PART II. SECTOR-BASED DATA AND INDICATORS

CHAPTER 10

Sectoral Emissions and International Cooperation

Greenhouse gas emissions come from almost every aspect of society, spanning transportation, agriculture, space heating, and many other activities. The GHG Flow Diagram, introduced in Chapter 1 (Figure 1.3, p. 4) shows the extent of these activities, and the relative contributions from particular sectors, end-uses, and gases. Part II of this report discusses sector and end-use data in greater detail, and the possible implications for international climate regimes.

There are two reasons for examining GHG data from a sectoral perspective. First, the analysis helps illuminate which sectors—and which activities, fuels, and processes within sectors—are contributing most to the buildup of GHGs in the atmosphere. Understanding emissions in this manner can help policymakers and investors focus on the areas of critical importance. Shaping policy and investment priorities in light of the relative contributions of different sectors is likely to bring about a more effective and efficient response to climate change.

Second, sectoral considerations may play an important role in future international climate change agreements. The 1997 Kyoto Protocol covers only about 28 percent of worldwide GHGs, mainly those from Canada, Europe, Japan, and Russia. For the period beyond Kyoto's 2008–2012 timeframe, many Parties to the UNFCCC are seeking to engage a broader set of countries in worldwide GHG mitigation efforts. To do this, a range of sectoral initiatives or agreements may be helpful. Several sectoral models are outlined in Box 10.1, some of which are already being used in the context of the Kyoto Protocol. Future international climate agreements may likewise benefit from using a combination of these approaches in their treatment of sectors. Other forms of sectoral cooperation, structured either on a bilateral or plurilateral basis, might also characterize the post-Kyoto climate regime.

There are many possibilities for sector-based agreements or initiatives. Rather than explore these in depth, Part II of this report examines more broadly which sectors might be appropriate for or conducive to international cooperation, and why. Figure 10.1

Box 10.1. Forms of International Sectoral Cooperation

Sector-specific parameters could be built into the international climate regime in a variety of ways, including:

1. **Sector-Only Model.** Development of multiple sector agreements and initiatives that, when taken collectively, cover a significant share of total emissions. Agreements might be separate from one another, although linkages between them might also be created, for example, through offset and emissions trading mechanisms.
2. **Carve-Out Model.** Development of a comprehensive agreement, which would exclude particular sectors that would be the subject of separate consideration.
3. **Complementary Model.** Development of a comprehensive agreement, which would coexist with particular sector agreements that would separately apply, or be integrated within a comprehensive agreement.
4. **Product Model.** Similar to any of the above models, but the agreements or initiatives would be based on reducing the emissions associated with widely traded products, such as commodities or appliances.
5. **Sector-Baseline Model.** Development of a comprehensive agreement—but probably covering only emissions from developed countries—that would coexist with sectoral agreements pertaining to developing countries. Developing countries might be required to generate some amount of reductions (sectorally or nationally),[85] or an agreement might generate reductions through incentives such as a credit-trading system.[86]

The Kyoto Protocol uses several of the above models. The Protocol uses a *carve-out* approach for international bunkers (aviation and marine) and for gases covered under the Montreal Protocol on Substances that Deplete the Ozone Layer. A *complementary* approach is taken in the land-use change and forestry sector, where the Protocol and subsequent actions by the Parties specify which emissions and absorptions are included, and what additional accounting safeguards are required. Finally, the Kyoto Protocol includes the Clean Development Mechanism. The CDM, while not a sectoral mechanism, employs a baseline approach for generating emissions at the project level.

lists seven criteria used to evaluate the suitability of different sectors for sectoral cooperation; each is described below and explored within specific sector contexts in the remainder of Part II (Chapters 11-17). Whether a sectoral initiative or agreement is appropriate is likely to depend substantially on these criteria, but also some others not listed, such as competitiveness between rival firms and technological potential to achieve emissions reductions within a particular sector.

