various instruments is synthesised in Sections 13.6.3 to 13.6.5, policy interactions are covered in Section 13.6.6.

Table 13.1 Classification of Mitigation Policies

Category	**Common types of mitigation policy instruments**
Economic instruments	Carbon tax, GHG emissions trading, fossil fuel taxes, renewable energy subsidies, others
Regulatory instruments	Energy efficiency standards, energy efficiency standards, renewable portfolio standard, zero-emission vehicle standard, ban on SF_6 uses, others
Other instruments	Information programs, voluntary agreements, government procurement, technology policies, others

13.6.1.2 Coverage and stringency of mitigation policies

An increasing share of emissions sources are subject to mitigation policies, though coverage is still incomplete (Nascimento et al., under review; Eskander and Fankhauser 2020). The share of G20 emissions covered by various policy instruments has increased steadily over the past two decades (Figure 13.3). Coverage of agriculture and forestry emissions is lower than that in other sectors and there is some differentiation in policy instruments across sectors. The mix of policies has shifted towards more mandatory policies over the past decade; that is more regulations and carbon pricing relative to information policies and voluntary action.

FOOTNOTE :[1] Several databases catalogue climate change legislation or mitigation policies, including Climate Change Laws of the World (Grantham Research Centre and others), Climate Policy Database (NDC Partnership), Policies and Measures database (IEA and IRENA) and European Union Climate Policy Database (European Environmental Agency).

Figure 13.3 Prevalence of policy instruments in G20 member countries

[Note: Bars indicate the share of G20 members' total emissions in 2018 that have such a policy in place in the respective sector. The bars overstate actual coverage since policies often exempt some emissions, such as those by small sources. Source: (Nascimento et al., under review)*]*

Analyses based on the Climate Change Laws of the World database reveal similar patterns (Schmidt and Fleig 2018; Eskander and Fankhauser 2020). The extent of climate legislation has increased steadily since 2012, but at a decreasing rate (Eskander and Fankhauser 2020). Among policy instruments, there has been a shift from voluntary and information programs to regulations and pricing policies (Schmidt and Fleig 2018).

While an increasing share of CO_2 emissions from fossil fuel combustion is subject to mitigation policies, there remain many countries and sectors where no dedicated mitigation policies apply to fuel combustion. Fossil fuel use is subject to energy taxes in the majority but not all jurisdictions, and in some instances, it is subsidised. The main gaps in current mitigation policy coverage are non-CO_2 emissions and CO_2 emissions associated with production of industrial materials and chemical feedstocks, which are connected to broader questions of shifting to cleaner production systems (Bataille et al. 2018a; Davis et al. 2018). Sequestration policies focus mainly on forestry and CCS with limited support for other capture and use options (Geden et al. 2019; Vonhedemann et al. 2020).

The stringency of mitigation policies varies greatly by country, sector and policy (see Box 13.7).

Box 13.7 Comparing the stringency of mitigation policies

Comparing the stringency of mitigation policies is complex and there is no single widely accepted metric or methodology. Economic instruments can be compared on the basis of their price or cost per tCO_2-eq. Even that is fraught with complexity given different definitions and estimations for fossil fuel subsidies. For non-price policies an implicit or equivalent carbon price can be calculated. Factors such as the tax treatment of compliance costs can increase the complexity.

To account for the combined effect of overlapping policies, averages can be calculated over implicit prices by sector. Aggregating estimates of 'effective carbon prices' for the policies implemented by a country yields an indication of the overall stringency of its policies measures, though such estimates are subject to numerous limitations.

The level of effective carbon prices, as estimates of overall policy stringency, differs greatly between countries and sectors. Countries with higher overall effective carbon prices tend to have lower carbon intensity of energy supply and lower emissions intensity of the economy, as shown in an analysis of 42 G20 and OECD countries (OECD 2018). The carbon price that prevails under a carbon tax or ETS is not directly a measure of policy stringency across an economy, as the carbon prices typically only cover a share of total emissions (Finch and Van den Berg, under review).

Estimates of the effective carbon price covering seven price-based policies in 25 high-emitting countries rose steadily from USD 2 in 2012 to USD 13 in 2019 (Carhart et al., under review). In 2019, 20 countries which together accounted for 28.7 $GtCO_2$ emissions had an average cost of emissions between 6 to 95 USD/tCO_2-eq. with European countries showing the highest average carbon prices, while five (together accounting for 3.4 $GtCO_2$) had negative or zero average costs of emissions due to fossil fuel subsidies. In countries with a positive average, fossil fuel taxes on average accounted for most of the total cost of carbon, while in countries that had a negative overall carbon cost, the dominant factor was fuel subsidies (Figure 13.4).

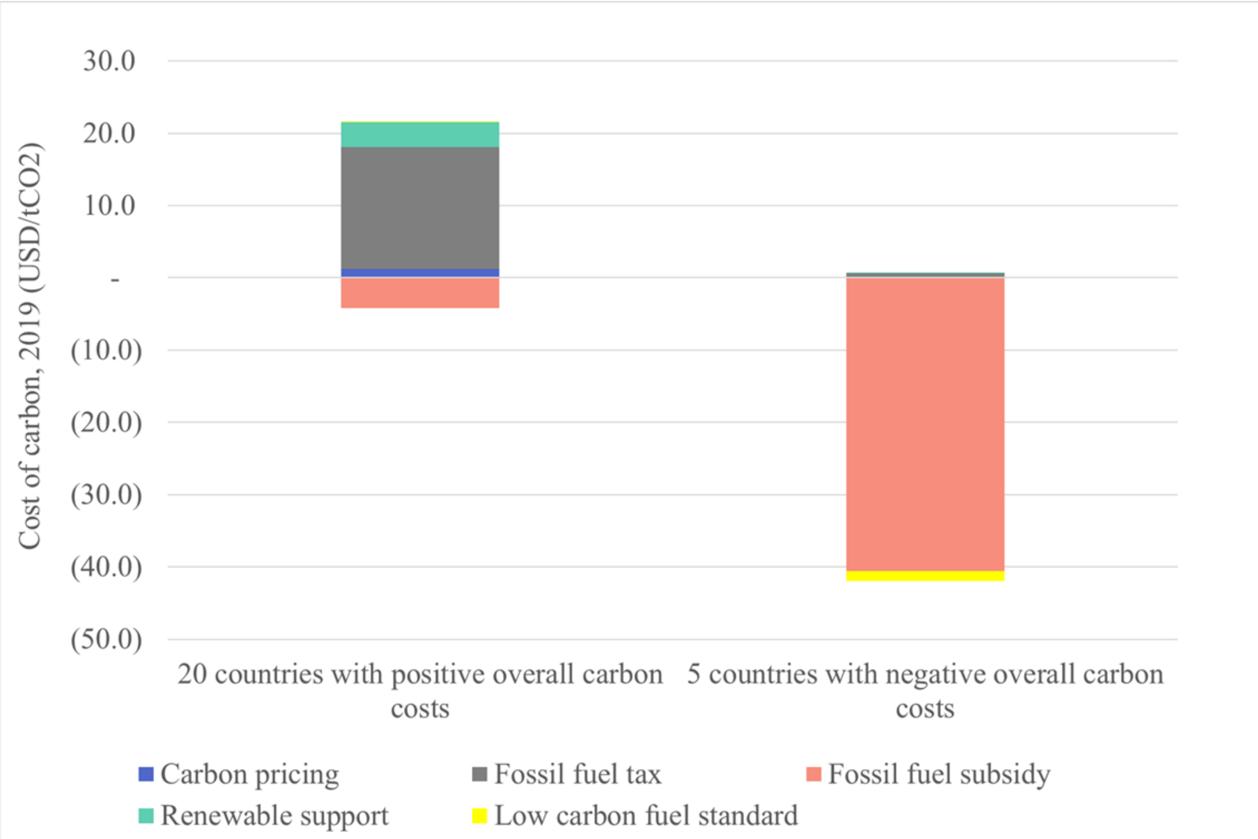

Figure 13.4 Cost of carbon from different policies, 25 selected countries, 2019 (USD/tCO_2), source: (Carhart et al., under review), IPCC calculations

Note: Aggregates computed from data in (Carhart et al., under review) *who provide estimates for a selection of 25 countries that account for 82% of global emissions. Selection of countries is defined by data availability. Split of countries in the Figure is determined by whether overall carbon costs are positive (20 countries, left hand bar) or negative (5 countries, right hand bar).*

13.6.2 Evaluation criteria

Policy evaluation is a "careful, retrospective assessment of merit, worth and value of the administration, output and outcomes of government interventions" (Vedung 2005). The inherent complexity of climate mitigation policies calls for the application of multiple criteria, and reflexiveness of the analysis with regard to governments' and societies' objectives for policies (Huitema et al. 2011).

Evaluation of climate mitigation policy tends to focus on the environmental effectiveness and economic efficiency or cost-effectiveness of GHG mitigation policies, with distributional equity sometimes as an additional criterion. In policy design and implementation there is rising interest in co-benefits and side-effects of climate policies, as well as institutional requirements for implementation. In the context of transitions to net zero emissions systems, the potential of policies to have transformative effects becomes relevant. Table 13.2 elaborates.

Evaluation of mitigation policies based on the full range of these criteria can assist in identifying the role that different policy instruments can play in transformation of systems and acceleration of mitigation efforts (see Section 13.9). Not all criteria are applicable to all instruments or in all circumstances and the relative importance of different criteria depend on the objectives in the specific the context. Evaluation in practice will follow a form of multi-criteria assessment (for example (Konidari and Mavrakis 2007)) or multi-criteria decision analysis (Cohen et al. 2019).

Table 13.2 Criteria for evaluation and assessment of policy instruments and packages

Criterion	**Description**
Environmental effectiveness	Reducing GHG emissions is the primary goal of mitigation policies and therefore a fundamental criterion in evaluation. Environmental effectiveness has temporal and spatial dimensions.
Economic effectiveness	Climate change mitigation policies usually carry economic costs, and/or bring economic benefits other than through avoided future climate change. Economic effectiveness requires minimising costs and maximising benefits.
Distributional effects	The costs and benefits of policies are usually distributed unequally among different groups within a society (Zachmann et al. 2018), for example between industry, consumers, taxpayers; poor and rich households; different industries; and different regions. Policy design affects distributional effects, and equity can be taken into account in policy design in order to achieve political support for climate policies (Baranzini et al. 2017).
Co-benefits, negative side-effects	Climate change mitigation policies can have effects on other objectives, either positive co-benefits (Mayrhofer and Gupta 2016) or negative side-effects. Conversely, impacts on emissions can arise as side-effects of other policies. There can be various interactions between climate change mitigation and the Sustainable Development Goals (Liu et al. 2019).

Institutional requirements	Effective implementation of policies requires that specific institutional prerequisites are met. These include effective monitoring of activities or emissions and enforcement, and institutional structures for the design and oversight of policies. Requirements differ between policy instruments. A separate consideration is the overall feasibility of a policy within a jurisdiction, including political feasibility (Jewell and Cherp 2020).
Transformative potential	Transformational change is a process that involves profound change resulting in fundamentally different structures (Nalau and Handmer 2015), or a substantial shift in a system's underlying structure (Hermwille et al. 2015a). Climate change mitigation policies can be seen has having transformative potential if they can fundamentally change emissions trajectories, or facilitate a step change in technologies, practices or products.

13.6.3 Economic instruments

Economic instruments, sometimes also referred to as market-based instruments, raise the prices of GHG-intensive goods and services thus creating a financial incentive to switch less emissions intensive options. Carbon taxes, emissions trading systems (ETS), offset payments, subsidies and fossil fuel subsidy removal fall into this category. Pricing instruments, especially ETS as well as carbon taxes, have become much more prevalent in recent years (Section 13.6.1).

13.6.3.1 Carbon Taxes

A carbon tax is a charge on carbon dioxide or other greenhouse gases imposed on specified emitters or products. While other taxes can also reduce emissions by increasing the price of GHG emitting products, the result may be inefficient unless the tax rate is proportional to the emissions intensity. A tax on value of fossil fuels, for example, could raise the price on natural gas more than the price of coal, and hence increase emissions if substitution towards coal were to outweigh reductions in energy use as a result of such a tax. In practice features such as exemptions and multiple rates can lead to debate as to whether a specific tax is a carbon tax (Haites et al. 2018).

22 carbon taxes had been implemented by national governments as of April 2020, mostly in Europe (Postic and Fetet 2020; World Bank 2020). Most of the taxes apply to fossil fuels used for transportation and heating and cover between 15 and 50% of the jurisdiction's emissions. Tax rates vary widely from less than USD 1 to over USD 122 per tCO_2-eq. How the tax revenue is used varies widely by jurisdiction.

Carbon taxes tend to garner the least public support among possible mitigation policy options (Rhodes et al. 2017; Rabe 2018; Maestre-Andrés et al. 2019; Criqui et al. 2019). Policymakers sometimes use the revenue to build support for the tax, allocating some to address regressivity, to address competitiveness claims by industry, to reduce the economic cost by lowering existing taxes, and to fund environmental projects (Gavard et al. 2018; Levi et al. 2020).

Carbon tax rates can be adjusted for inflation, increases in income, the effects of technological change, changing policy ambition, or the addition or subtraction of other policies. In practice numerous jurisdictions have not increased their tax rates annually and some scheduled tax increases have not been implemented (Haites et al. 2018). Predictability of future tax rates helps improve economic performance. Uncertainty about the future existence of a carbon price can hinder investment (Jotzo et al. 2012) and uncertainty about future price levels can increase the resource costs of carbon pricing (Aldy and Armitage 2020).

13.6.3.2 Emission trading systems

The most common ETS design – cap-and-trade – sets a limit on aggregate GHG emissions by specified sources, distributes tradable allowances (usually one tCO_2-eq each) approximately equal to the limit, and requires regulated emitters to submit allowances equal to their actual emissions.[2] The price of allowances is determined by the market, except in cases where government determined price floors or ceilings apply.

ETSs for GHGs were in place in 35 countries as of April 2020 (Postic and Fetet 2020; World Bank 2020). The EU ETS, which covers the 31 members of the European Economic Area, is the largest by far. ETSs tend to cover emissions by large industrial and electricity generating facilities and cover between 10 and 60% of the jurisdiction's emissions. Allowance prices range from just over USD 1 to USD 32.

Eight regional pilot ETSs with different designs have been implemented in China since 2013 to provide input to the design of a national system that is to become the world's largest ETS (Jotzo et al. 2018; Qian et al. 2018; Stoerk et al. 2019). Assessments have identified potential improvements to emissions reporting procedures (Zhang et al. 2019) and the pilot ETS designs (Deng et al. 2018).

All of the ETSs for which data are available have accumulated surplus allowances (Haites 2018). Most of those ETSs have implemented measures to reduce the surplus including removal/cancellation of allowances and more rapid reduction of the cap. Several ETSs have adopted mechanisms to remove excess allowances from the market when prices are low and release additional allowances into the market when prices are high, such as the EU "market stability reserve" (Hepburn et al. 2016; Bruninx et al. 2020). Initial indications are that this mechanism is at least partially successful in stabilising prices in response to short term disruptions such as the COVID-19 economic shock (Gerlagh et al. 2020). ETS design can also address issues such as market liquidity and the business conditions of covered companies (e.g. (Howie et al. 2020) on Korea's and Kazakhstan's ETS).

Some ETS also include provisions to limit the range of market prices, making them 'hybrids'. A price floor assures a minimum level of policy effect if demand for allowances is low relative to the ETS emissions cap. It is usually implemented through a minimum price at auction, as for example in California's ETS (Borenstein et al. 2019). A price ceiling allows governments to issue unlimited additional allowances at a pre-determined price. Price ceilings have to date not been activated.

13.6.3.3 Evaluation of carbon pricing experience

Environmental effectiveness and co-benefits

Economic theory firmly suggests that carbon pricing is effective in reducing emissions relative to the situation without an economic penalty on emissions. This is borne out in statistical studies of emissions trends in jurisdictions with and without carbon pricing. For example, in a two-decade sample covering 142 countries, the average annual emissions growth rate was around 2 percentage points lower in countries that had a carbon price, after controlling for other policies and structural factors (Best et al. 2020).

Numerous assessments of the emissions reductions achieved by ETSs, especially the EU ETS, have been undertaken (see (Narassimhan et al. 2018; FSR Climate 2019) for reviews). Emissions covered by a number

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FOOTNOTE :[2] In a baseline and credit system, each participant is assigned an annual emissions baseline usually based on actual output or activity and an emissions factor. A participant whose actual emissions are lower than its baseline receives credits equal to the difference. A participant whose actual emissions exceed its baseline must purchase sufficient credits to achieve compliance. Examples include systems in Canada (Rivers and Jaccard 2010) and Australia (MacGill et al. 2006).

of ETS declined in absolute terms (Haites 2018). In other systems, ETS are thought to have slowed the growth in emissions. The emissions reductions are due to other mitigation policies, exogenous developments, such as changes in fuel prices, as well as the ETS in the case of the EU (FSR Climate 2019) RGGI (Murray and Maniloff 2015) and Tokyo (Arimura and Abe 2020).

Assessments of the performance of carbon taxes relate to European carbon for periods prior to 2008 and of British Columbia's tax between 2008 and 2015 (see (Haites 2018; Haites et al. 2018; Metcalf and Stock 2020) for reviews; and Chile (Diaz et al. 2020). The assessments conclude that the taxes reduced emissions relative to business-as-usual, but in most cases actual emissions subject to the tax continued to rise (Haites et al. 2018). The carbon taxes tend to be small relative to fossil fuel taxes. The estimated emission reductions are due to changes in fossil fuel prices, changes in fossil fuel taxes, and other mitigation policies as well as the carbon taxes (Aydin and Esen 2018).

Few of the world's carbon prices are at a level consistent with that required to achieve the goals of the Paris Agreement, which one synthesis study estimated at USD 40–80/tCO_2 by 2020 (High-Level Commission on Carbon Prices 2017). Only a small minority of carbon pricing schemes in 2020 had prices above USD 30/t, and all schemes above USD 50/t were carbon taxes in a small number of European countries (World Bank 2020). Most carbon pricing systems apply only to some share of the total emissions in a jurisdiction, so the headline carbon price is higher than the average carbon price that applies across an economy (Finch and Van den Berg, under review). Model-based estimations of carbon prices consistent with achieving the goals of the Paris Agreement of limiting temperature increase to 2°C and aiming for well below 1.5°C will need to rise to 95-205 USD2015/tCO_2 by 2030 (Chapter 3, Section 3.6.1).

