Principles for embedded emissions accounting to support trade-related climate policy

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Abstract
Climate policy - though shaped by international regimes - has traditionally been heavily domestic in focus. Accordingly, public emissions accounting systems have been designed to support policies targeting emitting processes within the territory, and to facilitate the production of National Accounts. Now, a combination of emissions leakage, competitiveness, and both investor and consumer concerns are driving the rapid emergence of policies targeting emissions embodied in traded products. To support these product-targeted policies, governments are investing in the development of public embedded emissions accounting systems. While these systems have enormous potential to support the transition to a net-zero global economy, they equally have the potential to inhibit trade, slow the transition, and have a disproportionate impact on developing countries - both through their design, and through potential incompatibilities between accounting developed in different jurisdictions. It is imperative that these emerging systems are designed in accordance with principles consistent with both their environmental and economic implications. To identify these design principles, the current article examines the disparate literatures of carbon accounting and international trade law. We systematically review these two bodies of literature, extracting principles identified in prior publications. Noting the prominent place of principles in guidelines for carbon accounting practice, we additionally extract principles identified in a selection of existing emissions accounting guidelines. Systematic, interdisciplinary, analysis of these three bodies of knowledge from carbon accounting literature, carbon accounting practice, and trade law literature allows us to synthesize a set of key common goal principles for the design of public embedded emissions accounting schemes for traded products that captures both economic and environmental implications. These principles are Accuracy, Conservativeness, Monotonicity, Non-discrimination, Least restrictive means, Relevance, Subsidiarity, and Transparency. We also discuss distributional

principles such as Common but Differentiated Responsibilities, but note they remain subject to intense policy and academic debate.

Key policy insights

1. Public embedded emissions accounting will need to balance goals of climate change mitigation and free trade, and should thus incorporate principles underpinning both trade law and carbon accounting.
2. Our review of the literature in these two areas suggests that common goal principles from both realms can be incorporated without inherent conflict.
3. Distributional principles will also need to underpin development of these systems. These principles have been the subject of intense and ongoing debate in both trade and climate regimes, and the need to find a compromise between the two regimes has only intensified these discussions in international fora.
4. Practice has moved in advance of theory regarding principle development, with carbon accounting practice often having clearer overarching principles than the corresponding literature.

Keywords: embedded emissions; trade related climate policy; embedded emissions accounting; carbon accounting; regime; principles; trade law.

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Between 3 and 8 **keywords**: embedded emissions, trade related climate policy, embedded emissions accounting, carbon accounting, regime, principles, trade law

1 Introduction

In recent years, numerous nations have begun developing trade-related climate policy instruments, a category of policy nominally addressing a climate objective which has trade (and trade policy) implications (Aisbett, 2023). These policies, such as border carbon adjustments and green procurement policies, pursue two interrelated goals. First, they attempt to alleviate the competitiveness concerns caused by unilateral climate action that could grant an economic advantage to foreign producers. Second, these policies introduce economic incentives for trading partners to make a transition to less emissions-intensive production practices. A prominent example of such a scheme is the European Union's Carbon Border Adjustment Mechanism (Commission, 2021). There is a growing international effort to identify principles to underpin these policies, including a working group by the World Trade Organisation's Forum on Trade, Environment, and Sustainable Development Goals to develop principles for design and implementation of trade-related climate policy measures.

The implementation of effective trade-law and climate-law compatible trade-related climate policy will not be possible without simultaneous development by governments of embedded[1] emissions accounting frameworks. While private product accounting frameworks such as ISO standards and the GHG Protocol exist, they are not fit for purpose of underpinning public regulation (Reeve and Aisbett, 2022). International regimes for climate change mitigation, such as the Kyoto Protocol and the Paris Agreement, have endowed most national governments with existing public accounting systems based on Intergovernmental Panel on Climate Change (IPCC) Guidelines. While these existing public accounting systems are not currently fit for embedded emissions accounting at the product level, they represent existing capacity in development and application of emissions accounting, and are a strong candidate for forming the basis of future public embedded emissions accounting systems (Reeve and Aisbett, 2022).

The emergence of trade-related climate policy represents an expansion of the climate change governance regime. International regimes are "principles, norms, rules, and decision-making procedures around which actor expectations converge in a given issue-area" (Krasner, 1982). Principles are particularly important regime components when states negotiate new international regimes or governance arrangements (Braithwaite, 2002; Gunningham and Sinclair, 1999), or when regulating complex phenomena (Braithwaite, 2002). Being new, highly technical, sitting at the intersection of climate and trade regimes, and needing to continually respond to new scientific understandings, embedded emissions accounting systems are in need of a defensible set of principles. Principles for public embedded emissions accounting are not expected to be synonymous with principles for trade-related climate policy more broadly. Public embedded emissions accounting represents a specific instrument, in the form of an information system, that will be used to underpin other policies.

Embedded emissions accounting systems for traded products sit at the intersection of climate governance and trade law regimes. Accordingly, design principles for these systems should ideally be consistent with both regimes. Concerns have been raised in past years regarding the potential for conflict between trade and climate regimes (e.g., Brewer (2003)), hence we approach this review with the intent to identify principles across the two realms and to consider potential for conflict. There is also a risk that public embedded emissions accounting systems developed in different countries will not initially be compatible with each other. A common set of principles could serve as critical point of reference when disputes inevitably arise about design of systems that will necessarily advantage some

[1] The term embedded emissions is used here as synonymous with embodied emissions, as in IPCC AR6 Annex I: "Embodied (embedded) [emissions, water, land]: The total emissions [water use, land use] generated [used] in the production of goods and services regardless of the location and timing of those emissions [water use, land use] in the production process." IPCC, 2022: Annex I: Glossary (van Diemen et al., 2022)

nations and disadvantage others, and deliberate alignment with a common set of principles could minimise risk of divergent accounting systems arising in ways that inhibit trade.

The current work identifies a core set of common goal principles for public embedded emissions accounting systems, starting with a systematic review of the literature on principles for carbon accounting and principles for trade law. This includes principles applicable to emerging technologies, such as negative emissions technologies, that could gain increasing importance (Brander et al., 2021). We additionally extract the principles stated to guide several prominent embedded emissions accounting documents in practice, namely IPCC, ISO, and the GHG Protocol. A final list of eight common goal principles is then synthesised from all reviewed bodies of work, following several steps of analysis and consolidation. We emphasise the continued contention around distributional principles, and the importance of ongoing efforts for compromise in this space.

This work contributes in a theoretical sense to our understanding of interactions between the newly converging areas of carbon accounting and trade law, and in an applied sense to our understanding of key principles for public embedded emissions accounting systems. In consolidating principles relevant to public embedded emissions accounting systems, we draw on established theories of regimes and their governance (Braithwaite, 2002; Krasner, 1982), of principles for governance design (Braithwaite, 2002; Gunningham and Sinclair, 1999), and rationalist theories of international relations (Fearon, 1998).