The seven criteria shown in Figure 10.1 are used to evaluate sectors and subsectors using a combination of available data, literature review, and solicited expert opinion. The evaluation involves analyzing GHG emissions, the nature of the emitting sources, the quality of emissions data, as well as production, trade, and other sectoral data. Precise proxies for the different criteria are not available in every case, and quantitative precision is not possible. Accordingly, a qualitative assessment is used to convey the inclination of each sector toward a sectoral approach for each of the criteria. This is done by applying one of three relative grades: "+" (positive), no score, or "–" (negative). A "+" grade is used in cases where available evidence strongly indicates appropriateness or conduciveness to a sectoral approach, consistent with the rationale for each criterion. A "–" grade is assigned in cases where the evidence suggests barriers to sectoral cooperation. No grade is assigned in cases where evidence is mixed, ambiguous, or the criterion is irrelevant. The remainder of this chapter explains the criteria in more depth and summarizes the sector-specific findings from Chapters 11-17.

GHG Emissions

The first criterion is the share of global GHG (or CO_2) emissions encompassed by a particular sector. This factor does not relate directly to whether a particular sector is conducive or otherwise appropriate for sectoral cooperation, but it does point to the issue of environmental significance and therefore the importance of sectors in terms of policy and priority. The largest sectors are, in order, electricity & heat, industry, land-use change and forestry, agriculture, buildings, and transport (Figure 10.2, p.57). Future growth is expected to be most rapid in electricity and transport (see Figure 11.2).

The share of emissions will of course depend on the definition and boundaries of a particular sector, and here there are virtually unlimited possibilities. For instance, a sector could be defined as (1) *transport* (encompassing all transport modes); or (2) as *road* transport, *air* transport, *international air* transport, or some combination of these. Sectors could include direct (on-site) emissions or also indirect emissions (e.g., from public electricity and heat consumption). In some cases, sectors might encompass a small number of emitting processes or end products (for example, cement manufacture); in other cases thousands of processes or products might be aggregated together (for example, chemical manufacture). Definitions adopted here are described in the endnote that begins each chapter in Part II; more detail is provided in Appendix 2. It also should be noted that some sectors examined in Part II are not mutually exclusive; electricity (and heat in particular) is treated both as a discrete sector and a component of other power-consuming activities. In addition, sectors examined in Part II do not cover 100 percent of global emissions.

International Exposure

Sectors that are greatly exposed to international competition may be more appropriately targeted for sectoral cooperation. One of the main rationales for advancing sectoral cooperation as a means to broaden participation in the climate regime is to address concerns pertaining to international competitiveness and leakage, whereby emission reductions in one location are offset by unintended increases elsewhere (Box 10.2). Certain forms of sectoral cooperation might promote a more level regulatory playing field within a given sector, thereby keeping governments from shielding that sector domestically, which they may be likely to do with economy-wide (such as Kyoto-style) targets.

These concerns, shared by many Parties, are particularly acute when international agreements, such as the Kyoto Protocol, do not include major emitting countries. International exposure is assessed here by evaluating international trade and investment flows (including those associated with multinational corporations), through which emissions may shift to countries that afford comparative advantages for production. Sectors with a high degree of trade and investment flows may indicate appropriateness for a sectoral approach.

Subsectors that are especially exposed to international competition are those that produce widely traded products or materials. Of the areas examined here, this includes motor vehicles, aircraft, steel, chemicals, and aluminum. These subsectors tend to be characterized by a significant amount of international trade as well as cross-border investment, and, in some cases, a strong presence of multinational corporations.

Concentration of Actors

Sectors with fewer actors are likely to be more conducive to international sectoral initiatives. Cooperation tends to be easier if the relevant actors are fewer, and can be readily identified and brought to the table in a coordinated manner. This criterion is evaluated by assessing the number of companies or firms responsible for the majority of economic activity within each sector, including multinational corporations. The concentration of emissions across *countries* is also a relevant consideration for this criterion. Almost half of global cement emissions, for example, come from a single country, China. High concentration, or relatively small numbers, of significant firms or countries may suggest that a sector is conducive to a sectoral approach. Conversely, low concentration or disperse activity may suggest barriers to sectoral approaches.