In most jurisdictions where ETS or carbon taxes exist, they apply to the majority of carbon dioxide emissions from fossil fuel combustion emissions though some sources are not covered, such as some types of transport or fuels for heating. For example, the share of emissions CO_2 combustion emissions covered in 2019 was 45% in the EU ETS, 70% in Korea's ETS, 37% in Mexico's ETS, and between 3% to 60% under the carbon taxes of countries that are members of the European Environment Agency (Postic and Fetet 2020). As of May 2020, there were 61 carbon pricing schemes (ETS or carbon tax) in place or scheduled for implementation (World Bank 2020). In many jurisdictions however carbon dioxide emissions are not or only partially covered by carbon pricing or other dedicated mitigation policy instruments. The estimated total amount of emissions covered by carbon pricing instruments in 2019 was 5.4GtCO_2-eq. in OECD countries and 2.3GtCO_2-eq. in non-OECD countries (computed from (World Bank, accessed Dec 2020)), equivalent to around 23% of the world's CO_2 emissions from fossil fuel combustion (around 45% of fossil fuel CO_2 in OECD countries and around 10% in non-OECD countries (BP 2020). The scheduled implementation of China's national ETS is set to increase coverage to 4.6Gt (21%) in non-OECD countries and 10Gt (29%) in total.

Where carbon pricing or other policies are effective in reducing GHG emissions, they usually also achieve co-benefits including lower air pollution. For example, a Chinese study of air quality benefits from lower fossil fuel use under carbon pricing suggests that prospective health co-benefits would partially or fully offset carbon policy (Li et al. 2018). In some cases, carbon pricing would also bring co-benefits through reducing the economic distortions from fossil fuel subsidies, and improved energy security through greater reliance on local energy sources and less exposure to fossil fuel market volatility. Substantial carbon prices would be in the domestic self-interest of many countries if co-benefits were fully factored in (Parry et al. 2015).

Economic effectiveness

Economic theory suggests that carbon pricing on the whole is the most cost effective way to reduce emissions.

Few carbon taxes apply to emissions-intensive, trade-exposed (EITE) sources (Timilsina 2018), so competitiveness impacts are not usually a particular concern. An ex post analysis of European carbon taxes finds no robust evidence of a negative effect on employment or GDP growth (Metcalf and Stock 2020).

Studies of the economic impacts of the EU ETS find minimal, if any, adverse impacts on economic variables such as output, value added, employment, and investment (see Section 13.7). This is attributed to large allocations of free allowances especially EITE industries that could otherwise suffer losses in competitiveness, relatively low allowance prices, the ability of firms in some sectors to pass costs on to consumers, energy's relatively low share of production costs, and small but significant effects on innovation (Joltreau and Sommerfeld 2019).

Government revenue from carbon pricing globally has been estimated at USD 48 billion in 2019 (split almost evenly between carbon taxes and ETS allowances) (Postic and Fetet 2020). Revenue raised though carbon pricing is generally considered a relatively efficient form of taxation, and a large share of revenue enters general government budgets. Some of the revenue is earmarked or returned to emitters. Allowance allocation and revenue spending measures have been used to create buy-in at every major reform stage of the EU ETS (Dorsch et al. 2020).

Distributional effects

Price and regulatory policies have distributional consequences for businesses and consumers which can be addressed through policy. Regulations generally address distributional impacts through implementation provisions and sometimes by allowing compliance by trading between emissions sources. Pricing policies deal with the impacts on emitters through free allowance allocations in the case of an ETS or exemptions/rebates in the case of a carbon tax. Financial impacts of carbon pricing on consumers are sometimes dealt with through rebates, changes to other taxes, or social security payments. Compensation measures can be permanent or transitory. Increases in electricity prices are typically the largest distributional concern for consumers.

The distributional impact of a carbon pricing has "use-side" and "source-side" components. The "use-side" component, the increases in the costs of goods and services purchased by households, tends to be proportionately higher for low income groups (Timilsina 2018) except in developing countries where energy plays a smaller role in expenditure of low-income households (Yusuf and Resosudarmo 2015). In contrast, the "source-side" component, impacts on wages, capital, and transfer income, tends to be progressive, due to lower returns on capital and higher transfers to lower income households (Goulder et al. 2019). The net effect can range from regressive to progressive (Williams III et al. 2015; Goulder et al. 2019). Governments can rebate part or all of the revenue from carbon taxes to low income households, or implement other changes to taxation and transfer systems to achieve desired distributional outcomes (Jacobs and van der Ploeg 2019; Saelim 2019; Sallee 2019).

Distributional impacts have on the whole not been a significant issue for ETSs. Equity across participants generally is addressed through partially free allocation of allowances. Impacts on household incomes, with the exception of electricity prices, are too small or indirect to be a concern. Some systems are designed to limit electricity price increases (Petek 2020) or use some revenue for bill assistance to low-income households (RGGI 2019)..

Transformative potential

Carbon pricing is a broad-based policy instrument, best suited to achieve emissions reductions across the board, cost-effectively through a large number of usually incremental adjustments. At high and predictable levels over longer periods of time it could transform emissions trajectories, however experience in implementation suggests that the politically feasible level of carbon pricing is limited in most jurisdictions. It follows that carbon pricing has a central role in an overall policy portfolio.

13.6.3.4 Offset credits

Offset credits are voluntary GHG emission reductions for which tradable credits are issued by a supervisory body. A buyer can use purchased credits to offset an equal quantity of its emissions. There are voluntary and compliance markets for offset credits. In the voluntary market governments, firms and individuals purchase credits to offset emissions generated by their actions, such as air travel. The compliance market consists of specified offset credits that can be used for compliance with mitigation policies, especially ETSs (Newell et al. 2013; Bento et al. 2016; Michaelowa et al. 2019).

When used for compliance, governments typically specify a maximum quantity of offset credits that can be used, the types of emission reduction actions that can generate eligible credits and the geographic region from which the credits can originate. Initially, the EU ETS, Swiss ETS and New Zealand ETS accepted credits issued under the Clean Development Mechanism (CERs) and Joint Implementation (ERUs) mechanisms of the Kyoto Protocol, but they terminated or severely constrained the quantity of international credits allowed for compliance use after 2014 ((Shishlov et al. 2016) see Section 13.7.2).

Newer ETSs, including South Korea and the Chinese pilots, have limited offset credits to those from the same jurisdiction. (Lo and Cong 2017; Zhou et al. 2019). Offset schemes also exist as national instruments. An example is the Australian Emissions Reduction Fund (Climate Change Authority (Aus) 2017), where the government is the sole buyer of credits.

A key question for any offset credit is whether the emission reductions are ‘additional’: reductions that only happen because of the offset credit payment (Millard-Ball and Ortolano 2010; van Benthem and Kerr 2013; Bento et al. 2016; Burke 2016). To assess additionality and to determine the amount of credits issued, regulators develop methodologies to estimate baseline (business-as-usual) emissions that would have occurred without offset payments (Newell et al. 2013; Bento et al. 2016). Possible increases in emissions outside the project boundary (‘leakage’) is a related risk (Rosendahl and Strand 2011). However, some research suggests that various regulatory and measurement advances can significantly reduce the risk of severe non-additionality (Mason and Plantinga 2013; Bento et al. 2016; Michaelowa et al. 2019).

13.6.3.5 Subsidies for mitigation

Subsidies for mitigation encourage individuals and firms to invest in assets that reduce emissions, changes in processes or innovation. Governments routinely provide direct funding for basic research, subsidies for R&D to private companies, and co-funding of research and deployment with industry (Dzonzi-Undi and Li 2016). Research subsidies have been found to be positively correlated with green product innovation in a study in Germany, Switzerland and Austria (Stucki et al. 2018). Government subsidies for R&D have been found to greatly increase the green innovation performance of energy intensive firms in China (Bai et al. 2019) (See Box 13.9). For more detail see Chapter 16.

Subsidies of different forms are often provided for emissions savings investments to businesses and for the retrofit of buildings. Tax credits can be used to encourage firms to produce or invest in low-carbon emission energy and low-emission equipment. Investment subsidies have been found to be more effective in reducing costs and uncertainties in solar energy technologies than production subsidies (Flowers et al. 2016).

Subsidies to households have been provided extensively and in many countries for the deployment of rooftop solar systems, and increasingly also for commercial scale renewable energy projects, typically using ‘feed-in tariffs’ that provide a payment for electricity generated above the market price (Pyrgou et al. 2016). Such schemes have proven effective in deploying household level renewable energy, but lock in subsidies for long periods of time and in some cases provide subsidies at higher levels than would be required to motivate deployment. On the other hand, support for rollout clean technologies at high prices can be economically beneficial in the long run if costs are reduced greatly as a function of deployment (Newbery 2018).

Deployment support, much of it in the form of feed-in tariffs in Germany, enabled the scaling up of the global solar photovoltaic industry and attendant large reductions in production costs that by 2020 made solar power cost competitive with fossil fuels (Buchholz et al. 2019). There is also evidence for increased innovation activity as a result of solar feed-in tariffs (Böhringer et al. 2017a).

A variant of subsidies for deployment of renewable energy are auctioned feed-in tariffs or auctioned contracts-for-difference, where commercial providers bid in a competitive process, leading to lower price premiums (Eberhard and Kåberger 2016; Roberts 2020). The criteria for contracts-for-difference sometimes also include local co-benefits such as local economic diversification (Buckman et al. 2019). Similar arrangements could apply to deployment of other zero-emissions technologies.

Many governments have also provided subsidies for the purchase of electric vehicles, including with strong effect in China (Ma et al. 2017), sometimes at relatively high rates (Kong and Hardman 2019).

13.6.3.6 Removal of fossil fuel subsidies

Many governments subsidise fossil fuel consumption and/or production through a variety of mechanisms (Burniaux and Chateau 2014). Different approaches exist to defining the scope and estimating the magnitude of fossil fuel subsidies (Koplow 2018), and all involve estimates, so the magnitudes are uncertain. Removal of fossil fuel subsidies improves economic efficiency, increases government revenue and reduces GHG emissions, and will tend to reduce inequality.

The magnitude of fossil fuel subsidies can be estimated using an "inventory" or a "price gap" approach (Skovgaard and van Asselt 2019). The former identifies government measures that benefit fossil fuel producers or consumers and estimates their monetary value. The latter compares observed consumer prices with a benchmark price, often the world market price, and treats the difference as a subsidy. The OECD estimates subsidies for 43 countries using the inventory approach focussing on subsidies to production, while the IEA estimates consumption subsidies for about 40 countries using the price gap approach. The total subsidy is the sum of the two with some adjustment for overlaps (Steenblik et al. 2010). Other organisations that periodically estimate fossil fuel subsidies for multiple countries based on different definitions include the IMF ((Coady et al. 2017), updated in (Coady et al. 2019)) and Geddes (2020) (Figure 13.5).[3]

Consumption subsidies represent approximately 70% of the total. Most of the subsidies go to petroleum, which accounts for roughly 50% of the consumption subsidies and 75% of the production subsidies. Much of the variation over time in the consumption subsidies is due to fluctuations in the world price of oil which is used as the reference price. Developed countries accounted for 5% of the world's fossil fuel subsidies during 2010-19 according to IMF estimates ((Coady et al. 2017), (Coady et al. 2019) and updated).

Removing fossil fuel subsidies would lower CO_2 emissions, increase government revenues (Dennis 2016; Gass and Echeverria 2017; Rentschler and Bazilian 2017; Monasterolo and Raberto 2019), improve macroeconomic performance (Monasterolo and Raberto 2019), yield other environmental and sustainable development benefits (Rentschler and Bazilian 2017; Solarin 2020) and tend to reduce inequality (Dennis 2016; Monasterolo and Raberto 2019). The benefits of lower fossil fuel prices, especially in the case of gasoline, accrue mainly to higher income groups in developing countries, so subsidy removal on the whole will reduce inequality (Coady et al. 2015).

The magnitude of emissions reduction that could be achieved from fossil fuel subsidy removal depends on the specific context such as magnitude and nature of subsidies, energy prices and demand elasticities, and how the fiscal savings from reduced subsidies are used. Modelling studies of global fossil fuel subsidy removal result in emission reductions of between 1 and 10 percent by 2030 (Delpiazzo et al. 2015; IEA 2015;

FOOTNOTE :[3] The IMF estimates focus on a combined estimate for the value of subsidies and the lack of pricing of externalities including carbon dioxide emissions under assumptions about the value of the externalities. In Figure 13.5, only the estimated subsidy elements are shown.

Jewell et al. 2018; IISD 2019) it and between 6.4 and 8.2 percent by 2050 (Burniaux and Chateau 2014; Schwanitz et al. 2014).

An extensive literature documents the difficulties of phasing out fossil fuel subsidies (Gass and Echeverria 2017; Schmidt et al. 2017; van Asselt 2018; Kyle 2018; Perry 2020). Opposition comes from constituencies that depend on the subsidies, including fossil fuel industries and consumers (Fouquet 2016; Coxhead and Grainger 2018). Subsidy reductions can lead to short term energy price shocks that harm the most economically vulnerable (Zeng and Chen 2016; Rentschler and Bazilian 2017). Instances of fossil fuel subsidy reform or removal have been driven largely by national fiscal and economic considerations (Skovgaard and van Asselt 2019).

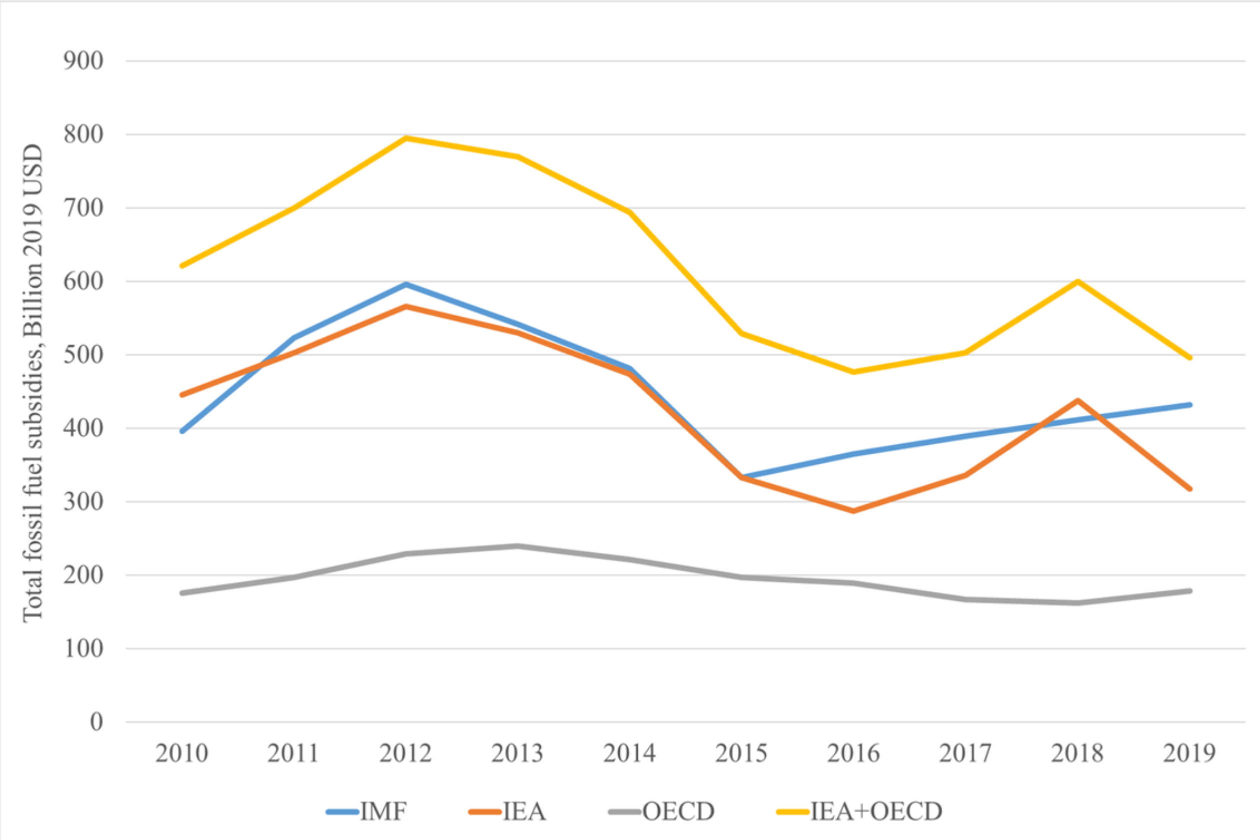

Figure 13.5 Total fossil fuel subsidies, 2010-19, in USD billion (2019)

Sources: IMF (Coady et al. 2019) - all countries; IEA (2020) - 40 countries, mainly consumption subsidies; OECD (2020) - 43 countries, mainly production subsidies]

13.6.4 Regulatory instruments

Regulatory instruments are applied by governments to cause the adoption of desired processes, technologies, products (including energy products) or outcomes (including emission levels). Failure to comply incurs financial penalties and/or legal sanctions. Regulatory instruments range from performance standards, which prescribe outcomes while allowing flexibility to achieve compliance, possibly including the trading of credits, to the more prescriptive approach of technology-specific standards, also known as command-and-control regulation. Real-world regulatory instruments range from highly flexible to highly prescriptive.

13.6.4.1 Performance standards, including tradable credits

Performance standards grant regulated entities freedom to choose the technologies and methods to reach a general objective, such as a minimum market share of zero-emission vehicles or of renewable electricity, or a maximum emissions intensity of electricity generated. Tradable performance standards (also called market-oriented standards or flexible regulations) enable even greater flexibility by allowing regulated entities to trade compliance achievement credits so that the aggregate outcome achieves the regulatory objective, even if individual entities do not. Under-performers can buy surplus credits from over-performers thereby reducing the aggregate cost of compliance relative (Fischer 2008).