2 Methods: systematic review and targeted review

To determine principles relevant to embedded emissions accounting frameworks for trade, we combine a systematic review of the academic literatures of trade law and carbon accounting (section 2.1) with a targeted review of several guidelines from practice closely associated with embedded emissions accounting for products (section 2.2).

2.1 Systematic review of academic literature

A systematic literature review follows an explicit protocol to identify papers (Bourcet, 2020), and provides a high level of comprehensiveness, replicability and protection from bias, as compared to narrative literature reviews (Pickering et al., 2015). We adapt the three-step systematic review process following the first three of the four steps used in Stechemesser and Guenther (2012), which was itself derived from Fink (2010). The following sections describe our three steps of identification: search terms and source, exclusion criteria, and review methodology.

2.1.1 Step 1: Research Questions, bibliographic article database, and appropriate search terms

We sought to compile the principles relevant to embedded emissions accounting for traded goods from academic literature in the areas of 1) carbon accounting and 2) trade law. Our research questions for systematic research were thus "What are the design principles of carbon accounting?" and "What are the design principles of trade law?". For the carbon accounting search[2], we used the term ("emission* accounting" OR "carbon * accounting") AND ("principle*"). This search was designed to include common variants that would otherwise have been missed (e.g. "carbon dioxide accounting...principles"). On the same grounds, our trade law search was ("trade law*" OR "trade agreement*") AND ("principle*"), to capture commonly synonymous terminology. These search terms were applied only to the title, abstract and/or keywords of the literature, in order to maximise the relevance of our search space. The publication database SCOPUS, which has indexed over 7,000

[2] A search for the terms ("embodied emissions accounting" OR "embedded emissions accounting") AND ("principle*") returned 0 results.

publishers (Elsevier, 2023), was used to identify relevant articles. Scope was not limited based on date of publication.

2.1.2 Step 2: Review criteria for inclusion or exclusion of relevant literature

Our systematic literature review is limited to academic outputs in English (Review, Letter, Editorial, Conference Paper, Book Chapter, Book, Article, as defined in SCOPUS). Both empirical and theoretical/conceptual publications are included, but we exclude conference proceedings, book reviews, presentations, and comments. Furthermore, we exclude any articles with fewer than 10 citations recorded in SCOPUS as of 22/11/2022. This exclusion criterion is implemented to limit our search to principles articulated in articles with some consideration and acceptance in the academic community.

Once these objective criteria limit the search space, we apply a subjective relevance criterion. Due to our focus on literature that is primarily about principles underpinning carbon accounting frameworks and trade law, abstract review is used to determine whether these categories are of primary importance, and articles are excluded if they do not meet this criterion. In the emissions accounting literature, common exclusions are papers that exclusively applied accounting processes without considering optimal design of such processes (e.g. Guo et al., 2012). This category is distinguished from Wang et al. (2018), for example, which applied accounting processes empirically but used this to inform a conceptual argument. The most common trade law exclusions are publications concerned with the relationship between trade agreements and a particular a social/political/legal issue unrelated to climate policy (e.g. food sovereignty – (Grey and Patel, 2015)). We additionally exclud two articles that dealt with definitions of ideology (Trakman, 2008) and binary criteria (Kennedy and Sgouridis, 2011), not principles.

2.1.3 Step 3: Methodological review criteria

We next review the included articles following the protocol detailed in Table 1, collecting details for bibliographic data and content data. Bibliographic data is directly extracted from each publication's listing in SCOPUS. We review the full text of each article to determine the principles identified by authors. For this, we search for the following keywords within each article: principles, basis, concept, must, should, ideal, condition, need, aim, goal. Upon identification of a keyword in the document, review of the surrounding sentences determines if the authors identify any principles of emissions accounting or trade law. The precise language used in each article is collected in a spreadsheet. The full set of articles and their identified principles are listed in Appendix Table A1. We also record definitions of principles, which are typically adjacent to the principle or flagged by terms such as "defined as" or "references" (see Appendix B).

Table 1. Review protocol

Item	**Description**	Example
Precise search term	What was the specific SCOPUS search term used to identify the publication in question?	TITLE-ABS-KEY(("emission* accounting" OR "carbon * accounting") AND ("principle*"))
Bibliographic data		
Author(s)	Who is/are the author(s) of the publication?	Kander A., Jiborn M., Moran D.D., Wiedmann T.O.
Year of publication	In which year was the work published?	2015
DOI Or, if no DOI, then ISSN/ISBN	What is the publication's DOI or ISSN/ISBN?	10.1038/nclimate2555

Publication type	What type of publication is it? (Review, Letter, Editorial, Conference Paper, Book Chapter, Book, or Article, as defined in SCOPUS)	Article
Journal name or equivalent	What is the name of the journal or equivalent?	Nature Climate Change
Citation count	How many citations does the publication have in SCOPUS as of 22/11/2022?	165
First author primary country	What is the country of the primary affiliation of the first author as defined by SCOPUS?	Sweden
Journal discipline	What discipline(s) is/are covered by the journal according to SCOPUS discipline?	Social Sciences: Social Sciences (miscellaneous); Environmental Science: Environmental Science (miscellaneous)
Methodology	What is the main contribution? (Theoretical/conceptual; empirical)	Theoretical/conceptual
Content Data – Emissions Accounting		
Principles of emissions accounting	What principles are identified explicitly in the publication? Precise terms that appear adjacent to principles, basis, concept, must, should, ideal, condition, need, aim, or goal	Sensitivity Monotonicity Additivity
Definitions of emissions accounting principles	How does the publication define its principles? Definitions were typically adjacent to the principle's appearance, though we cross-checked with search terms such as "defined as" or "references" to capture separately placed definitions.	First, it should be responsive to factors that nations can influence, for example the level and composition of their consumption, and their domestic carbon efficiency (sensitivity). Second, countries should not be able to reduce their national carbon footprints in ways that contribute to increased global carbon emissions (monotonicity). Third, the sum of national emissions for all countries should equal total global emissions (additivity).
Content Data – Trade Law/Agreements		

Principles of trade law/agreements	What principles are identified explicitly in the publication? Precise terms that appear adjacent to principles, basis, concept, must, should, ideal, condition, need, aim, or goal	Most-Favoured-Nation Special and Differential Treatment
Definitions of trade law/agreement principles	How does the publication define its principles? Definitions were typically adjacent to the principle's appearance, though we cross-checked with search terms such as "defined as" or "references" to capture separately placed definitions.	[Most-Favoured-Nation] the non-discrimination requirement under the Article 1 GATT setting forth the MFN principle; [Special and Differential Treatment] preferential considerations (SDT) for developing countries to meet their development interests