Figure 10.1. Criteria for Evaluating Sectors

Criterion	Evaluation Indicator(s)	Grading (+ / –)
GHG Emissions	Share of global total; trends	
International Exposure	▪ Scale of trade flows ▪ Scale of international investment ▪ Role of multinational corporations	High international exposure may suggest appropriateness (+) for a sectoral approach.
Concentration of Actors	Number of emitting sources (companies, countries) or product producers	High concentration may suggest conduciveness (+) to sectoral approach; low concentration may suggest a barrier (–)
Uniformity of Products/Processes	Number of distinct products, processes, and end products	High uniformity may suggest conduciveness (+) to sectoral approach; low uniformity may suggest a barrier (–)
Government Role	Regulations, subsidies, and other requirements	Existing regulations may suggest receptivity (+) to sectoral cooperation; Government protections may be evidence of constituencies that would be a barrier (–) to sectoral approach
GHG Measurement Issues	Measurement errors; degree of uncertainty.	Measurement challenges suggest appropriateness (+) of sectoral approach
GHG Attribution Issues	Trade in energy-intensive raw materials; diffuse production/consumption patterns.	Attribution difficulty may suggest appropriateness (+) of sectoral approach

Note: No grade is assigned in cases where evidence is ambiguous or the criterion is not relevant.

With respect to this criterion, actors tend to be concentrated in industry subsectors such as steel, cement, and aluminum. Producers of motor vehicles and aircraft are also relatively few, although the use of these products (where most emissions occur) is widely dispersed. Key actors in other sectors (and subsectors)—like electricity, chemicals, buildings, agriculture, and waste—tend to be dispersed, either across countries, firms, or domestic jurisdictions (for example, state and local actors).

Uniformity of Products/Processes

Sectors may produce diverse or uniform products, or may employ diverse or similar production processes. Sectors characterized by uniformity may be more conducive to sectoral initiatives, since abatement techniques or efficiency improvements are more easily transferred between like products and processes. Sectors producing uniform products may likewise be conducive to internationally harmonized policy approaches such as efficiency standards, technology standards, or performance benchmarks. This criterion is assessed by examining the number of distinct products, processes, and end products that exist within a sector or subsector. High uniformity of products and processes may indicate opportunities for sectoral approaches; on the other hand, low uniformity may signal a barrier to sectoral approaches.

Box 10.2. Leakage and International Competitiveness

Many countries—including those already covered by the Kyoto Protocol's emission controls—are concerned about jobs and loss of economic output caused by restricting GHG emissions. In particular, the concern is that agreements that do not cover all major emitters may lead to cross-border "leakage," whereby industries shift their production to countries that do not have emission limits. This phenomenon could be exacerbated by the increased incidence of cross-border investment and trade (Chapter 9).

In its review of this issue in the context of the Kyoto Protocol, the IPCC concluded that "relocation of some carbon-intensive industries to non-Annex I countries and wider impacts on trade flows in response to changing prices may lead to leakage in the order of 5–20 percent."[87] In other words, the worst case (20 percent leakage) suggests that a 5 percent reduction in GHG output in the industrialized world leads to a 1 percent increase in the developing world. This would be significant, although not highly damaging environmentally. Potential leakage can also be further minimized, according to the IPCC, through international emissions trading and internationally coordinated actions at the sector level.[88]

In some specific sectors, such as energy-intensive industries, leakage may be higher than the IPCC suggests. In other instances, leakage may be positive; that is, cleaner technology development in some countries might generate "spillover benefits," as those technologies are disseminated to other countries not covered by emission controls.[89] Overall, the extent of likely emissions leakage and loss of competitiveness is disputed, and models produce inconsistent results. Many factors shape competitiveness and foreign direct investment decisions, including labor costs and skills, market size, political stability, income levels, physical infrastructure, and a wide range of government policies (for example, tax, financial, and investment policies) are typically the main considerations. Energy prices or future climate change policy will also be a factor, although probably more so where there are significant restrictions on CO_2 emissions within energy-intensive sectors, such as steel or chemicals, where products are readily traded across borders.

Certain industry subsectors, such as chemicals, machinery, and food, include a huge range of products. Similarly, the drivers and sources of emissions in the buildings, agriculture, and land-use sectors are diverse and scattered. On the other hand, many emissions are associated with relatively uniform products, processes, and technologies, including cement, unwrought metals (for example, steel and aluminum), motor vehicles, aircraft, gas flaring, and waste processing.

Government Role

Governments often intervene in, privilege, or shelter different sectors to advance or protect particular interests or those of the public at large. This criterion is evaluated by examining the nature and extent of government interventions in particular sectors. Public ownership of industries, regulation, subsidies, and trade protections are examples of such interventions. Whether the government role is conducive (+) or a barrier (–) to sectoral agreements usually depends on the type of intervention within particular sectors. National governments are more likely to have vested political and economic interests in sectors in which they have intervened through public ownership, subsidies, or trade protections, and thus may be less likely to cede control to multinational agreements. Accordingly, sectors in which governments are significant stakeholders may not be good candidates for sectoral agreements, and may be more disposed to frameworks that preserve greater national autonomy. Such sectors might include electricity, forestry, agriculture, and waste. Provision of public services or protection of vested interests is commonplace in these areas.