Tradable performance standards have been applied to numerous sectors including electricity generation, transportation energy, personal vehicles, building energy efficiency, appliances, and large industry. An important application is Renewable Portfolio Standards (RPS) for electricity supply, which require that a minimum percentage of electricity is generated from specified renewable sources (Chapter 6). RPS are in operation in many countries and sub-national jurisdictions, for example the majority of US States have RPS of differing features and stringency (Carley et al. 2018). Each electricity provider is initially assigned a minimum requirement but has the flexibility to meet that minimum with its own generation sources or to underachieve and purchase surplus renewable energy credits from those who have exceeded the minimum requirement. This creates a price incentive to invest in renewable generation capacity. Such incentives can equivalently be created through feed-in tariffs, a form of subsidy (13.6.3) and some jurisdictions have had both instruments (Matsumoto et al. 2017).

Vehicle emissions standards are a common form of performance standard with flexibility (Chapter 9). One version of this policy, the zero-emission vehicle (ZEV) standard, requires vehicle sellers to achieve minimum requirements for sales of zero-emission vehicles in the jurisdiction (Bhardwaj et al. 2020).

Low carbon fuel standards (LCFS), which require that the average life-cycle carbon intensity of energy to decline over time, are another example. LCFS are in place in many different jurisdictions (Chapter 9) and have been applied to petroleum products, natural gas, hydrogen and electricity (Yeh et al. 2016). Like the RPS, the LCFS allows regulated entities to trade credits amongst themselves, with high carbon intensity providers cross-subsidising low carbon intensity providers (Axsen et al. 2020).

Trading and other flexibility mechanisms improve the economic efficiency of standards by harmonising the marginal abatement costs among companies or installations subject to the standard. Nevertheless tradable performance standards are less economically efficient in achieving emissions reductions than carbon pricing, sometimes by a significant amount (Quirion and Giraudet 2008; Chen et al. 2014; Holland et al. 2015; Fox et al. 2017; Zhang et al. 2018). This is mostly because each standard applies to only one option to reduce GHG emissions. For example RPS exclude emissions reduction options other than renewables (Young and Bistline 2018).

13.6.4.2 Technology standards

Technology standards take a more prescriptive approach by requiring a specific technology, process or product. They typically feature one of three approaches: requirements for specific pollution abatement technologies; requirements for specific production methods; or requirements for specific goods such as energy efficient appliances. They can also take the form of phase-out mandates, as applied for example to planned bans of internal combustion engines for road transport (Bhagavathy and McCulloch 2020), coal use (e.g. Germany's decisions to phase out coal (Oei et al. 2020)), and some industries processes and products (see Box 13.8). Technology standards are also referred to as command-and-control standards, prescriptive standards, or design standards.

Prescriptive regulations are a common climate policy, such as in energy supply (Chapter 6), agriculture and forestry (Chapter 7), urban land-use, infrastructure and buildings (Chapters 8, 9), transportation (Chapter 10), and industry (Chapter 11).

Technology standards tend to score lower in terms of economic efficiency than carbon pricing and performance standards (Besanko 1987). By mandating specific compliance pathways, they risk locking-in a high-cost pathway when lower cost options are available or may emerge through market incentives and innovation (Raff and Walter 2020). Furthermore, marginal abatement costs tend to be unequal between different sectors of the economy and across regulated entities in a given sector. Technology standards can also stifle innovation by blocking alternative technologies from entering the market (Sachs 2012). Benefits of technology standards include the ability to achieve far-reaching changes and for effects to take place quickly, that their legislation can be straightforward to design, and that their immediate results can be highly predictable (Montgomery et al. 2019).

13.6.4.3 Performance of regulatory policy instruments

Regulatory policy instruments tend to be more economically costly than pricing instruments, as laid out above. Against this disadvantage stand several advantages that can be important.

Regulatory policy often elicits greater political support than pricing policy (Tobler et al. 2012; Lam 2015; Drews and van den Bergh 2016). For example, surveys of citizens have found more support for flexible regulation including RPS, and more opposition to emissions pricing, in the United States (Rabe 2018), and British Columbia a decade after implementation of such policies (Rhodes et al. 2017).

The distributional impacts of regulatory policies can be pronounced, for example in the form of higher prices for consumers or higher costs for producers. On the other hand, the distributional impacts are inherently more confined than those of broad-based pricing instruments. Government compensation to companies or consumers for adverse financial impacts of regulatory policies is less common than for pricing policies because regulations normally do not raise revenue.

Regulatory policies have had both positive and negative social impacts (Lamb et al. 2020). For example, a renewable energy procurement obligation in South Africa successfully required local hiring with positive results (Walwyn and Brent 2015; Pahle et al. 2016) and a UK obligation on energy companies to provide energy retrofits to low-income households improved energy affordability according to participants (Elsharkawy and Rutherford 2018). A counter-example is the ban on household use of coal in Beijing which at least initially raised energy costs for modest and low-income families because of a lack of low-cost alternatives (Barrington-Leigh et al. 2019).

Institutional requirements depend on the specifics of the regulatory policies and context. In some cases, existing regulation and enforcement mechanisms can be used or built on.

Technology standards, including phase-out mandates, have particular promise to achieve transformative change in specific sectors and technologies (Tvinnereim and Mehling 2018).

Sequencing and ratcheting up the stringency of policy packages may require gradually complementing or replacing prescriptive, specific policies with incentive-based, broad-based policies (Pahle et al. 2018).

Box 13.8 Policies to limit emissions of Non-CO_2 Gases

Non-CO_2 gases weighted by their 100 year GWPs represent approximately 25% of global GHG emissions(US EPA 2019a). That total is comprised of methane (CH_4) – 67% -- nitrous oxide (N_2O) – 25% -- and fluorinated gases (HFCs, PFCs, SF_6 and NF_3) – 8%. Only a small share of these emissions are subject to mitigation policies.

Methane. Anthropogenic sources include agriculture, fossil fuel extraction and processing, fuel combustion, some industrial processes, landfills, and wastewater treatment (US EPA 2019b). Atmospheric measurements indicate that methane emissions from fossil fuel production are larger than shown in emissions inventories

(Schwietzke et al. 2016). Only a small fraction of global CH_4 emissions is regulated. Mitigation policies focus on landfills, coal mines, and oil and gas operations.

Regulations and incentives to capture and utilise methane from coal seams came into effect in China in 2010 (Tan 2018; Tao et al. 2019). Inventory data suggest that emissions peaked and began a slow decline after 2010 (Gao et al. 2020) but satellite data indicate that China's methane emissions, largely attributable to coal mining, continued to rise in line with pre-2010 trends (Miller et al. 2019). Methane emissions from sources including agriculture, waste and industry are included in some offset credit schemes, including the CDM and at national level in Australia's Emissions Reductions Fund (Climate Change Authority (Aus) 2017) and the Chinese Certified Emission Reduction (CCER) scheme (Lo and Cong 2017).

Nitrous Oxide. N_2O emissions are produced by agricultural soil management, livestock waste management, fossil fuel combustion, and adipic acid and nitric acid production (US EPA 2019b). Most N_2O emissions are not regulated and global emissions have been increasing. N_2O emissions by adipic and nitric acid plants in the EU are covered by the ETS (Winiwarter et al. 2018). N_2O emissions are included in some offset schemes.

HFCs. Most HFCs are used as substitutes for ozone depleting substances. The Kigali Amendment (KA) to the Montreal Protocol will reduce HFC use by 85% by 2047 (UN Environment 2018). To help meet their KA commitments developed country parties have been implementing regulations to limit imports, production and exports of HFCs and to limit specific uses of HFCs.

The EU, for example, issues tradable quota for imports, production and exports of HFCs. Prices of HFCs have increased as expected (Kleinschmidt 2020) which has led to smuggling of HFCs into the EU (European Commission 2019a). HFC use has been slightly (1 to 6%) below the limit each year from 2015 through 2018 (EEA 2019).

China and India released national cooling action plans in 2019, laying out detailed, cross-sectoral plans to provide sustainable, climate friendly, safe and affordable cooling (Dean et al. 2020).

PFCs, SF_6 and NF_3. With the exception of SF_6, these gases are emitted by industrial activities located in the European Economic Area (EEA) and a limited number (fewer than 30) of other countries. Regulations in Europe, Japan and the US focus on leak reduction as well as collection and reuse of SF_6 from electrical equipment. Other uses of SF_6 are banned in Europe (European Union 2014).

PFCs are generated during the aluminium smelting process if the alumina level in the electrolytic bath falls below critical levels (US EPA 2019b). In Europe these emissions are covered by the EU ETS. The industry is eliminating the emissions through improved process control and a shift to different production processes.

The semiconductor industry uses HFCs, PFCs, SF_6 and NF_3 for etching and deposition chamber cleaning (US EPA 2019b) and has a voluntary target of reducing GHG emissions 30% from 2010 by 2020 (World Semiconductor Council 2017). Europe regulates production, import, export, destruction and feedstock use of PFCs and SF_6, but not NF_3 (EEA 2019). In addition, fluorinated gases are taxed in Denmark, Norway, Slovenia and Spain.

13.6.5 Other policies

A range of other mitigation policy instruments are in use, often playing a complementary role to pricing and standards.

13.6.5.1 Transition policies

Effective climate change mitigation can cause economic and social disruption where there is transformative change, such as changes in energy systems away from fossil fuels (See Section 13.9). Consequently, there is growing interest in transitional assistance policies that can be aimed to ameliorate effects on consumers, workers, communities, corporations or countries (Green and Gambhir 2020) in order to create broad coalitions of supporters (Vogt-Schilb and Hallegatte 2017). Transition policies typically include transfers from governments to targeted groups, either monetary or in-kind, or broader policy change for example changes to fiscal settings. Transition policy options can be classified as compensation, exemptions, structural adjustment assistance, and comprehensive adaptive support (Green and Gambhir 2020).

13.6.5.2 Information programs

Information programs, including energy efficiency labels, energy audits, certification, carbon labelling and information disclosure, are in wide use in particular for energy consumption. They can reduce GHG emissions by promoting voluntary technology choices and behavioural changes by firms and households, ideally combining cost savings with emissions savings.

Energy efficiency labelling is in widespread use, including for buildings, and for end users products including cars and appliances. Carbon labelling is used for example for food (Camilleri et al. 2019) and tourism (Gössling and Buckley 2016). Information measures also include specific information systems such as smart electricity meters (Zangheri et al. 2019). Chapters 5 and 9 provide detail.

Information programs can correct for a range of market failures related to imperfect information and consumer perceptions (Allcott 2016). Alongside mandatory standards (13.6.4) information programmes can nudge firms and consumers to focus on often overlooked operating cost reductions. Consumers who are shown energy efficiency labels on average buy more energy efficient appliances than those who are not (Stadelmann and Schubert 2018). Information policies can also support the changing of social norms about consumption choices, which have been shown to raise public support for pricing and regulatory policy instruments (Gössling et al. 2020).

Energy audits provide tailored information about potential energy savings and benchmarking of best practices through a network of peers. Typical examples include the United States Better Buildings Challenge that has provided energy audits to support US commercial and industrial building owners, energy savings have been estimated at 18% to 30% (Asensio and Delmas 2017); and Germany's energy audit scheme for SMEs achieving reductions in energy consumption of 5 to 70% (Kluczek and Olszewski 2017).

Consumption-oriented policy instruments seek to reduce GHG emissions by changing consumer behaviour directly, via retailers or via the supply chain. Aspects that hold promise are technology lists, supply chain procurement by leading retailers, a carbon-intensive materials charge and selected infrastructure improvements (Grubb et al. 2020).

Insights about sound design and implementation of information programs include that the information provided to consumers in labelling programs is often not detailed enough to yield best possible results (Davis and Metcalf 2016) and that providing information about running costs tends to be more effective than providing data on energy use (Damigos et al. 2020). Sound implementation of labelling programs requires appropriate calculation methodology and tools, training and public awareness (Liang Wong and Krüger 2017). In systems where manufacturers self-report performance of their products, there tends to be misreporting and skewed energy efficiency labelling (Goeschl 2019).

13.6.5.3 Government provision

National, subnational and local governments determine many aspects of infrastructure planning, fund investment in areas such as energy, transport and the built environment, and purchase goods and services, including for government administration and military provisioning.

Public procurement rules usually mandate cost effectiveness but only in some cases allows or mandates climate change consideration in public purchasing, for example in EU public purchasing guidelines (Martinez Romera and Caranta 2017). Green procurement for buildings has been undertaken in Malaysia (Bohari et al. 2017). Taiwan's green public procurement law has contributed to reduced emissions intensity of the economy (Tsai 2017). In practice, awareness and knowledge of 'green' public procurement techniques and procedures is decisive for climate-friendly procurement (Testa et al. 2016) and experiences in low-carbon infrastructure procurement point to procedures being tailored to concerns about competition, transaction costs and innovation (Kadefors et al. 2020).

Infrastructure investment decisions lock in high or low emissions trajectories over long periods. Low-emissions infrastructure is typically only little more expensive over its lifetime, but faces additional barriers including higher upfront costs, lack of pricing of externalities, or lack of information or aversion to novel products (Granoff et al. 2016). In developing countries, some of these hurdles can be exacerbated by overall more difficult conditions for public investment.

Governments can also promote low-emissions investments through public-private partnerships and government owned 'green banks' that provide loans on commercial or concessional basis for environmentally friendly private sector investments (David and Venkatachalam 2019; Ziolo et al. 2019). Public funding or financial guarantees such as contracts-for-difference can alleviate financial risk in the early stages of technology deployment, creating pathways to commercial viability (Bataille 2020). Government provision can also play an important role in economic stimulus programs (See Box 13.10).

Box 13.9 Technology and R&D policy

Deep reductions in greenhouse gas emissions will require further technological innovations. Private businesses tend to under-invest in R&D because of market failures (Geroski 1995), hence there is a case for governments to support research and technology development. A range of different policy instruments are used, including government funding, preferential tax treatment, intellectual property rules, and policies to support the deployment and diffusion of new technologies. Chapter 16 treats innovation in-depth, including technology and R&D policy.

13.6.5.4 Divestment and disclosure

Divestment refers to the dis-investment by large institutional investors and other financial entities from stocks in companies involved in fossil fuel extraction, and other financial investments in high emissions assets. Divestment is predominantly promoted by civil society organisations (Ayling and Gunningham 2017), raising moral principles and arguments about the financial risks inherent in fossil fuel investments (Green 2018; Blondeel et al. 2019). Announcements by investors that they will divest have been shown to negatively affect the share price of listed companies, in a large sample of such announcements (Dordi and Weber 2019). Stock portfolios without fossil fuel stocks on balance performed equally well or better than benchmark portfolios, in different markets and over different timeframes.[4]

Financial accounting standards are increasingly used as frameworks to encourage or require companies to disclose how the transition risks from shifting to a low carbon economy and physical climate change impacts may affect their business or asset values (Chapter 15). The most prominent such standard was issued in 2017 by the Financial Stability Board's Task Force on Climate-related Financial Disclosures (TCFD 2017), an international body that monitors and makes recommendations about the global financial system.

Traditionally, corporate reporting has treated climate risks in a highly varied and often minimal way (Foerster et al. 2017). Disclosure of climate related risks creates incentives for companies to improve their carbon and

FOOTNOTE :[4] E.g., the US S&P500 from 2005 onwards (Henriques and Sadorsky 2018; Halcoussis and Lowenberg 2019), longer time periods for the broader US stock market (Trinks et al. 2018), the Canadian stock market (Hunt and Weber 2019), Dutch pension funds with different carbon footprints (Boermans and Galema 2019), and for stocks excluded from the Norwegian and Swedish sovereign wealth funds (Hoepner and Schopohl 2018).

climate change exposure, and ultimately regulatory standards for climate risk (Eccles and Krzus 2018). However, financial disclosure alone may not be sufficient for an adequate financial market response to climate risk (Ameli et al. 2020).

13.6.5.5 Voluntary agreements

Voluntary Agreements (VAs) result from negotiations between governments and industrial sectors that commit to achieve agreed goals (Mundaca and Markandya 2016). When used as part of a broader policy framework, VAs can enhance the cost effectiveness of individual firms in attaining emissions reductions while mandatory pricing and regulations act to incentivise industry participation in the agreement (Dawson and Segerson 2008). VAs come in the form of public voluntary programs (PVP) where a government regulator develops programs to which industries and firms may choose to participate on a voluntary basis (Lyon and Maxwell 2003, 2004) and Negotiated Agreements (NA) where the regulator bargains with individual industries or firms to produce contracts that are ratified by both parties (Grepperud and Pedersen 2004; Glachant 2007).

PVPs have been implemented in numerous countries. For example, the United States Environmental Protection Agency introduced numerous voluntary programmes with industry to offer technical support in promoting energy efficiency and emissions reductions, among other initiatives (United States Environmental Protection Agency 2017). A European example is the EU Ecolabel Award program (European Commission 2019b). VAs for industrial energy efficiency in Europe (Cornelis 2019) and Japan (Wakabayashi and Arimura 2016) have been particularly effective in addressing information barriers and for smaller companies.

VAs are often implemented in conjunction with economic or regulatory instruments, and sometimes are used to gain insights ahead of implementation of regulatory standards (e.g. energy efficiency PVPs in South Korea, (Seok et al. 2021)). In some cases, industries are permitted to negotiate VAs as partial fulfilment of a regulation (Rezessy and Bertoldi 2011; Langpap 2015). For example, the Netherlands have permitted industries participating in VAs to be exempt from certain energy taxes and emissions regulations (Veum 2018).

Box 13.10 Climate-friendly economic recovery from COVID-19

The pandemic of 2020-21 resulted in global economic recession, to which many governments responded with economic stimulus programs. Where such programs go beyond short-term wage and business subsidies to include government driven investment, they can support low-emissions infrastructure and industrial or business development. For example, the European 'Green Deal' has a large element of low-carbon investments for economic recovery (Elkerbout et al. 2020; Hainsch et al. 2020).

Economic recovery policies differ in their effectiveness in the creation of jobs and economic activity, speed of effect, and impact on GHG emissions (Bowen and Stern 2010). A large expert survey suggests that the following policy options tend to perform well on both economic multiplier and climate change: clean physical infrastructure, building efficiency retrofits, investment in education and training, natural capital investment, and clean R&D or rural support spending (Hepburn et al. 2020).