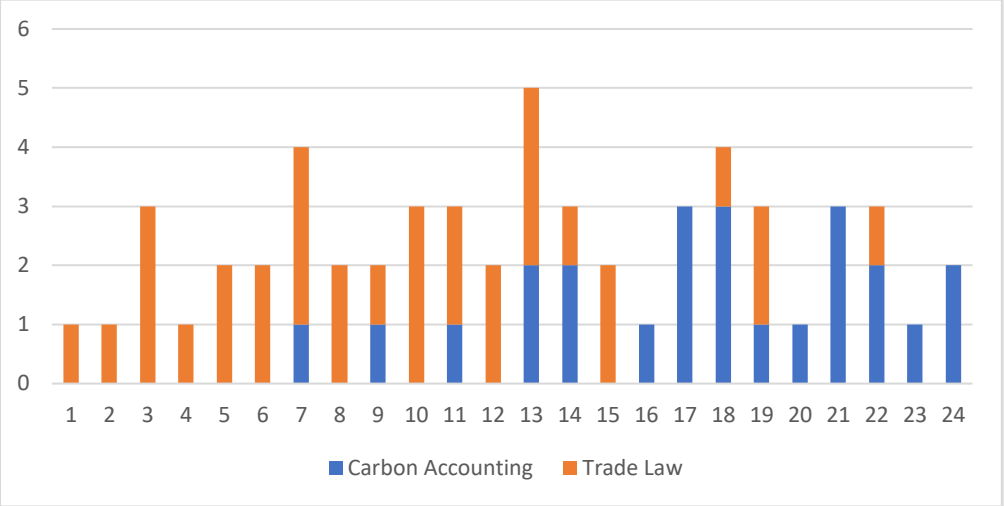
2.1.4 Summary of article characteristics

The complete list of articles reviewed and the principles extracted from each article appears in Appendix Table A1. We extract 81 unique terms meeting the review criteria to be recorded as a principle in the first instance. Lead authors of carbon accounting literature identified in the review are somewhat clustered in Europe, while the majority of trade law articles are led by authors based in North America (Figure 1). Articles reviewed are classified as covering a range of disciplines, but largely followed expected patterns, with trade law articles commonly classified as economics or social sciences, while carbon accounting articles are commonly classified as environmental science (Appendix Table A2). The majority of articles reviewed are conceptual/theoretical, not empirical (Appendix Table A3). Trade law articles tend to be older (2010 or earlier) while the majority of carbon accounting articles are more recent (2010 or later); Figure 2 shows these trends over time.

Figure 1: Regions of lead authors, by literature group

FIGURE 1 HERE

Figure 2: Publication year of articles captured in review, by literature group



2.2 Reviewing emissions accounting frameworks in practice to identify their principles

We additionally review the principles articulated in several documents from emissions accounting practice, with focus on well-established organisations and documentation that is widely recognised in the field of emissions accounting. Specifically, we consider the frameworks of the Intergovernmental Panel on Climate Change (IPCC), the International Organization for Standardization (ISO), and the Greenhouse Gas Protocol (GHG Protocol). The IPCC's relevant contribution came in the 2006 IPCC Guidelines for National Greenhouse Gas Inventories. While a refinement was published in 2019, the 2006 principles remain unchanged. The ISO has published numerous standards adjacent to the subject of emissions accounting for trade. We include those of direct relevance, specifically:

- ISO 14064-1:2018: Greenhouse gases — Part 1: Specification with guidance at the organization level for quantification and reporting of greenhouse gas emissions and removals.
- ISO 14064-2:2019: Greenhouse gases — Part 2: Specification with guidance at the project level for quantification, monitoring and reporting of greenhouse gas emission reductions or removal enhancements.
- ISO 14067:2018: Greenhouse gases — carbon footprint of products — Requirements and guidelines for quantification.

Since releasing its original Corporate Standard in 2001, the GHG Protocol has released 6 other Standards covering various topics in greenhouse gas measurement and management. We incorporate the most relevant seven of these standards into our analysis, reviewing documents as viewed on the GHG Protocol website in 2022. Standards reviewed are:

- The Corporate Standard
- The Product Standard
- The Cities Standard
- The Mitigation Goal Standard
- The Corporate Value Chain Standard
- The Project Standard (PS)
- The Policy and Action Standard (PAS)

The first five of these are fully consistent on included principles and definitions. The latter two (PS and PAS) each introduce one new term, Conservativeness and Comparability respectively.

Eight principles from practice emerge, and we identify five terms used in practice documents that are better categorised as rules (all described in Appendix C).

3 Methods: Theory-based Identification and Analysis

3.1 Synthesis of principles in academic literature

Our synthesis of principles in academic literature involved three core steps, which are summarised in Figure 3.

Figure 3: Categorising of principles identified in literature review
FIGURE 3 HERE

Step 1: Our review of emissions accounting and trade law literature gave an initial shortlist of 81 unique terms. Our first step in processing our raw data was to identify which of the 81 terms were indeed principles, and which were better characterised as rules. We follow Braithwaite's definition of principles as unspecific prescriptions and rules as specific prescriptions (Braithwaite, 2002). Principles are a defining characteristic of a regime, and even if rules and procedures are changed, the regime will remain consistent if the principles remain the same (Krasner, 1982). Appendix B describes our full list of principles, grouped by the sub-categories introduced in steps 2 and 3. Examples of rules included recommended methodologies for specific situations, and these rules are described in Appendix Table B3. The one exception to the mutually exclusive separation between principles and rules was when a rule was clearly and unambiguously (though potentially implicitly) designed to support a particular principle (or principles). If (any of) these implicit principles were not already identified in their own right, they were added to the appropriate table in Appendix B.

Of our initial list of 81 terms, 42 of these constitute rules rather than principles (Appendix Table B3). Given that rules are often interrelated with principles, in Appendix Table B3 we additionally identify which principles are most closely associated with each rule collected in literature review. We also identify three terms in trade law literature that were best characterised as ideologies rather than principles or rules; these are excluded (see Appendix Table B4). Following these identifications, we retain 36 unique principles (see Appendix Tables B1 and B2).

Step 2: Our objective is to synthesize and distil a long list of principles into a shorter and more useful one for designers of public embedded emissions accounting systems. This requires an understanding of the relationships between the terms in order to eliminate duplication and identify potentially nested or conflicting concepts. We begin by categorising principles according to the role that they play in the trade and climate regimes.

Both trade and climate governance regimes have at their heart the concept of collective action towards a common goal of mutual benefit, and as such must address two key questions: how to support achievement of the common goal; and how to distribute costs and benefits of the cooperation among participating states. In the rationalist, game-theoretic approach to international cooperation, these elements are the essence of the bargaining problem (Fearon, 1998). There are, of course, many other functions that regimes based on voluntary participation must fulfil, including enforcement. Interestingly, however, the principles we identified in our review could all be attributed to the common goal and distribution functions. The second step in our analysis, therefore, is to identify principles according to whether they are common-goal or distributional principles (see Appendix tables B1 and B2). Common-goal principles (Appendix Table B1) are those aimed at supporting the achievement of a common international goal. Distributional principles (Appendix Table B2) are those used for allocation of responsibility, costs, or benefits of actions with international consequences. The

second columns of Tables B1 and B2 provide the definition or context in which the term is used in a representative publication from our systematic review.