Conversely, particular patterns of government regulation within countries could provide a model for multinational cooperation, so long as those regulations have not created entrenched constituencies. For instance, government-established efficiency standards in motor vehicles, appliances, and buildings may be comparable across international lines, and thus might form the basis of international harmonization in these areas. It may also be the case that agreements in sectors lacking significant government involvement or active constituencies are less likely to meet with political resistance or efforts to protect autonomy.

GHG Measurement Issues

Certain sectors and activities present significant challenges concerning the measurement and understanding of emissions. For example, emissions from the land-use change and forestry (LUCF) sector have proven difficult in this regard. Imprecise emissions measurements are problematic for policy instruments such as emissions trading systems that are predicated on detailed and accurate GHG inventories. As such, uncertainties in certain sectors may undermine the effectiveness of certain policy tools within comprehensive agreements, and therefore signal the appropriateness of more tailored sectoral approaches. In addition to the LUCF sector, challenges associated with GHG measurement are prevalent in agriculture, waste, and aviation.[90]

GHG Attribution Issues

Even where measurement is relatively certain, some sectors and activities present unique challenges concerning the attribution of emissions to particular countries or other actors. This issue tends to arise where emissions occur in international territory (for example, aviation and seaborne shipping) or where there is a high degree of international trade in emissions-intensive products (as discussed in Chapter 9). For countries with transit hubs or energy-intensive

exports, the prevailing national GHG accounting systems may yield unfavorable results and therefore pose political challenges. Chemicals, steel, and aluminum are sectors that may warrant special sectoral treatment to address inequities in this regard. As noted in Box 10.1, a sectoral approach has already been initiated for emissions from international bunker fuels, which are not covered under the Kyoto Protocol.

Sectoral Summary and Implications for International Cooperation

By making assessments across a range of sectors and criteria, this report begins to identify the sectors that are relatively conducive to international cooperation—and those that are not. Figure 10.2 summarizes the results of the analysis for the sectors treated in Chapters 11-17. Areas that score particularly well overall include subsectors of transport and some industry subsectors. By contrast, electricity and heat and agriculture scored relatively poorly across the range of factors considered. Other sectors had mixed results.

It is important to note, however, that favorable scores do not necessarily indicate that sectoral agreements are feasible, desirable, or likely. A wide range of subjective factors not examined here are likely to play an important role in determining whether governments or companies address climate change along transnational sectoral lines. Furthermore, one criteria among those examined may play a dominant role, offsetting the conduciveness of other criteria.

For transport (Chapter 12), both motor vehicles (9.9 percent of global GHGs) and aircraft (1.6 percent) are characterized by a small number of actors (manufacturers), a high degree of international exposure, and relatively few differentiated products. International air travel has the added issue of difficulty in attributing emissions. These factors suggest cooperative ventures in either or both subsectors may be potentially fruitful; indeed, it is already clear that international air travel calls for special sectoral consideration. International cooperation in these areas could focus, for example, on establishing carbon efficiency or energy efficiency standards.

For the industry subsectors examined (Chapter 13), steel (3.2 percent of global GHGs), cement (3.8 percent), and aluminum (0.8 percent) have relatively high concentrations of actors and international exposure (though less so for cement), and relatively narrow product/process mixes. These factors, along with some trade-related attribution challenges, suggest areas where international cooperation may be helpful. Overall, aluminum and steel scored the highest, followed by cement. There is a range of possibilities with respect to the form of cooperation, such as common efficiency benchmarks or CO_2-intensity reductions. By contrast, chemicals scored poorly, owing largely to the huge diversity of actors and processes, which would be difficult to coordinate for a common purpose or to align within a single technology standard, efficiency standard, or other policy approach.