13.6.6 Empirical evidence on policy interactions

In most jurisdictions, multiple mitigation policies overlap and interact. In addition, mitigation policies overlap and interact with other policies that directly or indirectly affect GHG emissions such as fossil fuel subsidies, fuel taxes, and efficiency standards. Policy overlap tends to be particularly prevalent when multiple levels of government are involved. There is no universal strategy for dealing with policy overlap in practice.

Overlapping policies address multiple objectives. They can raise the cost of achieving GHG mitigation (Böhringer et al. 2016) and lower the cost of achieving others such as energy efficiency and expansion of renewable energy. The net effect is unclear. Multiple mitigation policies can be economically justified even if they interact, including combinations of pricing and regulatory instruments to achieve distributional objectives and increase robustness of policy frameworks (Stiglitz 2019). Policy overlap will tend to result in different optimal carbon prices across jurisdictions (Bataille et al. 2018b).

The existence of multiple, overlapping policies will usually increase administrative costs including compliance costs. However, ex-post analysis has shown that transaction costs of mitigation policies on the whole are low and that they are not a decisive factor in policy choice (Joas and Flachsland 2016).

The effectiveness, as well as economic and distributional effects, of a given mitigation policy will depend on the interactions among all of the policies that affect the targeted GHG emissions. The interactions tend to be more complex for market instruments than for regulations. A market instrument interacts with every other policy that affects the cost of the targeted emission reductions while a regulation mandates specific emission reduction actions by targeted sources independent of other policies.

The price imposed on GHG emissions by a carbon tax or emissions trading system can increase the effectiveness of overlapping mitigation policies, such as energy efficiency standards (Rosenow et al. 2016; Lecuyer and Quirion 2019). The effectiveness and distributional impacts of a pricing policy are affected by the regulatory treatment of the cost increases if sources are subject to price regulation, as is common for electricity and various transportation modes in many jurisdictions (Acworth et al. 2020). The share of the cost pass-through determines the incentive for mitigation by regulated firms and shifts in demand by customers and hence the distribution of costs between companies and consumers.

With an ETS emission reductions undertaken by some emitters due to overlapping mitigation policies may be offset by higher emissions by other ETS participants (Schatzki and Stavins 2012). This "waterbed effect" reduces the impact of the ETS and lowers carbon trading prices (Perino 2018), though ex post assessments find that the reductions generated by overlapping policies have not been fully offset by higher emissions within ETS. ETS design features such as a price floor and 'market stability reserve' can limit the waterbed effect (Edenhofer et al. 2017; Narassimhan et al. 2018; FSR Climate 2019; Kollenberg and Taschini 2019). A carbon tax does not change in response to the effect of overlapping policies (Goulder and Stavins 2011). Some regulations may be redundant if they cause reductions that would have happened anyway because of the existence of an overlapping carbon price.

Policy interactions often occur with the introduction of new mitigation policy instruments. For example, in China seven sub-national ETSs were implemented in 2013 alongside many existing policies including requirements to reduce emission intensity, increase energy efficiency and expand renewable energy supplies (Zhang 2015). These quantity-based ETSs interact with many other policies (Duan et al. 2017), for example price-based provincial carbon intensity targets (Qian et al. 2017). They also interact with the level of market regulation, for example full effectiveness of emissions pricing would require electricity market reform in China (Teng et al. 2017) and in many other jurisdictions.

Policy overlap can also create interaction between national and sub-national regulations. Policy interactions are also widespread among energy efficiency policies (Wiese et al. 2018). For example, the EU has some EU-wide policies such as the ETS, vehicle emission standards and energy efficiency standards alongside wide ranging policy flexibility for member states relating to renewable energy support, other regulations and national taxes (Rey et al. 2013). California's low carbon fuel standard (LCFS) increases the sale of biofuels in the state but the total supply of biofuels under the national renewable fuel standard does not change (Whistance et al. 2017). Approximately 85% of the emissions covered by California's ETS are also subject to other policies (Bang et al. 2017; Mazmanian et al. 2020).

13.7 International interactions of national mitigation policies

One country's mitigation policy can impact other countries in various ways including changes in their GHG emissions (leakage), creation of markets for emission reduction credits, technology development and diffusion (spill-overs), and reduction in the value of their fossil fuel resources.

13.7.1 Leakage effects

Compliance with a mitigation policy can affect the emissions of foreign sources via several channels over different time scales (See Box 13.11) (Zhang and Zhang 2017). The effects may interact and yield a net increase or decrease in emissions. The leakage channel that is of most concern to policymakers is adverse international competitiveness impacts from domestic climate policies.

Box 13.11 Channels of leakage

Competitiveness: Mitigation policy raises the costs and product prices of regulated sources which causes production to shift to unregulated sources, increasing their emissions.

Fossil fuel channel: Regulated sources reduce their fossil fuel use, which lowers fossil fuel prices and increases consumption and associated emissions by unregulated sources.

Terms of trade effect: Price increases for the products of regulated sources shift consumption to other goods, which raises emissions due to the higher output of those goods.

Technology channel: Mitigation policy induces low carbon innovation, which reduces emissions by sources that adopt the innovations that may include unregulated sources.

Abatement resource effect: Regulated sources increase use of clean inputs, which reduces inputs available to unregulated sources and so limits their output and emissions.

Scale channel: Changes to the output of regulated and unregulated sources affect their emissions intensities so emissions changes are not proportional to output changes.

Intertemporal channel: Capital stocks of all sources are fixed initially but change over time affecting the costs, prices, output and emissions of regulated and unregulated products.

In principle, implementation of a mitigation policy in one country creates an incentive to shift production of tradable goods whose costs are increased by the policy to other countries with less costly emissions limitation policies leading to higher emissions in those countries. Such 'leakage' could partially negate emissions reductions in the first country, depending on the relative emissions intensity of production in both countries.

Ex ante modelling studies typically estimate significant leakage for unilateral policies to reduce emissions due to production of emissions intensive products such as steel, aluminium, and cement (Carbone and Rivers 2017). However, the results are highly dependent on assumptions and typically do not reflect policy designs specifically aimed at minimising or preventing leakage (Fowlie and Reguant 2018).

Numerous *ex post* analyses, mainly for the EU ETS, find no evidence of any or significant adverse competitiveness impacts and conclude that there was consequently no or insignificant leakage (Branger et al. 2016; FSR Climate 2019; Koch and Basse Mama 2019; Venmans et al. 2020). This is attributed to large allocations of free allowances, relatively low allowance prices, the ability of firms in some sectors to pass costs on to consumers, energy's relatively low share of production costs, and small but significant effects on innovation (Joltreau and Sommerfeld 2019).

Leakage also can be addressed by a border carbon adjustment which exempts exports and imposes costs on imports equivalent to those borne by domestic firms (Böhringer et al. 2012; Fischer and Fox 2012; Zhang 2012; Böhringer et al. 2017b). No jurisdiction has yet implemented a border carbon adjustment although such a measure is currently under consideration by some governments (See Box 13.12).

Box 13.12 Border carbon adjustments

Import taxes on carbon-intensive goods could be used by countries with domestic mitigation policies to incentivise other countries to enact ambitious climate policies as a way of avoiding tariffs on their exports (Anouliès 2015). The option of such strategic use of border carbon adjustments (BCAs) has seen increasing political interest, including as a complement or alternative to conventional trade tariffs in an age of rising protectionism (Mehling et al. 2018).

BCAs could also be a way to address international competitiveness effects of mitigation policies. Charges on imports of emissions intensive goods, or export rebates, would even out the effective carbon penalty. Under existing ETS schemes, countries have instead chosen to address this concern successfully via free allowance allocations for covered emissions sources (13.6.3.2), however no such ready option is available for non-pricing instruments. Estimating carbon content of goods is difficult and potentially subject to economic interests, and BCA design would need to take WTO rules into account (Cosbey et al. 2019; Mehling et al. 2019).

13.7.2 Market for emission reduction credits

A mitigation policy may allow the use of credits issued for emission reductions in other countries for compliance purposes (see also Section 13.6.3.4 on offset credits). The EU, New Zealand and Switzerland allowed participants in their emissions trading systems to use credits generated by Clean Development Mechanism (CDM) and Joint Implementation (JI) projects for compliance (Haites 2016). Use of imported credits has fallen to very low levels since 2015 (World Bank 2014).

The Clean Development Mechanism (CDM) is the world's largest offset trading system (Chapter 14). From 2001 to 2019 over 7,500 projects with projected emission reductions in excess of 8,000 $MtCO_2$-eq were implemented in 114 developing countries using some 140 different emissions reduction methodologies (UNFCCC 2012; UNEP DTU Partnership 2020) . Credits reflecting over 2,000 $MtCO_2$-eq of emission reductions by 3,260 projects have been issued.

These CDM projects led to investment and in some cases technology transfer to the host countries (Murphy et al. 2015). Additionality of claimed emissions reductions is an inherent problem (Wara and Victor 2008; Schneider 2009; Millard-Ball 2013), but regulatory and measurement advances can significantly reduce that risk (Mason and Plantinga 2013; Bento et al. 2016; Michaelowa et al. 2019). Adverse social impacts, such as displacement of communities by forest projects, have also been documented for offset projects (Lansing 2015; Fisher et al. 2018b; Herr et al. 2019).

Article 6 of the Paris Agreement establishes mechanisms for potential future international trade of emission reduction credits (Chapter 14, Section 14.3).

13.7.3 Technology spill-overs

Entities subject to mitigation policies increase their low-carbon R&D (FSR Climate 2019). Innovation activity in response to a mitigation policy varies by policy type (Jaffe et al. 2002) and stringency (Johnstone et al. 2012). In addition, many governments have policies to stimulate R&D, so suppliers to regulated emitters may also increase their low-carbon R&D (Chapter 16, Section 16.5). Emitters in other countries may adopt some of the new low-carbon technologies. Technology development and diffusion is reviewed in Chapter 16.

13.7.4 Value of fossil fuel resources

Fossil fuel resources are a significant source of exports, employment and government revenues for many countries. The value of these resources depends on demand for the fuel and competing supplies in the relevant international markets. Discoveries and new production technologies reduce the value of established resources. Mitigation policies that reduce the use of fossil fuels also reduce the value of these resources. A single policy in one country is unlikely to have a noticeable effect on the international price, but similar policies in multiple countries could adversely affect the value of the resources. For fossil fuel exporting countries, mitigation policies in line with the Paris Agreement could result in greater costs from changes in fossil fuel prices and demand due to lower international demand than domestic policy costs (Liu et al. 2020).

The impact on the value of established resources will be mitigated, to some extent, by the reduced incentive to explore for and develop new fossil fuel supplies. Nevertheless, efforts to lower global emissions will mean substantially less demand for fossil fuels, with the majority current coal reserves and large shares of known gas and oil reserves needing to remain unused, with great diversity in impacts between different countries (McGlade and Ekins 2015) (Links to Chapter 3, Chapter 6, and Chapter 15).

Estimates of the potential future loss in value differ greatly. There is uncertainty about remaining future fossil fuel use under different mitigation scenarios, as well as future fossil fuel prices depending on extraction costs, market structures and policies. Estimates of total cumulative fossil fuel revenue lost range between 5-67 trillion dollars (Bauer et al. 2015) with an estimate of the net present value of lost profit of around 10 trillion dollars (Bauer et al. 2016). Policies that constrain supply of fossil fuels in the context of mitigation objectives could limit financial losses to fossil fuel producers (See Box 13.13).

Box 13.13 Fossil fuel supply-side policies

Policies to reduce emissions from fossil fuel use typically aim to reduce demand. Equivalently, the supply of fossil fuels could be constrained (Hoel 1994).

Under 'Fossil fuel supply-side policies' (Lazarus and van Asselt 2018), higher prices and lower use of fossil fuels would be achieved by limiting the supply of fossil fuel or taxes levied at the source. Revenue from taxes would accrue to governments in fossil fuel producing and exporting countries. Suppliers might enjoy higher prices, though terms-of-trade benefits of meaningful size could only be achieved if there was extensive cooperation between fossil fuel producers (Richter et al. 2018), (Böhringer et al. 2018).

Whether and to what extent fossil fuel producing countries might cooperate on supply-side policy is unclear (Asheim et al. 2019; Green and Denniss 2018).

13.8 Policy integration for multiple objectives: Sustainable development, mitigation and adaptation

Policy-making for climate mitigation occurs in the context of attention to multiple and simultaneous objectives of policy. Designing policy with attention to these interactions requires understanding impacts across objectives, interactions between mitigation and adaptation, and considerations of equity and long-term developmental pathways. Different aspects of these linkages are discussed in detail across the WG III report, including concepts and framings (Chapter 1, Section 1.4.2), shifting sustainable development pathways (Chapter 4, Section 4.3), cross-sectoral interactions (Chapter 12, Sections 12.6.1.1, 12.6.2), evidence of co-impacts (Chapter 17, Section 17.1, 17.3), links with adaptation (Chapter 4, Section 4.5) and accelerating the transition (Chapters 17, Sections 17.1.1.3, 17.3.5). This section discusses the challenges of policy-making that aims to achieve multiple objectives, first with attention to mitigation-related linkages, second with an adaptation focus; and third with a focus on equity and sustainable development in the context of mitigation and adaptation policy.

This section draws on a growing body of literature which assesses planning and implementation, and emphasises the need for multi-objective frameworks able to identify synergies as well as trade-offs at multiple scales (from local to global) and across sectors (agriculture, forest, energy, water, urban, health) (Berrang-Ford et al. 2015; Berry et al. 2015; Denton et al. 2015; Grafakos et al. 2019).

13.8.1 A Multiple objectives approach to climate mitigation

In most countries, and particularly when climate policy occurs in the context of sustainable development, policymakers are seeking to address climate mitigation in the context of multiple economic and social policy objectives *(medium evidence, robust agreement)* (Halsnæs et al. 2014; Campagnolo and Davide 2019; Cohen et al. 2019). Because empirical and modelling literature has identified the existence of synergies and trade-offs across different objectives of policy, addressing these requires careful attention to co-impacts. (*robust evidence, high agreement*). Studies suggest that co-benefits of climate policies are substantial, especially in relation to air quality, and can yield better mitigation and overall welfare, yet these are commonly overlooked in policy-making (Nemet et al. 2010; Ürge-Vorsatz et al. 2014; von Stechow et al. 2015; Mayrhofer and Gupta 2016; Roy et al. 2018; Karlsson et al. 2020) *(medium evidence, robust agreement)*. Other studies have shown the existence of strong complementarities between the SDGs and realisation of NDC pledges by countries (McCollum et al. 2018). An explicit attention to development pathways can enhance the scope for mitigation, by paying explicit attention to development choices that lock-in or lock-out opportunities for mitigation, such as around land use and infrastructure choices *(medium evidence, medium agreement)* (Cross-Chapter Box 4 in Chapter 4).

Countries may adopt different framings of the objectives of policy, depending on their specific socio-economic contexts and priorities, governance capacities (McMeekin et al. 2019) and perceptions of historical responsibility (Winkler and Rajamani 2014; Friman and Hjerpe 2015; Winkler et al. 2015; Pan et al. 2017; Schmidt and Fleig 2018). In some countries, climate mitigation may be the dominant framing for policy outcomes, while in others mitigation may be being bundled together with, or embedded within, efforts at achieving other social and environmental goals. Policymakers in developing countries, in particular may face particularly challenging demands from competing policy priorities focused on providing basic needs and addressing poverty and inequality, including energy poverty (Ahmad 2009; Fuso Nerini et al. 2019; Bel and Teixidó 2020; Caetano et al. 2020; Röser et al. 2020), leading to more embedded articulations of mitigation objectives.

Policymakers also have to decide between focusing on shifting incentives in the present versus explicitly inducing change over time. This choice reflects a growing emphasis in the literature since AR5 on the importance of explicit attention to inducing technological transitions (Geels et al. 2017b,a; Köhler et al. 2019), innovation (Mazzucato and Semieniuk 2018), and shifting development pathways (Chapter 4). Transformation requires signalling a clear direction (e.g. through the elaboration of shared visions, unambiguous guidance for low-carbon solutions, and coordination of actors involved in the transformation process) and to overcome policy silos through better coordination across policy arenas (e.g. climate policy and industrial policy) and governance levels (e.g. national and regional level) (Uyarra et al. 2016; Nemet et al. 2017). Similarly, integrating climate as an objective into developmental policies, by itself, while useful, may be insufficient for achieving deep decarbonisation (Chapter 17). In both cases, explicit attention to transition is warranted.