Step 3: Having identified both common goal and distributional principles, our third step is to identify and describe sub-categories within the common goal principles. These categories are not mutually exclusive, i.e., some principles from the literature address more than one goal. The third column of Table B1 records our allocation(s). The common goals (explicit or implicit) in both carbon accounting and trade law literatures are: "mitigation of climate change" and "free trade", with the former (latter) common goal more prevalent in the carbon accounting (trade law) literature. Mitigation of climate change requires meaningful reduction of emissions, while free trade can be understood to exist when government regulation is non-discriminatory and regulatory burden on trade is minimised (Driesen, 2000).

3.2 Consolidation of principles from literature and practice

In order to consolidate our "long list" of 36 principles from theory in Appendix B and the 8 principles from practice in Appendix C, three further steps are undertaken.

Step 4: For the list of 36 principles from academic literature identified in Appendix B, we replace definitions of principles found in the original source with their analogue for the context of public embedded emissions accounting systems to support trade-related climate policy. Appendix D presents the updated definitions with relevance for public embedded emissions accounting.

Step 5: Using the context-adapted definitions from step 4, we note emergent relationships between the different principles from carbon accounting literature, trade law literature, and trade law practice. For example, we note if principles are subsumed or contradicted by other principles in the list. Additionally, further principles that are not ultimately relevant in our context are identified. Step 5 is detailed in both Appendix D and in section 4.2.

Step 6: Having mapped relationships and overlaps between principles, we identify a minimum set of common goal principles that encompasses all the relevant common goal principles. This minimum set are marked with * in Appendix D. The final list of eight principles is presented in Table 4. We discuss distributional principles and the challenges of condensing these section 4.2.2.

4 Results and Discussion

4.1 Principles by sub-category and relationship mapping

4.1.1 Grouping principles from literature

Table 2 reports the 36 principles identified across carbon accounting and trade law literatures, grouped according to whether their primary role is achievement of the common goal in the relevant regime or to support distribution of costs and benefits, and then sub-grouped according to whether the common goals principles are related to free trade or climate change. Appendix B provides full definitions for each term that are as close as possible to the explicit or implicit definition in the original sources.

Table 2: Principles identified in literature, sub-divided into common goals (climate or trade related) and distributional principles; some principles fall into more than one category

		Carbon Accounting Literature	Trade Law Literature
Common goal principles	Climate change mitigation	- Accuracy - Additionality - Additivity - Completeness - Conservative - Consistency - Monotonicity - Robustness - Sensitivity	- Innovation and adaptive management - Precautionary principle - Transparency
	Free trade	- Consistency - Non-discrimination	- Accession - Comprehensiveness - Cooperation - Least restrictive means - Non-discrimination - Proportionality - Standstill - Subsidiarity - Transparency
Distributional principles		- Capability - Common but differentiated responsibilities - Consumer responsibility - Equity - Non-differentiated producer responsibility - Producer responsibility - Shared responsibility	- Common but differentiated responsibilities - Common Concern of Mankind - Comparability - Developmental Principles - Empowerment - Flexibility - Non-reciprocity - Polluter-pays - Reciprocity - Special and Differential Treatment

4.1.2 Describing principles from practice

We review eleven practice documents from the IPCC (x1), GHG Protocol (x7), and ISO (x3) to identify key principles. Eight principles are identified. In contrast to academic literature, many terms are common across all documents, and documents typically have a dedicated section describing principles.

All of these terms are common goal (climate) principles (Table 3). Definitions between documents are largely consistent (see Appendix C for description of definitions and any notable differences between sources). The principles of Transparency, Completeness, Consistency, and Accuracy appear in documentation from all three organisations. The principle of Comparability in IPCC and GHG Protocol documents is largely equivalent to Coherence in ISO documents, and represents a rarer case where documents sourced from practice did not use common terminology. The principle of Relevance appears in both GHG Protocol and ISO documents, again in an unusual case where definitions for the term differed. The GHG Protocol use of Relevance is focused on meeting needs of end users, while the ISO one is focused on using relevant accounting boundaries and sources.

Table 3: Principles in practice

Principle	IPCC	GHG Protocol (x7)	ISO (x3)
1. Transparency	Yes	Yes	Yes (14067 differs*)
2. Completeness	Yes	Yes	Yes
3. Consistency	Yes	Yes	Yes (14067 differs*)
4. Comparability	Yes	Yes (PAS only)	No
5. Coherence	No	No	Yes for 14067 only
6. Accuracy	Yes	Yes	Yes
7. Relevance	No	Yes	Yes *
8. Conservativeness	No	Yes (PS only)	Yes for 14064-2 only

**same term but different definition*

4.2 Mapping of principles

In creating a shortlist of principles for public embedded emissions accounting from our longlist of 36 principles from literature and 8 principles from practice, we aim to treat all principles as equally important as opposed to an approach that considers some principles more important than others. Thus, our shortlist attempts to encapsulate all aspects of the principles that we found in review. This approach is motivated by the intent to present principles without value judgements, and also because specific principles terms often appeared only once in literature review (see Appendix Table A1).

The principles that we identify can be seen to present multiple potential points of conflict in application, with extensive combinations in which conflict can occur. Rather than resolve these conflicts in the current work, we instead present the synthesis of core principles as a starting ground from which attempts can be made in future to order and assign priority to principles. These challenges will also be navigated by actors designing governance regimes while balancing priorities, and prioritisations in practice will likely be heavily influenced by political and policy processes. This section (4.2) summarises the relationships between principles, and the following section (4.3) further articulates the rationale behind each of the eight principles in our final list.

4.2.1 Common goals

We identified 20 common goals principles in our review of academic literature (12 climate change mitigation goals and 10 free trade goals, see Table 2). Climate change common goal principles (Figure 4, and Appendix Table D1.1) are primarily concerned with ensuring that carbon accounts reflect physical realities. Free trade common goal principles (Figure 5, Appendix Table D1.2) are primarily concerned with issues of non-discrimination and efficiency. Mapping the relationships between common goals principles allows us to identify five core climate change mitigation principles that appear to be necessary components of a minimum viable set to encapsulate the principles identified in our review (Figure 4 and Appendix Table D1.1). These principles are: Accuracy, Conservativeness, Monotonicity, Relevance, and Transparency. The core intent (in the context of embedded emissions accounting systems) of the remaining principles can be captured by combinations of these 5 and/or one of the core principles related to free trade (Least restrictive means, Non-discrimination, and Subsidiarity). We identify three principles that are unique and encompass the free trade common goals indicated by other principles; these are Non-discrimination, Least restrictive means, and Subsidiarity (Figure 5 and Appendix Table D1.2).