For land-use change and forestry (Chapter 17), the central challenge relates to GHG accounting. Emissions and absorptions are hard to measure and subject to large uncertainties. Emission absorptions that are claimed from particular policies or measures are reversible (for example, through subsequent land clearing). For these reasons, integrating this sector into a more comprehensive agreement, such as the Kyoto Protocol, has proven challenging. Due to quantification difficulties, a policy-based (qualitative) approach to mitigation might be more effective than quantitative approaches, such as emission targets and trading systems. Likewise, because emissions are concentrated in a relatively narrow band of tropical countries, geographically tailored initiatives might more effectively address CO_2 mitigation in this sector.

Figure 10.2. Summary of Sector Analysis

Sector	Share of Global GHG Emissions	International Exposure	Concentration of Actors	Uniformity of Products/Processes	Government Role	GHG Measurement Issues	GHG Attribution Issues
Electricity & Heat	24.6%		–	+	–		
Transport	13.5%						
Motor Vehicles	*9.9%*	+	+	+	+		
Aviation	*1.6%*	+	+	+		+	+
Industry	21.1%						
Chemicals	*4.8%*	+	–	–			+
Cement	*3.8%*		+	+			
Steel	*3.2%*	+	+	+			+
Aluminum	*0.8%*	+	+	+			+
Buildings	15.4%		–	–	+		
Agriculture	14.9%		–	–	–	+	
Land-Use Change & Forestry	18.2%			–	–	+	
Waste	3.6%		–	+	–	+	

Notes: Sectors shown do not comprise 100 percent of global emissions, nor are all sectors mutually exclusive. See Appendix 2. A "+" grade suggests high appropriateness or conduciveness for international sectoral cooperation. A "–" grade suggests a barrier to international sectoral cooperation. No grade means evidence is mixed, ambiguous, or not relevant.

For other sectors such as electricity and heat (Chapter 11), buildings (Chapter 14), agriculture (Chapter 15), waste (Chapter 16), and a range of industry subsectors, the conditions seem less appropriate or amenable to international sectoral cooperation. The reasons, however, differ across sectors, ranging from the lack of international exposure (electricity), diverse product/process mixes (industry, agriculture), and heavy governmental interventions or vested domestic interests (electricity, agriculture, waste).

The results here help illuminate both the perceived successful and unsuccessful aspects of the Kyoto Protocol.

Aggregating the most attractive sectors—such as steel, cement, aluminum, motor vehicles, and aircraft—suggests a coverage of about 20 percent of world emissions. Adding LUCF could increase this to closer to 35 or 40 percent. It may be possible to increase this share by redefining sectors or identifying traded products for which the conditions of cooperation are more promising. For example, focusing attention on fertilizer production and use would cut across both industry (chemicals) and agriculture (soils) sectors. Similarly, it could be possible to identify a range of specific products—such as home appliances—that could be the subject of agreements (for example, energy efficiency standards), much as motor vehicles or aircraft might. Such initiatives would impact residential emissions indirectly through reduced electricity consumption.

Overall, however, the findings suggest that a "sector-by-sector" approach to international cooperation on climate change is unlikely to be adequate or feasible. Rather, comprehensive agreements (covering most sectors and gases), with special provisions or supplementary agreements for specific sectors offer greater promise. The results here also help illuminate both the perceived successful and unsuccessful aspects of the Kyoto Protocol. One of the characteristics of the Protocol that fostered consensus was that it did *not* adopt a sectoral approach that intruded upon sensitive domestic policy terrain. Rather, national emission targets were agreed upon, with governments free to achieve their targets in any way they deemed appropriate, including using regulatory approaches crafted to their own national circumstances.

On the other hand, the Kyoto Protocol has not been able to easily accommodate certain sectors. As noted, emissions from international bunker fuels are carved out of the Protocol. Most emissions from land-use change and forestry (Chapter 17) are included, but due to the enormous accounting and technical challenges associated with this sector, rulemaking has been fraught with complexity and controversy. The LUCF findings here suggest that international cooperation in this sector is especially challenging, regardless of whether it is treated in a comprehensive agreement or a special sectoral agreement.

The Kyoto Protocol likewise has not secured the participation of the United States, Australia, and developing countries within its GHG mitigation provisions. One reason is that some key sectors in these countries are heavily exposed to international cooperation, thus creating a perception that participation will result in loss of jobs and economic output. As illustrated here, there is a relatively narrow band of sectors where this issue arises (covering a minority of emissions). Nevertheless, advancing international cooperation on climate change may benefit from tailoring sectoral approaches in particularly sensitive areas. The sector-specific analysis in the remaining chapters provides additional perspective.