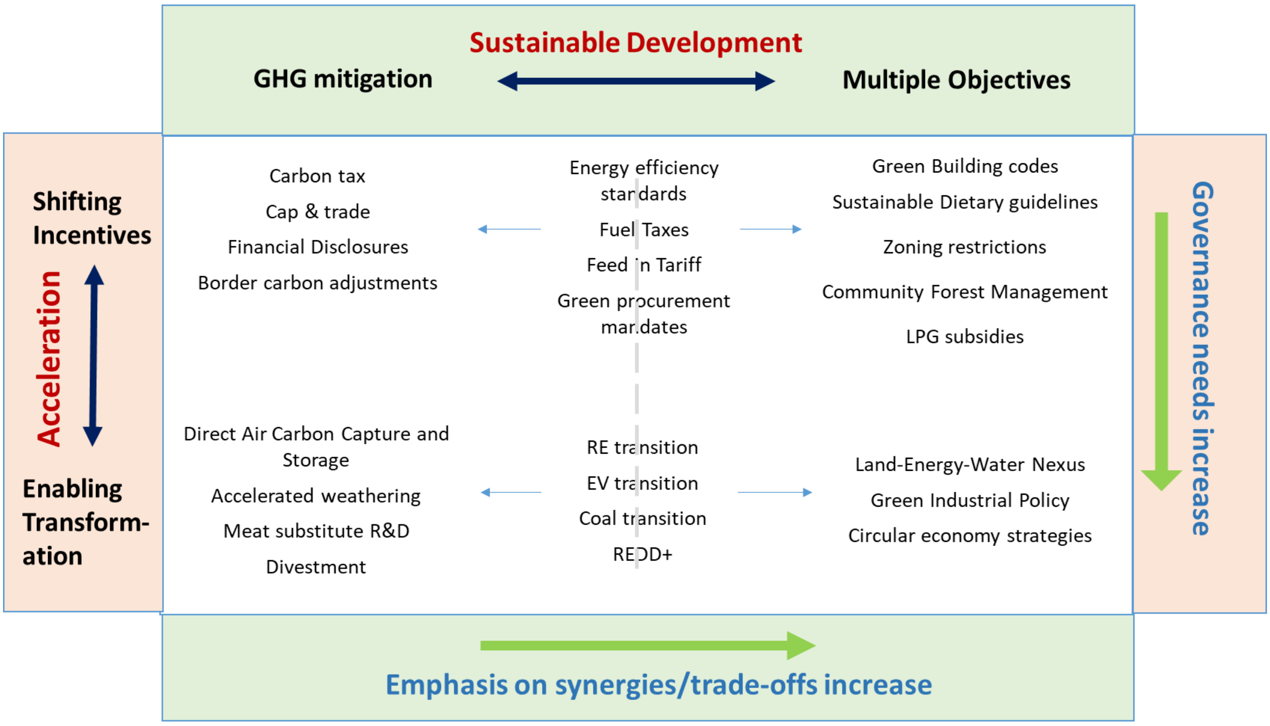

Figure 13.6 Mapping the Landscape of Climate-Development Actions

These choices are reflected in Figure 13.6, which represents a broad landscape on which governments make decisions about climate mitigation, which includes illustrative policies and policy packages that correspond to different approaches. Different locations on this decision space may be suitable for different country contexts at different times. Figure 13.6 also indicates that approaches which emphasise multiple objectives require greater attention to understanding synergies and trade-offs, while an emphasis on enabling transformation requires greater governance capacity, such as the institutional capacity to address climate governance challenges of coordination, strategic intent and mediating politics (See Section 13.2.3).

This broader approach to climate mitigation, taking account of multiple objectives and transitions over time, requires policy processes attuned to these tasks. A literature on 'climate policy integration' suggests that addressing climate change in an integrated manner requires a dual focus on framing the objectives sought in a coherent way and institutional clarity on the forms of coordination across policy domains and scales (Adelle and Russel 2013) .

Climate policy integration and mainstreaming are interchangeably used to describe the governing process or policy outcome that integrates climate (mitigation and adaptation) objectives in the design and implementation of relevant sectoral and development policies, planning and practices (Nilsson et al. 2012; Nunan et al. 2012; Adelle and Russel 2013; Runhaar et al. 2014; Runhaar 2016; Scobie 2016; Rietig 2019). Mainstreaming may have greater resonance in developing nations due to its focus on incorporating climate change into development activities and is more often used in the context of adaptation (Chapter 1, Section 1.4.2).

The starting point for consideration of cross-cutting problems like climate change lies upstream of policy formulation. Candel and Biesbroek (2016) suggest a four part framework for considering policy integration. First, the policy frame or problem statement can help shape understandings of the problem and therefore alternative solutions; for example, a greenhouse gas limitation framework versus a co-benefits framing would likely yield different approaches. Second, the range of actors and institutions involved in climate governance – the policy subsystem – and the density of interactions among them determines the scope and range of actions. Third, the goals articulated, the level at which it is articulated – system wide or individual sub-systems such as energy – and the coherence with other related policy goals such as energy security or energy access, are salient to integration. Fourth, the adoption of specific policy instruments is the final element in the framework.

The literature also suggests several lessons for operationalising climate policy integration. In practice, integration has to occur in the context of an already existing policy structure, which suggests the need for finding windows of opportunity to bring about integration, which can be created by international events, alignments with domestic institutional procedures, and openings created by policy entrepreneurs (Garcia Hernandez and Bolwig 2020) . Integration also has to occur in the context of existing organisational routines and cultures, which can pose a barrier to integration (Uittenbroek 2016). Experience from the EU suggests that disagreements at the level of policy instruments are amenable to resolution by deliberation, while normative disagreements at the level of objectives require a hierarchical decision structure (Skovgaard 2018). As this discussion suggests, the challenge of integration operates in two dimensions: horizontal -- between sectoral authorities such as ministries or policy domains such as forestry -- or vertical -- either between constitutional levels of power or within the internal mandates and interactions of a sector (Di Gregorio et al. 2017).

Also salient to policy making for multiple objectives and transition is an emergent multi-disciplinary literature on policy mixes. Policy mixes are also referred to as policy packages or policy portfolios, and seek to examine sustainable low-carbon transitions that encompass market failures, structural transformational system failures, in various sectors (Rogge and Reichardt 2016; Kern et al. 2019). These include energy (Rogge et al. 2017), transport (Givoni et al. 2013), industry (Scordato et al. 2018), agri-food (Kalfagianni and Kuik 2017) and forestry (Scullion et al. 2016).

Comprehensiveness, coherence or balance and consistency are important criteria for policy mixes (Rogge and Reichardt 2016; Scobie 2016; Carter et al. 2018; Santos-lacueva and González 2018). Comprehensiveness assesses the extensiveness of policy mixes, including the breadth of system and market failures it addresses. For example, instrument mixes that include carbon pricing, policies supporting new low-carbon technologies and a moratorium on coal-fired power plants may not only be politically more feasible than stringent carbon pricing, but may also limit efficiency losses and lower distributional impacts (Bertram et al. 2015b). Coherence or Balance captures whether policy support is balanced across different instrument purposes, combining for example technology push approaches such as public R&D and demand pull approaches such as an energy tax, which has been shown to support innovation in OECD countries (Costantini et al. 2017). Consistency addresses the alignment of policy instruments and the policy strategy, which may have multiple objectives (Rogge 2019). Consistency has been identified as an important driver of low-carbon transformative change, particularly for renewable energy (Lieu et al. 2018; Rogge and Schleich 2018).

Methodological approaches for developing real world policy mixes emphasise the importance of combining top down and bottom up mapping of policy mixes. A top down approach traces the governing entities, their strategies and corresponding policy instruments pertaining to an overarching strategic intent, such as promoting certain low-carbon technologies (Quitzow 2015; Schmidt and Sewerin 2019). A bottom up policy mix analysis starts from a specific geography and policy domain such as energy efficiency and renewable energies in the United States (Sovacool 2009), and helps identify multiple relevant governing levels and policy fields, and enables the consideration of both intentional and unintentional policy effects. When combined, the two approaches can yield a comprehensive coverage of governing entities, policy strategies and instrument mixes providing a thorough starting point for the analysis and design of climate policy mixes (Kivimaa and Kern 2016; Reichardt et al. 2016; Huang 2019; Ossenbrink et al. 2019).

In practice, integrated policy for multiple objectives and transitions also has to account for existing policies, existing interests, and context specific governance enablers and disablers. Cross-Chapter Box 7 in Chapter 13 draws on case studies of sectoral transitions from other chapters in this report (Chapters 5 – 12) to provide illustrations of integrated policy making in practice. Common to all the cases is a future-oriented vision of sectoral transition often focused on multiple objectives, such as designing tram-based public transport systems in Bulawayo, Zimbabwe to simultaneously stimulate urban centres, create jobs and enable low carbon transportation. Sectoral transitions are enabled by policy mixes that bring together different combinations of instruments – including regulations, financial incentives, convening, education and outreach, voluntary agreements, procurement and creation of new institutions – to work together in a complementary manner. The effectiveness of a policy mix depends on conditions beyond design considerations and also rests on the larger governance context within which sector transitions occur, which can include enabling and disabling elements. Enabling factors illustrated in Cross-Chapter Box 7 include strong high level political support, for example to address deforestation in Brazil despite powerful logging and farmer interests, or policy design to win over existing private interests, for example, by harnessing distribution networks of kerosene providers to new LPG technology in Indonesia. Disabling conditions include local institutional contexts, such as the lack of tree and land tenure in Ghana, which, along with the monopoly of the state marketing board, posed obstacles to Ghana's low carbon cocoa transition. These examples emphasise the importance of attention to local context if policy integration and the design of policy mixes are to effectively lead to transitions guided by multiple climate and development objectives.

Cross-Chapter Box 7: Integrated Policymaking for Sector Transitions

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Real world sectoral transitions reinforce several critical lessons from the conceptual literature on policy integration: the need for a clear sector outcome framing, the importance of a carefully coordinated policy mix, and the importance of supporting governance factors. The WGIII report includes several case studies in the sectoral chapters, which are synthesised in Table 1 below along key dimensions reflecting these insights. These illustrative examples help elucidate the complexity of policymaking in driving sectoral transitions. Achieving a high-level strategic goal (Column A) entails pursuing multiple mitigation and development objectives (column B), often determined through a broad stakeholder engagement process. These are operationalised through a combination of multiple policy instruments and governance actions (column C) often aimed at solving coordination and political economy challenges. These examples also emphasise the importance of attention to local context (column D) if policy integration and the design of policy mixes are to effectively lead to transitions guided by multiple climate and development objectives.

1 **Cross-Chapter Box 7, Table 1**

Chapter	A. Illustrative Case	B. Objective	C. Policy mix	D. Governance Context	
				Enablers	**Barriers**
Box 5.7 Ch 5	Shift in mobility service provision through public transport, Kolkata IND	- Shift public perceptions toward narrative of comfortable, affordable public transport - Attract potential car users towards public transport	- Re-frame auto-rickshaws as green and integrated transit through subsidies for LPG conversion, standardised permits, fares, routes - Procure new fuel efficient, low floor buses for middle classes willing to pay premium fares - Single agency to harmonise operation and scheduling across modes - Invest in digital infrastructure: transport card and app - Ban on cycling in major arterial roads	- Historical preference for public transport, strong public bus infrastructure - Effective coordination with private auto-rickshaws and cab owners - Synergies across transformations in multiple modes, with common drivers (digitalisation, enhanced fuel efficiency) - Growing awareness of fuel wastage through mass media, environmental campaigns - Private app-cab companies driving a norm shift towards sharing	- Multiple public transport modes, with separate networks, behaviours and meanings increase coordination costs - Existing norms around desire for private mobility - Conflicts between justice and congestion management objectives, e.g. public protests against cycling ban
Box 6.3 Ch 6	LPG Subsidy ("Zero Kero") Program, Indonesia	Decreasing fiscal expenditures on domestic kerosene subsidies by replacing it with LPG	- Government subsidised provision of LPG cylinder and other initial equipment - Subsidised pricing adjusted to local transportation costs - Conversion of existing actors in kerosene supply chain into LPG chain	- Provincial government support in targeting licensees and beneficiaries - Co-operation of a monopoly state-owned LPG marketer, Petramina - Synergies in kerosene and LPG distribution infrastructure enabling supplier redeployment - Surging oil prices	- Continued user preference for traditional solid fuels (mainly firewood) - Initial design not focused on health and social objectives, leading to regressive impacts
Box 7.12 Ch 7	Action Plan for Prevention and Control of Deforestation in the Legal Amazon (PPCDAm), Brazil	Deforestation control, sustainable use and sustainable development of the Brazilian Amazon region	- Expanded protected areas; homologation of indigenous lands - Increased inspections, improved satellite- based monitoring - Performance linked restrictions on public credit for cities - Alternative livelihood provision, rural property regularisation - New institutions (Brazilian Forest Service, Public Forest Management Law, Minimum Price Guarantee Policy) - Voluntary commitments by businesses to control deforestation in supply chains - REDD+ mechanism called the Amazon Fund	- Inclusive agenda-setting process involving all key stakeholders (President, federal and state policymakers, business leaders, civil institutions, movements) - Extensive public consultations and Parliamentary deliberation on guidelines	- Political polarisation leading to erosion of environmental governance - Weakening environmental rule of law (e.g. Amazon Fund governance changed in disagreement with donors) - Reduced representation and independence of civil society in decision-making bodies
Box 7.14	Climate smart cocoa (CSC)	- Promote sustainable intensification, livelihoods	- Distribution of shade tree seedlings (subsidised or free), other assistance with agroforestry	- Strong traditionally-recognised governance structures (e.g. Community Resource	- Institutional and bureaucratic challenges for smallholders - Lack of

Ch 7	production, Ghana	and enhance adaptive capacity of smallholder cocoa producers - Reduce cocoa-induced deforestation and GHG emissions	- Access to extension services (agronomic info, agro-chemical inputs) - Community based governance structure for benefit sharing, forest conservation, alternate livelihood training - Multi-stakeholder program design, including farmers, NGOs	Management Area Mechanisms), ensuring procedural equity and adapting CSC practices to local context - Private sector role in popularising CSC production	secure land/tree tenure - State monopoly on cocoa marketing, export - A biased discourse about sustainable intensification and dependence on agro-chemicals - Dominance of MNCs in the sector
Box 8.2 Ch 8	Coordination Mechanism for Joining Fragmented Urban Development Policy, Shanghai CHN	Integrating policy making across economy, energy and environment objectives, with focus on low-carbon development	-Central level targets setting and performance evaluation and locally initiated cross-sectoral policy experiments (e.g. local carbon labelling , integrated environmental planning cycle) - Empowered agency (SMDRC) with overarching authority for coordinating cross-department collaborations - A special fund, managed by the SMDRC, for directly funding projects and policies with a multi-institution, multi-sector scope	- Explicit mandate for experimentation and policy learning from the Central government - Co-benefits to urban ecosystem: Low-carbon projects provided resources to urban bodies creating lock-ins, and enabled local capacity building for transition - Strong existing policy landscape and administrative capacity in areas such as air pollution and energy efficiency	- Challenging starting point - low share of RE, powerful fossil fuel lock-in, high economic growth rate - High resource requirements for upscaling successful cross-sectoral experiments
Box SM9.1 Ch 9	Policy package for building energy efficiency, EU	Reducing energy consumption, integrating RE and mitigating GHG emissions from buildings	- Energy performance standards set at cost optimal level; for new buildings, performance standard set at near zero energy - Long Term Renovation Strategies (LTRSs) for decarbonising the national building stock by 2050 - Obligation to show energy performance certificate during sale/rent agreement (information instrument) - Complementary regulatory pressures through other EU Directives	- Binding EU-level economy-wide emissions target, energy savings target and effort sharing regulations (for sectors), inducing additional national actions - Supportive urban policies adopted by major cities involved in partnerships - Strong emphasis on financing renovations, including funds raised from auctions of allowances under ETS	- Ambition gap between EU targets and member state policies - Lack of requisite technical capacity at local level to implement complex standards - Low energy prices resulting in direct rebound effects - Complex governance structure resulting in uneven stringency and coordination challenges
Box 10.2 Ch 10	African Electromobility-Case Studies in Bulawayo and Kampala	- Become a low to net zero emissions city - Enable simultaneous development of transport and urban sectors - Create local employment - Provide rationale for partnerships with investors - Seek opportunities for technology leapfrogging	- Public-private partnership for financing major transport and urban infrastructure: > mostly public financing for road preparation > mostly private procurement of low-cost trackless trams > private construction and development of urban centres at station precincts (with rooftop solar) > mostly public operation and maintenance - Demonstration aid projects with leapfrogging opportunities with new electric transit and new electric motorbikes (for freight)	- Rapid economic development in recent years - Stated emphasis on reshaping developmental trajectory around SDGS - City level Net Zero target - Co-benefits such as employment generation in urban centre development (e-transit example) and local employment (e-motorbikes example	- Collapse of industrial base in the first decade of the 21st century - Limited fiscal capacity for public funding of next gen infrastructure - recharging to enable e-motorbikes to be genuinely competitive as they are already very cost-effective in running and maintenance costs.

Box 11.3 Ch 11	IN4Climate NRW – Initiative for a climate-friendly industry, North Rhine-Westphalia DEU	- To collaboratively develop innovative strategies towards a climate-neutral industrial sector - Position the regional industry as a climate front-runner while securing competitiveness	- Platform to bring together members of industry, scientific community and government in self-organised *innovation teams* > Teams identify breakthrough technologies, set concrete impulses (e.g. pilots), specify infrastructure needs and appropriate policy frameworks - Budgetary support for physical space, admin functions - Scientific network on standby for rapid technical services (e.g. technology assessments, market analysis) - Accommodative rules on goal setting and timelines	- Intensive and dedicated cross-branch cooperation (e.g.. multiple industries collaborated to jointly articulate sector-wide hydrogen infrastructure needs) - Receptive national policy processes, due to credibility of In4Climate as a respected network - Availability of ministry officials within innovation teams to critique preliminary policy options	Strong compliance rules limit cooperation to pre-competitive status (before feasibility studies)
Box 12.5 Ch 12	Food2030 Strategy, Finland	- Local, organic and climate friendly food production - Responsible and sustainable food consumption - A competitive food supply chain - Increasing consumer ability to make informed choices	- Targeted funding, knowledge support for technological innovations in food, AFOLU sectors - Legislation, guidance on public procurement schemes to enable small-scale organic farming and processing - Education and information instruments (media campaigns, websites) to shape responsible food behaviours	- A one-year deliberative stakeholder engagement process across sectors and political parties - Comprehensive institutional structure for cross-sector coordination (bodies for agenda-setting, guiding policy implementation and reflexive discussions)	- Weak role of integrated impact assessments to inform agenda-setting - Few independent policy evaluations - Monitoring and evaluation close to Ministry in charge, abating reflexivity - Lack of standardised indicators of holistic progress

13.8.2 Integrating adaptation, mitigation, and sustainable development

There is growing consensus that current mitigation efforts are inadequate to bridge the emissions gap in 2030; there is no level of mitigation that will completely erase the need for adaptation (Mauritsen and Pincus 2017). Isolated mitigation policy is not enough to face climate change impacts globally, leaving an urgent need for a more integrated framework for mitigation, adaptation, and sustainable development (Jordan et al. 2018; Mills-Novoa and Liverman 2019; Wang and Chen 2019). Adaptation action includes addressing exposure and reducing vulnerability by preparing for flooding, responding to heat stress, ensuring robust sanitation, and securing food supply under changing conditions (IPCC 2014a). The imperative exists to do both in the most efficient and equitable and inclusive way possible while acknowledging other pressing priorities such as those associated with the broader project of sustainable development (Landauer et al. 2019; Grafakos et al. 2020).