Figure 4: Mapping of climate change common goals principles (core principles are denoted by a black outline; green indicates climate change mitigation common goal principles, yellow is free trade common goal principles)

FIGURE 4 HERE

Figure 5: Mapping of free trade common goals principles (core principles are denoted by a black outline; green indicates climate change mitigation common goal principles, yellow is free trade common goal principles)

FIGURE 5 HERE

4.2.2 Distributional

We identify 16 distributional principles in our review. Many of these principles are fundamentally in conflict (see Appendix Table B2 for definitions), in contrast with common goals principles where conflicts could arise but are not inherent. This is not unexpected. Common goal principles relate to achieving mutual benefit, or at least a common benefit, while distributional principles by definition must grapple with who pays costs and who receives benefits. Distributional principles are thus more likely to inherently conflict with each other. Given the nature of climate change and trade law literature, our review reflects concern about distributional principles internationally – designers of public embedded emissions accounting may need to also consider domestic distributional concerns, such as Equity and Empowerment (see Appendix Table D2 for definitions).

In the carbon accounting space, the principle of Common but Differentiated Responsibilities (CDR) is enshrined in UNFCC guidelines which call for "participation [by all states] in an effective and appropriate international response, in accordance with their common but differentiated responsibilities and respective capabilities and their social and economic conditions" (UNFCCC, 1992). The principle itself captures the tension between different distributional issues, and its implications have been the subject of ongoing debate (McGee and Steffek, 2016).

Debates over differential treatment principles in trade law have been ongoing for even longer than in international environmental law. Here, the principle of Special and Differential Treatment (SDT) appears in over 150 WTO texts. Acknowledging differential capabilities and a right to development, SDT allows developed countries to provide developing countries with preferential treatment, and provides developing countries some flexibility in when and how they meet their trade law obligations (WTO, 2023).

Neither CDR nor SDT as a principle is expected to be directly transferrable to embedded emissions accounting, despite representing the best comprises reached in their respective regimes. The prevalence of distributional principles in review necessitates that distributional issues be considered in design of public embedded emissions accounting schemes, yet the principle in question will need to evolve to fill the unique space at the intersection of these regimes. Like CDR, the WTO principle of Special and Differential Treatment (SDT) implies that all states should contribute to common goals, but that capacity and equity considerations imply not all can or should contribute equally (Gibb, 2000; Ochieng, 2007). In considering the common goals principles from review, it is notable that several of these deal with issues of capacity. Namely, Least Restrictive Means states that accounting must meet climate needs while minimising trade restriction; this should include restrictions that arise from limited capacity of some jurisdictions to meet accounting requirements. Conservativeness and Relevance likewise inform this balance: Conservativeness in stating approaches for when further accuracy cannot *reasonably* be achieved, and Relevance in stating that systems must meet the needs of users, which we define to include the entities producing accounts. Further, Non-discrimination in practice will require actors to navigate multiple potentially applicable distributional principles beyond those related to capacity, including Reciprocity, Equity, and Flexibility (see section 4.3.2.1). Thus, while we do not identify a distributional principle for the shortlist in Table 4, we note that distributional principles are related to several of the common goals principles identified and will need to inform development of public embedded emissions accounting systems.

4.3 Principles to inform design of public embedded emissions accounting systems

The consolidated list of core common goal principles relevant to the development of public embedded emissions accounting systems is presented in alphabetical order in Table 4. Also included in the table are short definitions of the principles as we see them in this context. Terms that were identified in literature review yet that do not appear individually in the table have not been discarded; rather, common goal principles are considered to be captured by those principles listed in Table 4 (with relationships described in section 4.2 and Appendix D), and distributional principles underpin some common goals and also must continue to evolve in parallel (see section 4.2.2). The remainder of this section discusses the eight consolidated common goal principles in more detail, including motivating their selection and further explaining their relationship to some of the principles that are not part of the consolidated list.

Table 4: Common goal principles relevant to design of embedded emissions accounting frameworks

Principle	Definition
Accuracy	True embedded emissions should neither be under-estimated or over-estimated.
Conservativeness	Where further accuracy cannot reasonably be achieved, assumptions, default values and alternative methods should be chosen such that the risk of reported emissions (removal) being an underestimate (overestimate) of the true values is minimised.
Monotonicity	Embedded emissions accounting systems should not allow actors to decrease their reported emissions in a way that may increase overall emissions.
Non-discrimination	Embedded emissions accounting systems should not generate explicit or implicit advantage or disadvantage for like products, where “like” includes true emissions impacts.
Least restrictive means	Embedded emissions accounting systems should be designed to meet the requirements of their intended use in the least trade restrictive means possible.
Relevance	Embedded emissions accounting systems should be designed to support the needs of the intended uses and users.
Subsidiarity	Data collection and accounting should be conducted at the lowest level of aggregation and control that is consistent with meeting its intended use.
Transparency	Information should be provided sufficient to allow stakeholders to assess robustness and reliability.

4.3.1 *Climate change common goals principles*

4.3.1.1 Accuracy

The principle of Accuracy is identified in both emissions accounting literature and practice, and calls for the inventory to contain neither underestimates nor overestimates so far as can be judged (Penman et al., 2006). Accuracy can be particularly challenging to achieve in accounting for land use activities, and academic literature in this area has highlighted both the necessity and the ongoing challenges in this space for developing countries achieving this aspect of IPCC guidelines (Baker et al., 2010). In our interpretation, Accuracy includes Completeness (described by the IPCC as reporting estimates for all relevant categories of sources and sinks), because incomplete accounting will underestimate true emissions within the specified boundary. Literature also calls for improved Robustness of inputs to modelling exercises for emissions (Usubiaga and Acosta-Fernández, 2015), which would facilitate Accuracy. This reflects that the integrity of data used for accounting and modelling is critical to achieving an accurate account.

Recent work considering national-level greenhouse-gas accounting for effective climate policy in international trade put forth three key principles: Additivity, Monotonicity, and Sensitivity (Kander et al., 2015). We retain Monotonicity separately, but consider that for embedded emissions accounting (as opposed to national accounts) the principles of Additivity and Sensitivity are covered by other principles. Additivity, the principle that the sum of national emissions for all countries should equal total global emissions, should be covered by the combination of Accuracy and Monotonicity. That is, if emissions are neither underestimated nor overestimated (accuracy) *and* systems do not allow actors to decrease their reported emissions in a way that may increase overall emissions (monotonicity), then the sum of emissions from accounting modules along a supply chain should equal total supply chain embedded emissions (thus achieving additivity). Sensitivity is discussed in the sections for Relevance (4.3.1.4) and Subsidiarity (4.3.2.3).