Adaptation and mitigation are deeply linked in practice – at the local level, for instance, asset managers have to address integrated low-carbon resilience to climate change impacts and urban planners do the same (Ürge-Vorsatz et al. 2018; Grafakos et al. 2020). Similarly, ecosystem-based (or nature-based) solutions, for instance, hold out the potential to simultaneously sink carbon, cool urban areas through shading, purify water, improve biodiversity, and offer recreational opportunities that improve public health (Raymond et al. 2017). The specific adaptation and mitigation linkages will differ by country and region, as illustrated by Box 13.14 on Africa.

Box 13.14 Adaptation and mitigation synergies in Africa

Synergies between mitigation and adaptation actions and sustainable development exist at both sectoral and national levels that can enhance the quality and pace of development in Africa. Available data on NDCs show the top mitigation priorities in African countries include energy, forestry, transport and agriculture and waste, and adaptation priorities focus on agriculture, water, energy and forestry. The energy sector dominates in mitigation actions and the agricultural sector is the main focus of adaptation measures, with the latter sector being a slightly larger source of greenhouse gases than the former (Mbeva et al. 2015; African Development Bank 2019; Nyiwul 2019).

Renewable energy development can support synergies between mitigation and adaptation through stimulating local and national economies through microenterprise development; providing off-grid affordable and accessible solutions; and contributing to poverty reduction through increased locally available resource use and employment and increased technical skills (Nyiwul 2019; Dal Maso et al. 2020). The Paris Agreement's technology transfer and funding mechanisms could reduce renewable energy costs and providing scale economics to local economies.

Barriers to achieving these synergies include the absence of suitable macro-and micro- level policy environments for adaptation and mitigation actions: coherent climate change policy frameworks and governance structures to support adaptation; institutional and capacity deficiencies in climate and policy research such as on data integration and technical analysis; and the high financial needs associated with the cost of mitigation and adaptation (African Development Bank 2019; Nyiwul 2019). Strengthening of national institutions and policies can support maximising synergies and co-benefits between adaptation and mitigation to reduce silos and redundant overlaps, increase knowledge exchange at the country and regional levels, and support engagement with bilateral and multilateral partners and mobilising finance through the mechanisms available (African Development Bank 2019).

There is a growing consensus that integration of adaptation and mitigation will advance sustainable development goals and lower emissions of GHGs and that ambitious mitigation efforts would reduce the need for adaptation efforts in the long term (IPCC 2014b). A better understanding of the synergies between both adaptation and mitigation policy implementation, to enhance or accelerate the reduction of GHGs while strengthening resilience and reducing vulnerability may enable enhanced integration (Klein et al. 2005; IPCC 2007; Mills-Novoa and Liverman 2019; Solecki et al. 2019). Integrated approaches to adaptation and mitigation planning and implementation, such as the use of wetlands to create accessible recreational areas that improve public health while improving biodiversity, sinking carbon and protecting neighbourhoods from extreme flooding events, may lead to more efficient and cost-effective policies (Klein et al. 2005; Locatelli et al. 2011; Mills-Novoa and Liverman 2019). To fully maximise their potential, co-benefits and trade-offs should be explicitly sought, rather than accidentally discovered (Berry et al. 2015; Spencer et al. 2017), and policies designed to account for both (Caetano et al. 2020).

The Fifth Assessment report of the IPCC emphasises the importance of climate-resilient pathways as an approach to addressing climate change and current and future threats to development. Climate resilient pathways are development trajectories that combine adaptation and mitigation through specific actions to achieve the sustainable development goals from household to states level, risks and opportunities vary by location and the specific local development context (*high confidence*) (IPCC 2014a; Denton et al. 2015). These include specific climate actions at energy, ecosystems, urban, and social systems; promoting collaborative learning between institutions and stakeholders (Lemos and Morehouse 2005; Moss et al. 2013); and considering multiple drivers of vulnerability (O'Brien 2018). Moreover, climate change adaptation has been aligned with the process of building climate-resilient systems, overlapping with sustainable development goals and disaster risk reduction (Prasad et al. 2009; Lewison et al. 2015; Fankhauser and McDermott 2016; Romero-Lankao et al. 2016; Solecki et al. 2019).

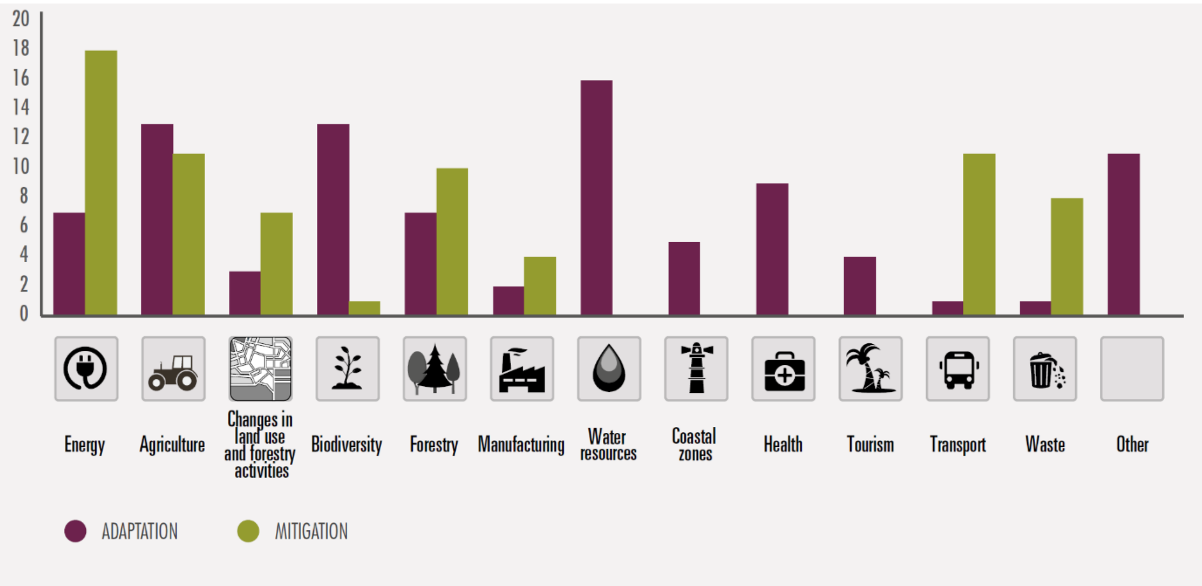
Synergies between adaptation and mitigation are included in many of the NDCs submitted to the UNFCCC, as part of overall low-emission climate-resilient development strategies (UNFCCC Secretariat 2016). A majority of developing countries have agreed to develop National Adaptation Plans (NAPs) in which many NDCs initiatives contribute to 17 SDGs (Schipper et al. 2020) as well to mitigation efforts (Hönle et al. 2019; Atteridge et al. 2020). For example, developing countries recognise that adaptation actions in sectors such as agriculture, forestry and land use management can reduce GHGs, however, some trade-offs exist between bioenergy or reforestation and the land needed for agricultural adaptation and food security (African Development Bank 2019; Hönle et al. 2019; Nyiwul 2019). For some of the Small Islands Development States (SIDS), forestry and coastal management (mangrove planting), are sectors that intertwine both mitigation and adaptation (Atteridge et al. 2020). Economic diversification efforts through renewable energy portfolios are being sought in synergy with economic development, employment opportunities and economic welfare at sector levels (Alves et al. 2020; Hasan et al. 2020). Integrated efforts also occur at the city level, such as the Climate Change Action Plan of Wellington City, which includes enhancing forest sinks to increase carbon sequestration while at the same time protecting biodiversity and reducing groundwater runoff as rainfall increases (Grafakos et al. 2019).

Assessing the results of adaptation has been challenging because of the lack of clarity of goals and sparse data with the appropriate indicators (Tompkins et al. 2018). In addition, there is neither classification of adaptation options, nor systematisation of measures at the global or regional levels. An "adaptation deficit" occurs when a country is unable to respond to the current impacts of climate variability due to various barriers that hamper adaptation (Milman and Arsano 2014; Shackleton et al. 2015; Fankhauser and McDermott 2016). Developing and emerging countries with such deficits will suffer more impacts of extreme events than developed countries. Those countries usually produce marginal impact of emissions, and therefore climate adaptation and mitigation need to be considered in broader political, economic and development goals (Fankhauser and McDermott 2016).

Some approaches are intended to identify synergies, such as the REDD initiative focus on mitigation by carbon sequestration that also generates co-benefits such as: nature protection, political inclusion, monetary income, economic opportunities. However, some unintended trade-offs may have occurred such as physical displacement, loss of livelihoods, increased human–wildlife conflicts, unequal distribution of benefits to local population groups (Bushley 2014; Duguma et al. 2014a; Gebara et al. 2014; Anderson et al. 2016; Di Gregorio et al. 2016, 2017). Box 13.15 provides illustrations of lessons from REDD+ implementation in Latin America.

Box 13.15 Latin America Region Adaptation linking Mitigation: REDD+ lessons

Thirty-three countries in the Latin American region have submitted their NDCs, 70% of their initiatives have included mitigation and adaptation options focusing on a sustainable development (Bárcena et al. 2018; Kissinger et al. 2019). However, most of the A&M policies are disconnected across sectors (Loaiza et al. 2017; Locatelli et al. 2017). National governments have identified their relevant sectors as: energy, agriculture, land use change and forestry, biodiversity, and water resources (Figure 1 below). The region houses 57% of the primary forest of the planet, thus REDD+ is an M&A project aiming to reduce GHG while provide ecosystems services to vulnerable communities (Bárcena et al. 2018). Lessons for a successful REDD+ program pointed out a multilevel structure from international to national up to strong community organisation, as well as secure resources funding, with most of the projects relying on external sources of funding (Loaiza et al. 2017; Kissinger et al. 2019) (*medium evidence, high agreement*). Although this initiative has been for years, there has not yet been any national assessment of co-benefits and potential trade-offs between sectors, or with local communities (Locatelli et al. 2017). Conflicts have emerged over political views, government priorities of resources (oil, bioenergy, hydropower), and weak governance among national and local authorities, indigenous groups and other stakeholders such as NGOs which play a critical role in the technological and financial support for the REDD initiative (Locatelli et al. 2011; Reed 2011; Gebara et al. 2014; Kashwan 2015; Locatelli et al. 2017). A more holistic approach is needed which recognises these social, environmental and political drivers.



Box 13.15, Figure 1 Latin America and the Caribbean: High priority sectors for mitigation and adaptation

[Number of countries that name the following sector in their national climate change plans and/or communications. The purple and green bars represent adaptation and mitigation respectively. Figure reproduced from (Bárcena et al. 2018).*]*

The term 'nexus' is used to describe the linkages between water, energy, food, health and other socio-economic factors in some integrated assessment approaches (Rasul and Sharma 2016). The Food-Energy-Water (FEW) nexus for example considers how water is required for energy production and supply, how energy is needed to treat and transport water, and how both are critical to food production (Mohtar and Daher 2014; Biggs et al. 2015). Climate change impacts all these dimensions in the form of multi-hazard risk (Froese and Schilling 2019). Although integrative, the FEW nexus faces many challenges including: limited knowledge integration; coordination between different institutions and levels of government; politics and power; cultural values; and ways of managing climate risk (Leck and Roberts 2015; Romero-Lankao et al. 2017; Mercure et al. 2019). . More empirical assessment is needed to identify potential overlaps between sectoral portfolios, as this could help to delineate resources allocation for synergies and to avoid trade-offs.

Beyond food, energy and water, there are adaptation, mitigation and sustainable development linkages across several sectors, illustrated in Table 13.3. Inter-relations between mitigation and adaptation need a cross-sectoral framework which allows for broader synergies and the identification of trade-offs in implemented climate actions.

1 **Table 13.3 Relationships between adaptation and mitigation measures**

Policy/action	Interrelation explained	Reference
	Adaptation that contributes to mitigation	
Coastal adaptation and blue carbon; developing strategies for conservation and restoration of blue carbon ecosystems generating resilient communities and landscapes.	Conservation of habitats and ecosystems, protect communities from extreme events, increase food security, and provide ecosystem services. At the same time, restoration of mangroves, tidal marshes, and seagrasses have high rates of carbon sequestration, act as long-term carbon sinks, and are contained within clear national jurisdictions. Example: Conservation programs on Brazilian mangroves. Spanish Seagrass meadows, and in the Great Barriers Reef in Australia	(Andresen et al. 2012; Herr and Landis 2016; Duarte 2017; Doll and Oliveira 2017; Howard et al. 2017; Gattuso et al. 2018; Cooley et al. 2019; Karani and Failler 2020; Lovelock and Reef 2020)
Ecosystems base Adaptation (EBA) are measures that simultaneously reduce poverty, protect or restore biodiversity and ecosystem services, and remove atmospheric greenhouse gases. **Nature Based Solutions (NBS)** current policy platforms are shifting their focus from EBA to-NBS, broadly defined as solutions to societal challenges that are inspired and supported by nature.	EBA combine biodiversity and ecosystem services into an adaptation and development strategy that increases the resilience of ecosystems and communities to climate change through the conservation, restoration, and sustainable management of ecosystems. Examples: coastal ecosystems globally	(McAllister 2007; Colls et al. 2009; Duarte 2017; Raymond et al. 2017; Rubio 2017; Gattuso et al. 2018)
"**Urban Greening"** urban forestry, planting in road reserves and tree planting along main streets. Green Infrastructure for water retention.-	Urban reforestation produce cooling effect and water retention while helps to reducing carbon dioxide from the atmosphere. Green walls and rooftops increase energy efficiency of buildings and decrease water runoff and provide insulation for the buildings. Examples; Chicago, Wellington, Indonesia	(Santamouris 2014; Anderson et al. 2016; Sharifi and Yamagata 2016; Grafakos et al. 2018; Pasimeni et al. 2019)
Climate adaptation at the management city scale would lead to carbon reduction to support climate mitigation. Examples from: north and global south.	Cities' responses with Climate Actions Plans include, local governance, urban spatial planning and capacity-building initiatives. Cities with A&M combined Climate Change Action Plans: Bangkok, Chicago, Montevideo, Wellington, Durban, Paris, Mexico City, and Melaka.	(Nakano et al. 2017; Bai et al. 2018; Peng and Bai 2018; Grafakos et al. 2019; Zen et al. 2019)
	Mitigation that contributes to adaptation	

REDD[+] mechanism: an incentive for developing countries to protect their forest resources and coastal wetlands	Sustainable REDD+ increases the carbon sinks and consequently reduces GHGs emitted into the atmosphere. Reduce destruction of forest resources and biodiversity Protecting natural forest also conserves soil and water by reducing erosion	(Busch et al. 2011; Dickson and Kapos 2012; Bushley 2014; Gebara et al. 2014; Pham et al. 2014; Anderson et al. 2016; Jodoin 2017a; Froese and Schilling 2019)
Household energy-efficiency measures as mitigation policy, with key energy policies may improve socioeconomic development	Energy Efficiency (EE) emerges as a feasible and sustainable solution in Latin America, to minimise energy consumption, increase competitiveness levels and reduce carbon footprint. Achieving high levels of EE in the building sector require strengthen their legal framework and new policies towards lowering the energy consumption of the built environment.	(Chan et al. 2017; Silvero et al. 2019; Zabaloy et al. 2019; Alves et al. 2020)
Sustainability first: Holistic approaches		
Integrated community sustainability plans	Climate change mitigation and adaptation are embedded in a plan to improve affordability, biodiversity, public health, and other aspects of communities.	(Burch et al. 2014; Shaw et al. 2014; Stuart et al. 2016; Dale et al. 2020)
Inclusive future visioning processes using social-ecological systems or socio-technical systems thinking	Participatory processes that highlight the cultural and social dimensions of climate change responses and synergies/trade-offs between priorities rather than an exclusive focus on technical aspects of solutions.	(Gillard et al. 2016; Krzywoszynska et al. 2016)
Climate Resilience cities, integrating New Urban Agenda (NUA), SDGs and Disaster Risk Reduction for local and subnational governments	Resilient cities including A&M options and DRR to build a resilient plan for urban planning, health, life quality and jobs creation.	(Blok 2016; Gomez Echeverri 2018; Giampieri et al. 2019; Long and Rice 2019; Pasimeni et al. 2019; Romero-Lankao et al. 2016)
Trade-offs		
Land use strategies (urban form) for mitigation or adaptation considered in isolation, may cause a conflict in land planning.	GHG reductions, by increasing density, land use mix and transit connectivity could increase climate stress and reduce green open spaces. It may increase the UHI and expose population to coastal inundation.	(Viguié and Hallegatte 2012; Floater et al. 2016; Xu et al. 2019)
Low-carbon and climate change resilient building codes that fail to account for affordability	"Greening" programmes may produce positive mitigation and adaptation outcomes but also accelerate displacement and gentrification.	(Viguié and Hallegatte 2012; Wolch et al. 2014; Haase et al. 2017; Garcia-Lamarca et al. 2021; Sharifi 2020)

13.8.2.1 Governing the linkages between mitigation and adaptation at the local, regional, and global scales

Supranational levels of action such as the EU climate change policy have influenced the development and implementation of Climate Change Action Plans (CCAPs) at the subnational level (Heidrich et al. 2016; Reckien et al. 2018; Villarroel Walker et al. 2017). While adaptation is gaining prominence and is increasingly included in the NDCs of EU nations, the implementation of adaptation and mitigation by EU states are at different stages (Fleig et al. 2017). Fleig et al. (2017) found that all EU states, with the exception of Hungary, have adopted a framework of laws tackling mitigation and adaptation to climate change. However, an assessment of climate legislation in Europe pointed out that there has been no coordination between mitigation and adaptation, and that implementation varies according to different national conditions (Nachmany et al. 2015).

In the Global South, climate change policies tend to be established in the context of sustainable development and of other localised priorities (e.g., air pollution and health). National climate policy is given prominence to adaptation based on country vulnerability, climatic risk, and in particular the inclusion of gender, local/traditional and indigenous knowledge (Beg et al. 2002; Duguma et al. 2014b). Despite the evidence that mitigation and adaptation can be effective and efficient (Klein et al. 2005) and can potentially reduce trade-off among their interactions, there is still limited evidence of how climate adaptation and emission reduction policies would contribute to SDGs (Di Gregorio et al. 2017; Antwi-Agyei et al. 2018; Campagnolo and Davide 2019).