4.3.1.2 Conservativeness

Conservativeness is likewise identified in both emissions accounting literature and practice. In carbon accounting literature, it is described as arising from practice as a principle to support participation of developing countries (Baker et al., 2010). In cases where high levels of accuracy are infeasible due to issues such as lack of data, then Conservativeness requires avoiding underestimation of emissions or *over*estimation of removals (removals being approaches such as carbon capture and/or sequestration). Application of the principle of Conservativeness to new products and processes with high uncertainty is also aligned with the Precautionary Principle, a sometimes contentious approach within trade law that attempts to balance environmental and trade concerns by stating that where sufficient accuracy is not possible for new products and processes, conservative assumptions must be applied (Cheyne, 2007). Further, in presenting a path forward when further Accuracy cannot *reasonably* be achieved, Conservativeness can support design of accounting systems that do not require unreasonable degrees of capacity for their users to meet. That is, when designing accounting systems to be met by developing countries, Conservativeness would likely be critical for determining methods that balance Accuracy and Least Restrictive Means (a principle from trade law that requires accounting to consider the associated regulatory burden).

4.3.1.3 Monotonicity

In carbon accounting literature regarding national accounting, Monotonicity is defined as the principle that countries should not be able to reduce their national carbon footprints in ways that contribute to increased global carbon emissions (Kander et al., 2015). We interpret Monotonicity in the context of embedded emissions accounting systems to imply that reporting entities cannot choose estimation approaches that hide some of their embedded emissions – especially through attributing them to other products that are not captured in the system. This is an active concern in embedded emissions accounting for products such as hydrogen which would be captured in early EU CBAMs, particularly regarding treatment of co-products such as oxygen (Department of Climate Change, Energy, the Environment and Water, 2022; IPHE, 2022). Where emissions are moved outside the accounting

system boundary, there is less pressure to control and reduce them, and therefore it is likely they will increase (or at least fail to decrease as they otherwise would have) (White et al., 2021). Likewise, adherence to Monotonicity and Accuracy would give compliance with several identified rules for accounting, such as avoidance of double-counting.

Monotonicity does not currently appear in carbon accounting practice, but it supports the practice-based principles of Accuracy and Relevance, where Relevance in the GHG Protocol states the need for accounting to serve decision-making needs of users (including those seeking environmentally friendly products). Monotonicity directly supports climate change mitigation as a common goal by opposing actions that could reverse progress towards achievement of that common goal (i.e., by stating that reported local emissions should not be reduced in ways that increase actual global emissions). It has an analogue in Standstill, a free trade common goal principle that states countries should not introduce measures that would have the effect of reversing progress towards free trade. Adherence to the principle of Monotonicity would explicitly centre climate change mitigation goals in discussions to resolve conflicts between other principles, such as Accuracy and Least Restrictive Means.

4.3.1.4 Relevance

Relevance in the GHG Protocol requires that accounting serve the decision-making needs of the user. In the context of public embedded emissions accounting, we define this to mean the needs of entities both compiling and using the accounts. This is related to distributional principle requirements to consider capacities of different reporting entities, including in developing countries: if the reporting is beyond what can be accomplished by an entity compiling accounts, then the system is not meeting the needs of that user. In recommending best practices for national level carbon accounting, the principle of Sensitivity is introduced to indicate that accounting should be responsive to factors that nations can influence (Kander et al., 2015). In the case of embedded emissions accounting, we consider the principle of Relevance to imply Sensitivity in the sense that accounting requirements should be focused on factors these entities have visibility of and some level of control over. That is, the principle of Sensitivity is implied by the principle of Relevance from the perspective of the reporting entities since these entities are often also users of the system (e.g., to gain certification for their products) and Relevance for them requires they be responsible for accounting for products or processes over which they have control.

4.3.1.5 Transparency

Transparency is a widely accepted best-practice principle of regulation and governance well beyond carbon accounting. In our review, it appears in all three bodies of work from carbon accounting practice, emphasising the need for clear documentation. Transparency supports trust and legitimacy of embedded emissions accounting systems, and therefore their Relevance to their intended use of overcoming information failures and activating markets for low-emissions products. Likewise, Transparency of reporting, when combined with the principle of Accuracy, will be key to achieving the principles of Comparability and Consistency identified in literature from practice. That is, accounting is at its most valuable when it can be compared over time and between places (Penman et al., 2006). Transparency and Accuracy should facilitate this.

4.3.2 Trade law common goals principles

4.3.2.1 Non-discrimination

Non-discrimination between “like products” based on location of production is the central tenet of trade law (Bagwell and Staiger, 2001). The interpretation of “like products” has been the subject of a long debate (Choi, 2012), particularly with regard to health and environmental implications of otherwise like products (Bernasconi-Osterwalder et al., 2005). Increasingly there is agreement that the likeness of products depends on health and environmental attributes for which customers/markets have a demonstrable willingness to pay or for which there is internationally agreed need for policy or

regulation (Charnovitz, 2002), although it remains hotly debated whether otherwise similar products with different embedded emissions should be considered unlike products (Bacchus, 2017).

The importance of the principle of non-discrimination in our context can best be understood by considering what may constitute a discriminatory embedded emissions accounting system. There are two main elements of relevance: the quantum of embedded emissions the system would estimate for like products from different locations; and how difficult it is for producers in different locations to participate in the system. Different assumed default emissions values for different locations, for example, could potentially be construed as discriminatory. Similarly, a system that places a higher burden of evidence on products produced in certain locations could potentially be construed as discriminatory. In a world in which actual average emissions intensity and governance quality does actually vary with location, the principle of non-discrimination clearly has potential to clash with principles such as Accuracy and Conservativeness.

The principle of Non-discrimination subsumes or otherwise covers several of the common goal principles identified in our review for both climate change mitigation and free trade goals. A non-discriminatory embedded emissions accounting system should generate comparable estimates for like products. Hence, we consider the carbon accounting practice principle of Comparability (i.e., comparable reporting across countries) to be inherent in the principle of Non-discrimination. Similarly, a non-discriminatory system should generate similar estimates for like products that have genuinely similar embedded emissions. Finally, the principle of Accession (non-exclusivity) is a special case of Non-discrimination in that it requires existing parties to agreements to encourage others to join and to share information with them to support this (Elek et al., 1999).

The principle of Non-discrimination relates to some of the Distributional principles identified. A *de juro* (according to the letter of the law) interpretation of Non-discrimination aligns with trade law principles such as Reciprocity, the GATT principle under which one country agrees to reduce its level of protection in return for a reciprocal ‘‘concession’’ from its trading partner (Bagwell and Staiger, 2001). Meanwhile, since different countries and firms have different institutional capabilities, a *de facto* (according to the real-world impacts) interpretation of Non-discrimination aligns with principles such as Flexibility and Capability (Appendix Table D2). Flexibility, identified in review of trade law literature as the need to consider different levels of economic development among economies (Elek et al., 1999), can be relevant to acehive Non-discrimination by considering different production and accounting conditions in different locations. Capability refers to the need for more advantaged actors to bear greater burdens, and is a component of CDR; it is also explicitly referenced in carbon accounting literature recommending strategies to break climate negotiation impasse (Grasso and Roberts, 2014).