The Paris Agreement 2015 for climate change, the Sendai Framework 2015 for disaster risk reduction, and the New Urban Agenda for sustainable urban systems, all contribute to the Sustainable Development Goals. These international policy frameworks provide an integrated approach for both adaptation and mitigation, while promoting sustainable development and climate resilience across scales (from global, regional, to local government actions (Duguma et al. 2014b; Heidrich et al. 2016; Di Gregorio et al. 2017; Locatelli et al. 2017; Nachmany and Setzer 2018; Mills-Novoa and Liverman 2019).

Local governments and cities are increasingly emerging as important actors climate change (Gordon and Acuto 2015) (see also Section 13.5). While cities and local governments are developing Climate Change Action Plans (CCAPs), joint plans of adaptation and mitigation are a minor percentage, with few cities establishing inter-relationships between them (Nordic Council of Ministers 2017; Grafakos et al. 2018). Moreover, few integrated policies have considered the culture and values of the stakeholders involved, focusing mostly on a technocratic solution. More inclusion of studies about social issues are necessary across sectors and levels of government (O'Brien 2018; Di Gregorio et al. 2019; Birchall and Bonnett 2021). Compared to national climate governance, local governments are more likely to develop and advance climate policies, generating socio-economic or environmental co-benefits, and improve communities' quality of life (Gill et al. 2007; Bowen et al. 2014; Duguma et al. 2014b; Mayrhofer and Gupta 2016; Deng et al. 2017; Hennessey et al. 2017). There may be a disconnect, however, between the responsibility that a particular jurisdiction has over mitigation and adaptation (environmental city officials, for instance) and the scale of resources or capacities that they have available to bring to bear on the problem (regional to national provision of energy and transport).

13.8.3 Governance for Equity and Sustainable Development

Climate policy integration carries implications for the pursuit of SDGs, as there are important linkages between climate and sustainable development agendas, as evidenced by literature on SDG interlinkages (Tosun and Leininger 2017), NDC-SDG linkages (Dzebo et al. 2017; Nilsson and Persson 2017; Dzebo et al. 2018), climate-resilient development pathways (Roy et al. 2018) and systems perspectives (Fuso Nerini et al. 2018). This literature argues for long term policy planning that combines the governance of national climate and SD goals, builds institutional capacity across all sectors, jurisdictions, and actors, enhances participation and transparency and holistically integrates the social dimensions of policies.

However, there is some evidence that integration has not been successfully achieved through single multi-sectoral strategy documents, such as broad sustainable development strategies; such documents are better understood as vision documents rather than operational documents (Nordbeck and Steurer 2016). Where mainstreaming of environmental concerns has been attempted through national plans, they have only had success when backed by strong political commitments that support a vertical coordination structure rather than horizontal structures led by the focus ministry (Nunan et al. 2012). Other lessons are that integration of the budget process is particularly important, as are aligned timeframes across different objectives (Saito 2013).

There are important links between inequality, justice and climate change (Ikeme 2003; Bailey 2017). Many of these operate through the benefits, costs and risks of climate action (distributive justice), while others focus on differential participation and recognition of subnational actors and marginalised groups (procedural justice) (Bulkeley and Castán Broto 2013; Bulkeley et al. 2013; Hughes 2013; Reckien et al. 2018; Romero-Lankao and Gnatz 2019).

Justice principles are rarely incorporated in climate change framing and action (Sovacool and Dworkin 2015; Genus and Theobald 2016; Heikkinen et al. 2019; Romero-Lankao and Gnatz 2019). Yet, equity is salient to mitigation debates, because climate change mitigation policies can have also negative impacts (Brugnach et al. 2017; Ramos-Castillo et al. 2017; Klinsky 2018), exacerbated by poverty, inequality and corruption (Reckien et al. 2018; Markkanen and Anger-Kraavi 2019). Climate change justice also brings to the forefront questions of health and wellbeing, as communities face simultaneously the impacts of climate change and the impacts of policies to reduce carbon emissions (Levy and Patz 2015). A new emerging agenda on just urban transitions is likely to reinvigorate climate justice debates at the subnational level (Hughes and Hoffmann 2020).

As a result, successful policy integration goes beyond optimising public management routines, and must resolve key trade-offs between actors and objectives (Meadowcroft 2009; Nordbeck and Steurer 2016). A lack of policy integration could lead to detrimental equity and justice outcomes, including worsening poverty, increased inequality and ineffective women-centred mitigation policies (Roy et al. 2018; Caetano et al. 2020; Michael et al. 2020). Moreover, to operationalise equity policy mixes need to be designed with the realities of excluded populations in mind, thus accounting for the fact that policies create winners and losers through explicit design to ameliorate distributional effects (Kern and Rogge 2018; Roberts et al. 2018) (Also see 13.5). Winners may include low-carbon entrepreneurs and future generations while potential losers include incumbents with vested interests, and neighbours of low-carbon infrastructure projects (Geels 2014; Rosenbloom 2018). For example, mitigation policies such as carbon pricing can be supplemented with other policies to directly ameliorate impact on incumbents while supporting new entrants (Passey et al. 2012). Building coalitions for climate mitigation action can help manage the politics of the transition, for example through green industrial policy (e.g. supporting renewable energies through feed-in tariffs) and introducing carbon pricing (Meckling et al. 2015).

Negative policy feedback – the effect of a policy to slow down future policy -- can result from ineffective policy instruments, competing policy objectives, and exogenous factors such as financial crises. Conversely, low-carbon technological innovation can play a key role in enabling a ratchet up of climate policy – a positive feedback -- over time by reducing costs and creating jobs (Schmidt and Sewerin 2017). The process of designing and implementing low-carbon transitions is significant, because low-carbon transitions cannot only be slowed down through resistance from vested interests, but also through a lack of public acceptance (Bicket and Vanner 2016).

The potential for transformative climate change policy that delivers both adaptation and mitigation is also shaped by a number of enabling and disabling factors tied to governance processes (Burch et al. 2014) (also see Section 13.9). As Box 13.16 suggests various factors that enhance the scope for integrated governance, such as create space for inclusion, explicitly address synergies and trade-offs and allow for measurement, evaluation and course correction.

Box 13.16 Enabling and Disabling Factors for Integrated Governance of Mitigation and Adaptation

Ensuring participatory governance and social inclusion

Interlinkages in the water, energy and food nexus highlight the importance of inclusive processes, requiring coordination among sectoral institutions and capacity building that link science, practice and policy at multiple levels (Shaw et al. 2014; Nakano et al. 2017; Cook and Chu 2018; Romero-Lankao and Gnatz 2019). Likewise, the cultivation of urban grassroots innovations and social innovation may accelerate progress (Wolfram and Frantzeskaki 2016), as does the support of nature-based citizen science (Groulx et al. 2017).

Considering synergies and trade-offs with broader sustainable development priorities

The explicit consideration of synergies and trade-offs with broad sustainable development priorities will enable more integrated policy making (von Stechow et al. 2015). Policy frameworks for assessment mitigation and adaptation in the context of sustainable development, for example analysis of energy and water resources policies implementation and their trade-off with agriculture, are just emerging (Huggel et al. 2015; Antwi-Agyei et al. 2018).

Employing a diverse set of tools to reach targets

Building codes, land use plans, public education initiatives, and nature-based solutions such as green ways are just a few of the tools that may be brought to bear on both adaptation and mitigation simultaneously (Burch et al. 2014). Ecological restoration is another such suite of tools, for instance the Brazilian target of restoring and reforesting 12 million hectares of forests by 2030, which can enhance biodiversity and ecosystem services while also sinking carbon (Bustamante et al. 2019).

Monitoring and evaluating key indicators, beyond only greenhouse gas emissions, such as biodiversity, water quality, and affordability

Pursuing an integrated approach to adaptation and mitigation requires the development of a wider range of key indicators and a robust process for collecting data on these indicators. Challenges are related to the limited evidence-base policy on synergies, co-benefits, and trade-offs across sectors and jurisdictions (Di Gregorio et al. 2016; Locatelli et al. 2017; Zen et al. 2019). Moreover, adaptation policies mostly lack measurable targets or expected outcomes making even tougher to design an integrated framework (OECD 2017).

Iterative and adaptive management

Adaptive management helps to address the underlying uncertainty (Kundzewicz et al. 2018) that characterises implementation of integrated approaches to adaptation and mitigation. Policy integration needs to be considered iteratively along the process of development, implementation, and evaluation of climate policies.

Strategic partnerships that coordinate efforts

Integrated adaptation and mitigation require the participation of a multitude of actors and various scales, and in various sectors. Strategic partnerships among the actors, therefore bring diverse technical skills and capacities to the endeavour (Burch et al. 2016; Islam and Khan 2017). However, realising strategic approaches for joint adaptation and mitigation require adequate financial, technical and human resources.

Participatory and collaborative planning approaches can help overcome injustices and address power differentials

Participatory and collaborative planning approaches can provide multiple spaces of deliberation where marginalised voices can be heard (Blue and Medlock 2014; UN Habitat 2016; Castán Broto and Westman 2017; Waisman et al. 2019). These tools organise climate and sustainability action by addressing its democratic deficit and facilitating the recognition of multiple perspectives in environmental planning alongside material limits of development (Agyeman 2013).

13.9 Accelerating for transformational change

13.9.1 Introduction

This section focuses on the means to accelerate GHG emission reduction, including through economy-wide restructuring efforts. In these cases, policymakers may have multiple objectives beyond climate mitigation alone, but which also include positive climate mitigation outcomes. Meeting ambitious mitigation and development goals depends on the decisions taken about a broad range of development choices, not only climate policy choices, and on the tools used to achieve those choices – since some pathways open up more tools to accelerate mitigation and achieve SGD goals together (Chapter 4, and Figure 4.9). A dimension of delivering successful, combined mitigation acceleration and sustainable development objectives is the effort taken to integrate different goals (such as mitigation, adaptation, equity and sustainable development) as described in the previous section (Section 13.8). Overall, successful implementation of climate goals also relies on a wide range of factors including institutional capacity and processes (Section 13.2), scales and capacity of action (Section 13.3); structural context specific factors (Section 13.4); actors (Section 13.5); policies (Section 13.6, 13.7); and other enabling conditions (Section 13.9.2; Chapters 4, 5, 15, 16 and 17).

This section assesses the approaches for acceleration of climate mitigation in the context of the above understandings and put forward by an emergent, multi-disciplinary literature since AR5. 'Gaps' in implementation have led to suggestions that acceleration of GHG reductions may be better achieved by moving from incremental to wider cross-economy, coordinated, systemic-change approaches. This is, in part, because these approaches may be better suited to overcoming the challenges of the current, locked-in high GHG global economy. GHG intensive systems are multi-facetted and made up of, and held together by, an inter-linked set of issues, not limited to but including economic, social and technological factors. Seto et al (2016) argue that there are three sorts of carbon 'lock-in': technological and infrastructural; institutional and decision-making; and individual behavioural and social structural, and that these lock-ins have formed over many decades. Understanding how best to weaken these lock-ins to allow space for low GHG development pathways is likely to be an essential component for acceleration.

The sub-sections below expand on this with: the link between enabling conditions and system transitions (Section 13.9.2); the 'gaps' in climate mitigation goals and delivery (Section 13.9.3); the potential of transformation packages for climate mitigation (Section 13.9.4); and conditions for a deliberate acceleration of climate mitigation (Section 13.9.5).

13.9.2 Enabling acceleration

There is now robust evidence and high agreement that the presence of enabling conditions are essential for successfully delivering climate mitigation goals (whether single policies; policy packages; or cross-economy restructuring packages). Enabling conditions 'affect the feasibility of adaptation and mitigation options, and can accelerate and scale-up systemic transitions that would limit temperature increase and enhance capacities of systems and societies to adapt to the associated climate change, while achieving sustainable development, eradicating poverty and reducing inequalities…..' (See Annex A: Glossary).

The high level enabling conditions were specifically identified in IPCC SR1.5 as multi-level governance, institutional capacities, behavioural and lifestyles, technological innovation, policy, and financial systems (IPCC 2018). AR6 WG III Chapters 4 and 17 have explored the interactions of climate action and distributional impacts. Sustainable development and the actions taken to deliver the SDGs implicitly include justice as a requirement of climate mitigation and adaptation (Section 13.8.3), so that justice is also an enabling condition (See Box 13.17). In addition, multiple chapters and sections in the AR6 WG III Report focus on individual enabling conditions such as those related to people and behaviour (Chapter 5); finance for investment (Chapter 15); innovation policy (Chapter 16); sustainable development, and its relationship with accelerated stringency (Chapter 1 and Chapter 17). This sub-section does not repeat their messages but focuses on enabling conditions for acceleration, including systemic change.

Policy instruments and institutions, are both enabling conditions, and are necessary, but insufficient, for the successful delivery of systemic transitions (IPCC 2018). Multiple authors list (some of) a core set of enabling conditions for a particular policy success, such as institutions, policy and regulatory framework, economic issues, financial issues, laws, capacity, information, knowledge and public awareness (Haselip et al. 2011; Duguma et al. 2014b; Recalde 2016; Waisman et al. 2019; Zabaloy et al. 2019). Because the enabling condition literature is context specific, authors may then specify additional conditions for specific policy goals and places. For example, international border conditions (energy price volatility, cooperation agreements, international funding opportunities) and national border conditions (institutional framework, political will, energy subsidies, human and capital capacities, natural conditions (energy resources, endowment) are important enabling conditions for the effectiveness in delivering energy efficiency policies in South America (Zabaloy et al. 2019).

System wide transitions (like land and ecosystem transition, or an industrial system transition) require all enabling conditions while individual mitigation options, or more specific policy implementation goals, may not need all of them, but a combination (IPCC 2018). If policymakers would like to accelerate GHG reductions, or other objectives which co-benefit that outcome, then identifying the enabling conditions for any given goal, including transformation and acceleration, is an important step (e.g. Chapter 4; Roberts et al. 2018).

Box 13.17 Institutions for Just Transition

A number of countries around the world have created institutions to facilitate a just transition away from fossil fuels and towards low carbon systems. These include Canada with a Just Transition Task Force set up in 2017 (Pinker 2020); the German Coal Commission formed in 2018 to facilitate Germany's coal phase-out and Just Transition process (Agora Energiewende and Aurora Energy Research 2019; Reitzenstein and Popp 2019); Scotland's Just Transition Commission established in 2019 (Skea et al. 2020); The European Union's European Green Deal announced in December 2019 (and updated in 2020 with its stimulus package (European Commission 2020b)) introduced plans for the creation of the Just Transition Mechanism (JTM) to provide advice, support and technical assistance to the most carbon-intensive regions (European Commission 2020c,d); and the Partnerships for Opportunity and Workforce and Economic Revitalisation (POWER) Initiative in the US to assist communities and regions adversely affected by America's energy production (Chamberlin et al. 2019). Other countries that are also creating Just Transition institutions and policies include New Zealand with its Just Transitions Unit (Ministry of Business Innovation and Employment of New Zealand 2020) and Spain's Framework Agreement for a Just Transition of Coal Mining and Sustainable Development of the Mining Regions for the Period 2019-2027 (Piggot et al. 2019). For more detail, see Chapter 4.

13.9.3 From incremental change to transformation

A 'gaps' literature illuminates various 'gaps' in required implementation rates, stringency, actions, capacity and time to deliver sufficient climate mitigation while remaining within 2˚C (Chapter 2 and 3). This includes, inter alia, current global agreements (UNEP 2020); country specific agreements (for example, Canada (Gibson et al. 2018); the UK (Scott et al. 2018; Committee on Climate Change 2020); the ASEAN countries (Vidinopoulos et al. 2020); sector agreements (for example, the Dutch chemicals production industry (Janipour et al. 2020); geographic areas e.g. EU (Capros et al. 2019); urban centre actions and agreements (Tozer 2019). Other 'gaps' are not only related to policies, technologies and capabilities. For example, a gap is identified between climate policies, NDCs and the needed ambition of political economy (Vogt-Schilb and Hallegatte 2017); while others identify a gap between government education and recommendations and higher impact actions, creating a gap between official recommendations and individuals understanding of how to align their behaviour with climate targets (Wynes and Nicholas 2017).

The 'gaps' in delivery of goals and the complexity and multi-facetted nature of rapidly decarbonising our current interconnected systems (such as energy, food, health in a just way) has led to suggestions that additional, more systemic and structural response actions may be needed for successful climate mitigation. For example, major, long term sectoral transformation is needed to reach net-zero GHG emissions (UNEP 2020), where transformational change is a process that involves profound change resulting in fundamentally different structures (Nalau and Handmer 2015) or a 'substantial shift in a system's underlying structure' (Hermwille et al. 2015b). A long term sectoral transformation would be successful if it can fundamentally change emissions trajectories or facilitate a step change in technologies, practices or products (see Table 13.2).

Bernstein and Hoffmann (2019) and Rockström et al. (2017) argue that the presence of multi-level, multi-sectoral lock-ins of overlapping and interdependent political, economic, technological and cultural forces mean that a new approach of co-ordinated, cross-economy, systemic climate mitigation is necessary. Becken (2019) argues that only systemic changes at a large scale will be sufficient to break or disrupt existing arrangements and routines in the tourism industry. O'Brien (2018) posits that sector-focused, or a silo approach, to mitigation may need to give way to decisions and policies which reach across sectoral, geographic and political boundaries and involve a broad set of interrelated processes – practical, political and personal; whilst Linner and Wibeck (2020), set out to explain what that means in concrete terms. Gillard et al (2016) argues that a response to climate change has to move beyond incremental responses, aiming instead for a society wide transformation which goes beyond a system perspective to include learning from social theory. Others argue that moving beyond incremental emissions reductions will require expanding the focus of efforts beyond the technical to include people, and their behaviour and attitudes (Eyre et al. 2018).

13.9.4 Transformation or stimulus packages

Economy-wide restructuring packages as a way to channel domestic economies to deliver particular, desired outcomes is a widely accepted tool of government (for example the Roosevelt's New Deal packages in the US between 1933 and 1939). A number of country-level stimulus package were put in place after the 2008 Global Recession, and there was support for a Global Green New Deal from UNEP (Steiner 2009; Barbier 2010). Cross-economy structural change stimulus or GND packages may provide opportunities for another approach to accelerate climate mitigation.

This approach has already been taken up to some degree by a number of countries / blocs. For example, California and Germany, through its *Energiewende*, are early examples of a US state and a country which have tried to link their economies to a sustainable future through energy-wide efforts of structural change (Morris and Jungjohann 2016; Burger et al. 2020).

There have since been a number of cross economy Green New Deals implemented for the EU Green New Deal (see Box 13.1 for the EU Green New Deal; Elkerbout et al. 2020; Hainsch et al. 2020; UNEP 2020) with calls for other New Deals (e.g. a Blue New Deal (Dundas et al. 2020) or deals to bring together climate and justice goals (Hathaway 2020; MacArthur et al. 2020).

The COVID-19 Pandemic 2020-2021 has resulted in global economic recession, which many Governments have responded to with economic stimulus programs. It has also led to more analysis of the potential of cross-economy stimulus packages to benefit climate goals, including what lessons can be learned from the stimulus packages put in place as a result of the 2008-9 Global Recession.

Table 13.4 Examples of constituents of successful Green Stimulus Framework

Constituent	Reference Examples
Long term commitments of public spending	Barbier (2020)
Pricing reform	Barbier (2020); UNEP (2020)
Affordability	Barbier (2020)
Minimising unwanted distributional impacts	Barbier (2020)
Clean physical infrastructure	Hepburn et al. (2020); UNEP (2020)
Building energy efficiency retrofits	Hepburn et al. (2020)
Investment in education and training	Hepburn et al. (2020)
Natural capital investment	Hepburn et al. (2020); UNEP (2020)
Clean R&D	Hepburn et al. (2020); UNEP (2020)
Energy efficiency upgrades	Jotzo et al. (2020)
Afforestation and ecosystem restoration	Jotzo et al. (2020); UNEP (2020)
RE projects	Jotzo et al. (2020); Omri et al. (2015); UNEP (2020)

The United Nations Environment Programme (UNEP) reviewed the green stimulus plans of the G20 following the 2008-9 Global recession to examine what worked; what did not; and the lessons which could be learnt (Barbier 2010). This work was updated (Barbier 2020) and is shown in Table 13.4 above. Others argue that post 2008 recession stimulus package outcomes benefited both environmental and industrial objectives and a long-term policy commitment to the transition to a sustainable, low economy, makes sense from both an environmental and industrial strategy point of view (Fankhauser et al. 2013).

With the outbreak of the COVID-19 Pandemic in 2020, past stimulus packages have been further investigated: 231 central bank officials were interviewed and identified five key policies for both economic multipliers and climate impacts metrics (Hepburn et al. 2020, see Table 13.4 above). In lower and middle income countries, rural support spending was more relevant, while clean R&D was less so. The study illuminated that there were different phases to recovery packages – the initial 'rescue' spending but then a second 'recovery' phase that can be more fairly rated green or not green. They concluded that recovery phase policies can deliver both economic and climate goals; co-benefits can be captured (i.e., support for EV infrastructure can also reduce local air pollution etc.) but that the package design is important (Hepburn et al. 2020). Others provide a framework which allows a systematic evaluation of options, given objectives and indicators, for COVID-19 stimulus packages. They conclude that the programmes which most closely match green stimulus are afforestation and ecosystem restoration programmes; energy efficiency upgrades and RE projects. These type of policies provide short term goals of COVID-19 whilst making progress on longer terms objectives (Jotzo et al. 2020, see Table 13.4 above).

Conversely, other short term fiscal or recovery measures in stimulus packages may perpetuate high carbon and environmental damaging systems; for example, fossil fuel based infrastructure investment; fiscal incentives for high carbon technologies or projects; waivers or roll-backs of environmental regulation; bailouts of fossil fuel intensive companies without conditions for low carbon transitions or environmental sustainability (UNEP 2020).

Of the $12.7 trillion so far spent on stimulus packages, $3.7 trillion (as of October 2020) is linked to environmental outcomes (Vivid Economics 2020). The packages in EU, France, Spain, the UK and Germany (German Federal Ministry of Finance 2020) result in net benefits for the environment while Canada, and India have high total positive green stimulus spend but overall this is negated by the expenditure to non-environmental areas (Climate Action Tracker 2020; UNEP 2020; Vivid Economics 2020). The Republic of Korea is reported as a net benefit program in some studies (UNEP 2020) and a net negative in others (Vivid Economics 2020).

Stimulus packages can have both climate positive and climate negative effects. Attention in the early efforts of the development and design of stimulus (and other cross-economy packages, such as Green New Deals) are likely to lead to climate rewards later on.

13.9.5 Steps for acceleration

The multi-disciplinary literature exploring how to accelerate climate mitigation and transition to low GHG economies and systems has grown rapidly over the last few years. Acceleration is also confirmed as an important sub-theme of the more specific transition literature (Köhler et al. 2019). While literature focusing on how to accelerate the impact of climate mitigation is derived from empirical evidence, there is very little *ex post* evidence of directed acceleration approaches.

The overlapping discussions of how to accelerate climate mitigation; transition to low carbon economies; and shift development pathways depends heavily on country specific dynamics in political coalitions, material endowments, industry strategy, cultural discourses, and civil society pressures (Sections 13.4, 13.5, 13.8). Ambition for acceleration at different scales and stringency (whether for cities, country climate policies, country industrial strategies, or national economic restructuring) increase governance challenges, including coordination across stakeholders, institutions, and scales. 'There is therefore no "one-size-fits-all" blueprint for accelerating low-carbon transitions' (Geels et al. 2017a; Roberts et al. 2018).

Rosenbloom et al, (2020) describe the key challenges to accelerating climate mitigation and sustainability transitions as: the ability for low carbon innovations to emerge in whole systems; the need for greater interactions between adjacent systems; the resistance from declining industries; the need for changes in consumer practices and routines; and coordination challenges.

Coordination is described as a necessary but insufficient condition of acceleration. For example, coordination of actions and coherent narratives across sectors and cross economy, including within and between all governance levels and scales of actions, is beneficial for acceleration (Zürn and Faude 2013; Hawkey and Webb 2014; Huttunen et al. 2014; Magro et al. 2014; Warren et al. 2016; Jänicke and Quitzow 2017; Hess 2019; Kotilainen et al. 2019; McMeekin et al. 2019; Victor et al. 2019; Hsu et al. 2020b).

The acceleration literature links two over-arching actions: first, a strategic approach to overcoming the challenges to acceleration by a parallel focus on destabilising high carbon systems whilst simultaneously encouraging low carbon systems; and second, focusing on a coordinated, cross-economy systemic response, including harnessing enabling conditions (Hess 2019; Rogelj et al. 2015; Hvelplund and Djørup 2017; Gomez Echeverri 2018; Markard 2018; O'Brien 2018; Roberts et al. 2018; Tvinnereim and Mehling 2018; European Environment Agency 2019; Geels et al. 2017b; Kotilainen et al. 2019; Victor et al. 2019; Burger et al. 2020; Hsu et al. 2020b; Newell and Simms 2020; Otto et al. 2020; Rosenbloom et al. 2020; Rosenbloom and Rinscheid 2020; Strauch 2020).

An example of strategic targeting of the challenges to acceleration is the focus on destabilising carbon-intensive systems, thereby reducing opposition to more generalised acceleration policies, including the encouragement of low carbon systems (Hvelplund and Djørup 2017; Rosenbloom 2018; Roberts and Geels 2019; Victor et al. 2019; Rosenbloom et al. 2020; Rosenbloom and Rinscheid 2020). Destabilising high carbon systems includes deliberately phasing out unsustainable technologies and systems (Kivimaa and Kern 2016; David 2017; European Environment Agency 2019; Johnsson et al. 2019; UNEP 2019; Carter and McKenzie 2020; Newell and Simms 2020); confronting the issues of incumbent resistance (Roberts et al. 2018); and avoiding future emissions and energy excess by reducing demand (Rogelj et al. 2015; UNEP 2019; Victor et al. 2019).

Other strategic goals include tackling the equity and justice issues of 'stranded regions' (Spencer et al. 2018); arguments for greater attention to system architecture to enable increased acceleration to low carbon electricity supply, in this case in the wind industry (McMeekin et al. 2019); and the importance of maintaining global ecosystem of low carbon supply chains (Goldthau and Hughes 2020).

Some strategic policy goals combine national and global action. For example, global NGO coalitions have formed around strategic policy outcomes such as the 'Keep it in the Ground' movement (Carter and McKenzie 2020), and are supported via coordinated networks, such as the Powering Past Coal Alliance (Jewell et al. 2019), and with knowledge dissemination, for example, the 'Fossil Fuel Cuts Database' (Gaulin and Le Billon 2020).

A social transformation is likely to be as important as the technical challenges in a coordinated, cross-economy approach to acceleration. For example, some argue for social tipping interventions (STI) alongside other technical and political interventions so that they can 'activate contagious processes of rapidly spreading technologies, behaviours, social norms, and structural reorganisation' (Otto et al. 2020). They argue that these STIs are *inter alia*: removing fossil fuel subsidies and incentivising decentralised energy generation; building carbon neutral cities; divesting from assets linked to fossil fuels; revealing the moral implications of fossil fuels; strengthening climate education and engagement; and disclosing information of GHG emissions (Otto et al. 2020). Others illuminate the importance of narratives and framings in the take-up (or not) of acceleration actions (Sovacool et al. 2020). Newell and Simms, (2020) are optimistic about the possibilities of transformation but also highlight the importance of political economy to rapid and just transitions.

In summary, a synthesis of the multi-disciplinary, acceleration literature suggests that climate mitigation is a multifaceted problem which spans cross-economy and society issues, and that solutions to acceleration may lie in coordinated systemic approaches and change. Broadly, this literature agrees on a dual approach of non-incremental systemic change and a targeting of specific acceleration challenges, with tailored actions drawing on enabling conditions. A sequencing of these actions, aimed at undermining the pillars of high carbon systems at the same time as supporting the pillars of low carbon systems may help. The underlying argument of this is that there is a strategic logic to focusing on actions which undermine high carbon systems at the same time as encouraging low carbon systems, because destabilising current high carbon systems may weaken their lock-in mechanisms, which in turn may limit the opposition to policies and actions aimed at accelerating climate mitigation and may enable more support for low carbon systems. Finally, new modes of governance may be better suited to this approach in the context of transformative change.

13.10 Further research

13.10.1 Climate institutions and governance

- The number of countries passing climate legislation is increasing, but more research is needed on the different approaches to legislation, how they map to different country contexts, and the impacts of legislation
- National and subnational governments are increasingly establishing dedicated organisations for climate governance, providing them with human and financial resources, or introducing new responsibilities to existing organisations. More research is needed on approaches to mainstream climate governance, and in particular how to organise governmental resources to bring about long-term transformations toward low carbon systems. Closely associated is understanding the capacity needs of governments, at all levels.
- Further research on the drivers of subnational climate action, the scope for coordination or leakage with other scales of action, and the effect, in practice on GHG outcomes is necessary.
- Comparative case research on how countries develop NDCs, and whether and how that shapes national policy processes, would contribute to an understanding of the effectiveness of the NDC process.
- Climate governance research is dominated by the experiences of a few large, developed or emerging countries. More research is needed on small and medium-sized countries and economies, especially in the global south. Moreover, we need more systematic, comparative and longitudinal studies.

13.10.2 Climate politics

- We need more knowledge about the full range of approaches that governments and non-governmental actors may take to overcome lock-in to carbon-intensive activities including through addressing material endowments, cultural values, institutional settings and behaviours.
- We need more research on all the various factors that influence emergence of popular movements for and against climate actions, and their impacts both in terms of direct GHG emission reduction but also for wider co-benefits.
- Research on the role of a wider group of civic organisations in climate mitigation, including religious actors, consumer groups and development aid organisations would be beneficial. Literature on the role of labour unions on climate politics is very limited and also needs further development.
- Understanding the impacts of media – traditional and social – on climate mitigation needs further research, as does the ways it can be used to accelerate climate mitigation.
- The role of corporate actors in climate governance requires research. While some research exists on energy intensive industries, but more research should focus on a broader range of corporate actors across countries.
- The wave of climate litigation is so recent that we do not know yet what role they may play in steering climate mitigation action. Systematic comparative research may enhance our understanding of the differing role of litigation across various juridical systems.

13.10.3 Climate policies

- The body of *ex post* empirical studies of climate change mitigation policy outcomes is still emerging. More research is needed on the effects of different policy instruments with different design features and in different combinations, under different national and local conditions of implementation, in particular in developing countries. Such research needs to assess the effectiveness, economic and distributional effects, co-benefits and side effects of mitigation policies.
- Further research is also needed on empirical experiences with transition of industries to zero-emissions models, and how policy design and the institutional context can facilitate greater stringency of policy settings to achieve the transformative potential of policies.
- Research is needed on possible policies and packages of policies to reduce emissions sources that currently are largely unregulated, including various non-CO_2 emissions and CO_2 emissions associated with production of industrial materials and chemical feedstocks. Research on policies to encourage carbon capture and use options other than forestry and CCS is also needed.
- As policies gain in stringency, empirical research will become more important on the existence and extent of carbon leakage across countries, and the relative impact of different channels of leakage. Further research will be useful on the effectiveness of existing and potential policy instruments that may address leakage or other international interactions of climate policy, including potential instruments such as border carbon adjustments and supply-side fossil fuel policies.

13.10.4 Coordination and acceleration of climate action

- As climate action accelerates, we will need more comparative case knowledge about how to ensure a just transition that gains wide popular support. In order to better grasp this, we need more knowledge about actual and perceived distributional effects in different contexts.
- More research is needed on the effects of increased coordination and integration for climate mitigation, and between what actors, sectors or governance levels integration and coordination is most important
- Studies on the political and policy related links between adaptation and mitigation is just emerging and would benefit from greater understanding of how adaptation and mitigation interact with development at all scales.
- Further theoretical and empirical research on the necessary institutional, cultural, social and political conditions to accelerate climate mitigation would also be welcome.
- A better understanding of how to transform economies and societies is necessary for acceleration, for both developed and developing countries. Similarly, research about social transformation, its importance and its role in acceleration is needed for both developed and developing countries.
- A greater understanding of the benefits of coordinated, cross economy structural change as a way to accelerate GHG reduction would be helpful. More understanding of how Green New Deal approaches and stimulus packages are developed and evaluation of them would be useful.

13.11 Frequently Asked Questions

FAQ 13.1 What policies and strategies can be applied to combat climate change?

Policy instruments to reduce greenhouses gas emissions include economic instruments, regulatory instruments and other approaches.

Economic policy instruments directly influence prices to achieve emission reductions through taxes, permit trading, offset systems, subsidies, and border tax adjustments. Taxes for carbon intensive products and services increase their cost and trigger improved efficiency or reduced consumption. Fuel taxes increase cost of fuel use, indirectly reducing greenhouse gas emissions. Subsidies for mitigation support low-carbon technologies by reducing their cost for consumers.

Regulatory instruments establish specific technology or performance requirements. Technology standards specify pollution abatement technologies, production methods or goods. Performance standards are more flexible; they set carbon intensity objectives not directly linked to specific technologies. Regulatory instruments may also target related parameters, such as energy efficiency, rather than emissions.

Other instruments include information programs, government provision of goods, services and infrastructure, divestment strategies, and voluntary agreements between governments and private firms.

These instruments may directly target GHG emission reduction, or may target other multiple objectives, such as urbanisation or energy security, with the effect of reducing emissions. Climate policy-making should account for both direct instruments and those aimed at multiple objectives. In practice, climate mitigation policy instruments operate in combination with other policy tools, requiring attention to the interaction effects between instruments. See also FAQ 13.2 and 13.3.

FAQ 13.2 What roles do different levels of government institutions play in climate mitigation, and how can they be effective?

Climate governance is constrained and enabled by countries' political systems, material endowments and culture, which leads to a variety of country specific approaches to climate mitigation.

National institutions set emission reduction targets, enable coordination between different actors and agencies, and strengthen accountability through improved transparency, monitoring mechanisms and stakeholder involvement. Countries have followed different approaches in developing institutions and governance for climate mitigation. Some focus on greenhouse gases emissions by adopting comprehensive climate laws and creating dedicated ministries and institutions focused on climate change. Others consider climate change among broader scope of policy objectives, such as poverty alleviation, economic development and co-benefits of climate actions, with the involvement of existing agencies and ministries.

Sub-national institutions, including at the urban scale, also play crucial roles in climate mitigation. They often lack national support, funding, and capacity. Despite this, subnational actors have created new entities or re-purposed existing offices to focus on climate change. An important issue for sub-national action is adequate coordination with climate action at other scales. Climate action at the sub-national level has a greater chance of being implemented when linked to existing local issues such as travel congestion alleviation, or air pollution control. See also FAQ 13.3.

FAQ 13.3 How can actions at the sub-national level contribute to climate mitigation?

Sub-national actors (e.g. individuals, organisations, jurisdictions and networks at regional, local and city levels) often have remit over areas salient to climate mitigation, such as land use planning, waste management, infrastructure, and community development. Despite constraints on legal authority and dependence on national policy priorities in many countries, subnational climate change policies exist in more than 120 countries.

Economic instruments for GHG mitigation are widespread with 32 carbon pricing initiatives (emission trading systems, carbon tax or both) in subnational jurisdictions as of 2020. Regulatory instruments at the sub-national level include land use and transportation planning, performance standards for buildings, utilities, transport electrification, and energy use by public utilities, buildings and fleets. Other policies include information and capacity building, such as carbon labelling aimed at providing information to consumers; mandatory building performance standards; disclosure and benchmarking policies to increase awareness and track progress; as well as government provision of public goods, services, and infrastructure.

The main drivers of climate actions at sub-national levels include high levels of citizen concern, jurisdictional authority and funding, institutional capacity, national level support and effective linkage to development objectives. Subnational governments often initiate and implement policy experiments that could be scaled to other levels of governance.

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