4.3.2.2 Least restrictive means (LRM)

Least Restrictive Means (LRM) is a principle articulated in the WTO, and reflects that governments should pursue non-trade policy objectives using the least trade-restrictive means possible (Costinot, 2008). Several points are worth making in this regard. Firstly, that the LRM principle does acknowledge that governments have the right to pursue non-trade objectives, even if they have negative consequences for trade (Sykes, 2003). Conversely, the principle requires that the action taken be demonstrably effective at supporting the claimed policy objective, and that the action taken be the least trade restrictive among similarly effective actions (Sykes, 2003). Proportionality, a principle in international law requiring that the least intrusive measures be used (Cottier et al., 2019), is closely related to LRM. Finally, we note that our interpretation of LRM in the context of public embedded emissions accounting systems is that it implies minimising the regulatory burden created by the systems, including burdens of cost and time. This is related to our earlier discussion of Relevance, i.e., that the system should meet the needs of its users *including* those users bearing the burden of producing the accounts. LRM thus has relevance in a distributional sense, in that it requires actors to

consider the capacities of reporting entities and other nations when setting accounting requirements. We do, however, acknowledge that it is not necessarily the case that the LRM system in every case will be the one that has lowest regulatory burden. For countries where local producers do not have comparative advantage in meeting reporting and regulatory requirements, a high regulatory burden system may encourage more trade (imports) from countries with firms that are relatively good at complying with such requirements (Aisbett and Silberberger, 2021).

4.3.2.3 Subsidiarity

Subsidiarity is a broadly applicable governance principle that has found application in the trade law literature and practice (Fox, 1999). The general meaning of subsidiarity is that what can be done as well or better at a lower level must be done at the lower level. In the case of embedded emissions accounting, "what can be done" is the counting, reporting, and hoped-for reduction of emissions. The principle of Sensitivity, recommended for national carbon accounting practice (Kander et al., 2015), is useful in conceptualising Subsidiarity for embedded emissions accounting. Sensitivity requires that accounting be responsive to factors that reporting entities can influence. In the context of Subsidiarity, this would require that reporting be conducted at the facility where the relevant emissions occur. This is closely related to the Reality "principle" (Brander et al., 2021), a rule that states emissions should be counted where they occur. However, there will be a need to balance this against resourcing constraints – not all facilities will have the capacity to rigorously count and report emissions. While national level carbon accounting requires aggregation at the nation level, embedded emissions accounting for products has the option to count distinct 'modules' within the supply chain and keep these visibility separate for traded products (White et al., 2021). This approach could support subsidiarity by allocating reporting responsibility most directly to the emitting entity, while verification and accounting of this reporting could still be undertaken at national levels by public agencies.

A possible concern with the implications of the principle of Subsidiarity in our context is that it places responsibility for emissions accounting on entities (including firms) that may not have the Capability to bear the implied regulatory burden (Appendix Table D2). This could have implications for *de facto* Non-discrimination and for distributional principles broadly.

5 Discussion and conclusions

Public accounting systems for emissions embedded in traded products will need to grapple with trade law issues, outside the scope of national accounting schemes that have previously been dominant. That is, embedded emissions accounting systems will straddle the regimes of climate change mitigation and of trade law, and we identify core principles in each of these literatures that did not have a true analogue in their neighbouring regime.

This work is of interest to academic theory in representing a novel attempt to consider principles for a nascent regime, and for its review of two literatures commonly in tension to identify common goals. While policy arrangements and regimes typically evolve ad hoc over time (Gunningham and Sinclair, 1999; Wison, 2000), governments worldwide have become interested in deliberately shaping emerging regimes, particularly in the environment and climate spaces (Howlett and Rayner, 2006; Jordan et al., 2003). While regimes themselves tend to emerge spontaneously, through negotiation, or more rarely as imposed orders (Young, 1982), the policy arrangements of regimes themselves can be designed more deliberately (Howlett and Rayner, 2007). The present work represents a novel exercise to consider principles underlying the developing instrument of public embedded emissions accounting, currently a nascent and rapidly evolving area. In doing so, this work brings together two sets of literature from the more established trade law and climate law regimes, and considers how the principles from these existing regimes could be interpreted for application to public embedded emissions accounting. It further highlights that in many areas, practice for embedded emissions accounting has moved in advance of theory in adopting clear and consistent principles for climate

change common goals, shaped to an extent by the role of the IPCC within the international climate regime.

We expect this work to be of importance to policymakers as source of reference when developing policy and guidance in a fast paced area. When international climate change regimes and associated instruments emerged, it occurred slowly, with several decades of agenda setting and scientific evaluation prior to the establishment of the IPCC (1988), Kyoto Protocol (1992), and successor agreements such as the Paris Agreement (2015) (Andresen and Agrawala, 2002). Management of public embedded emissions accounting will build on knowledge and agendas of existing regimes including that of climate change and trade law, but will be under pressure to develop at a rapid pace. This creates a window where insights from academic theory could meaningfully inform future agenda setting and instrument design.

While our review identified common goal principles for trade law and climate change mitigation that can be pursued simultaneously without inherent conflict, we did not identify an existing distributional principle that is directly transferrable. Rather, both Common but Differentiated Responsibilities in carbon accounting and Special and Differential Treatment in trade law represent existing codified attempts to balance the need for jurisdictional commitments against differences in respective capabilities and their social and economic conditions, but CDR has been subject to legal challenges (McGee and Steffek, 2016) and SDT has been subject to protracted negotiations in practice (Ochieng, 2007). Development of a distributional principle applicable to embedded emissions accounting will likely arise following ongoing international negotiations. Several common goals principles deal with the distributional need to consider capacity in setting accounting requirements, namely Least Restrictive Means, Relevance, and Conservativeness. Non-discrimination is likewise inextricable from application of distributional principles, though the relevant principles will vary with interpretation. Developed countries would be expected to support developing countries in creating accounting capacity. This could include trade facilitation approaches similar to those used for International Green Economy Collaborations, such as sharing resources to develop domestic accounting capacity in developing countries (Aisbett et al., 2023).

Future work could draw on our methodological approach and list of principles for the instrument of embedded emissions accounting to consider design principles underlying other elements of the emerging trade-related climate policy regime more broadly. This may include work that considers environmental and social matters more broadly, particularly from harm reduction perspectives. There is also scope for future work in research and in practice to address the translation of design principles into specific design features and methodologies for public embedded emissions accounting frameworks. This phase will likely involve substantial political pressures and pressures from trade partners, including for the interpretation of balance to be struck between principles when operationalised in practice. Principles identified in this work could be considered to give attributes such as trustworthiness (through accuracy, completeness, and monotonicity) and interoperability (through accuracy and transparency) to emerging schemes, but we do not take the step of considering scheme attributes explicitly - such attributes will also be shaped by factors such as international reputation of relevant governing bodies. Future work could also consider how or whether to assign priorities to principles during potential points of conflict. The list of principles put forward in this work is expected to form a reference point for these types of future investigations.

6 Author contribution statement

LW and EA conceived the article, designed and executed the study, analysed data, and both wrote and revised the article. OP collected and analysed data, and contributed to writing and revisions. WC contributed to study design and article review.

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9 Declaration of interest statement

We consulted with our partner organisations through the Linkage grant, namely CER, CCA, and DFAT. Grant rules maintain full academic freedom in analyses and publications.

10 Data availability statement

The spreadsheet containing literature review records of extracted principles and definitions is made fully available through the Australian National University's Data Commons, a repository that collects, maintains, preserves, promotes and disseminates research data from the ANU community. We ask that this data set be cited if used in future work. Please contact the corresponding author with any questions. [A DOI and suggested citation will be added here prior to publication.]

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12 Appendix A: Methods tables

12.1 Table A1: list of articles reviewed and principles extracted

Literature	Reference	Author(s)	Reference year	Principles
Carbon	C1	Kander A., Jiborn M., Moran D.D., Wiedmann T.O.	(2015)	Sensitivity; Monotonicity; Additivity
Carbon	C2	Ter-Mikaelian M.T., Colombo S.J., Chen J.	(2015)	Accurate forest emissions accounting
Carbon	C3	Vetné Mózner Z.	(2013)	Consumption-based; Production-based
Carbon	C4	Baker D.J., Richards G., Grainger A., Gonzalez P., Brown S., DeFries R., Held A., Kellndorfer J., Ndunda P., Ojima D., Skrovseth P.-E., Souza C., Stolle F.	(2010)	Accuracy; Conservative
Carbon	C5	Druckman A., Bradley P., Papathanasopoulou E., Jackson T.	(2008)	Consumption-based; Production-based; Robustness measured by input-output consistency
Carbon	C6	Wang H., Zhou P.	(2018)	Consumption-based; Production-based; Common but differentiated responsibilities; one-factor-each-time
Carbon	C7	Grasso M., Roberts T.	(2014)	Consumption-based; Production-based; Responsibility; Capability
Carbon	C8	Droege S.	(2011)	Common but differentiated responsibilities; Non-discrimination; Production-based; Consumption-based
Carbon	C9	Usubiaga A., Acosta-Fernández J.	(2015)	Residence principle; Territory principle; Robustness
Carbon	C10	Wang Z., Li Y., Cai H., Wang B.	(2018)	Consumption-based; Production-based

Carbon	C11	Ostwald M., Henders S.	(2014)	Additionality; Consumption-based; Production-based
Carbon	C12	Adewale C., Reganold J.P., Higgins S., Evans R.D., Carpenter-Boggs L.	(2018)	"Use of consistent broad agricultural system carbon footprint boundaries"; "Incorporation of soil emissions and sequestration"; "Development and use of fine-scale emission factors for agricultural inputs"
Carbon	C13	Steckel J.C., Kalkuhl M., Marschinski R.	(2010)	Historical responsibility; Grandfathering; Equal-per-capita; Consumption-based; Production-based; Equity
Carbon	C14	Liu H., Fan X.	(2017)	Value-added accounting; Production-based; Consumption-based
Carbon	C15	Chen W., Lei Y., Feng K., Wu S., Li L.	(2019)	Income-based; Production-based; Consumption-based;
Carbon	C16	Cairns R.D., Lasserre P.	(2006)	Forward-looking credits; Stock change; Atmospheric flow
Carbon	C17	Zhang K., Xue M.-M., Feng K., Liang Q.-M.	(2019)	Consumption-based; Production-based; Beneficiary principle; Ability-to-pay principle
Carbon	C18	Downie A., Lau D., Cowie A., Munroe P.	(2014)	Biogenic method; Stock method; Simplified method
Carbon	C19	Brander M., Ascui F., Scott V., Tett S.	(2021)	Reality principle
Carbon	C20	Tukker A., Wood R., Schmidt S.	(2020)	Consumption-based OR Residential; Production-based OR Territorial; Income OR Value Added
Carbon	C21	Kirschbaum M.U.F., Cowie A.L.	(2004)	Biospheric carbon exclusions

Carbon	C22	Lintunen J., Uusivuori J.	(2016)	Optimality
Carbon	C23	Zheng Z.	(2021)	Non-differentiated producer responsibility; Producer responsibility; Consumer responsibility; Shared responsibility
Trade	T1	Bagwell K., Staiger R.W.	(1999)	Reciprocity; Non-discrimination
Trade	T2	Hafner-Burton E.M.	(2005)	Coercion
Trade	T3	Perrings C., Dehnen-Schmutz K., Touza J., Williamson M.	(2005)	Polluter-pays
Trade	T4	Macdonald K.	(2007)	Empowerment
Trade	T5	Bagwell K.; Staiger R.W.	(1998)	Reciprocity; Non-discrimination
Trade	T6	Bagwell K.; Staiger R.W.	(2001)	Reciprocity; Non-discrimination
Trade	T7	Gibb R.	(2000)	Non-discrimination; Special and differential treatment; Reciprocity; Non-reciprocity
Trade	T8	Bagwell K.; Staiger R.W.	(2004)	Non-discrimination; Reciprocity; Nullification/Impairment
Trade	T9	Ludema R.D.	(2001)	Conciliation; Reciprocity
Trade	T10	Blanchard E.J.	(2010)	Reciprocity

Trade	T11	Costinot A.	(2008)	National treatment; Mutual recognition; Least restrictive means
Trade	T12	Fox E.M.	(1999)	Market access; Transparency; Subsidiarity
Trade	T13	Baldwin R.; Evenett S.; Low P.	(2009)	Non-discrimination
Trade	T14	Bagwell K.; Staiger R.W.	(2012)	Reciprocity; Non-discrimination
Trade	T15	Cheyne I.	(2007)	Precautionary principle
Trade	T16	Beshkar M.	(2010)	Reciprocity
Trade	T17	Aoki R.; Prusa T.J.	(1993)	Non-discrimination/uniform protection; Discriminatory protection
Trade	T18	Bown C.P.	(2004)	Most-favoured-nation (MFN); National treatment; Reciprocity
Trade	T19	Choi W.-M.	(2012)	Like products
Trade	T20	Weiss C.	(2006)	Precautionary principle; Innovation and adaptive management
Trade	T21	Bagwell K.; Staiger R.W.	(2015)	Reciprocity
Trade	T22	Bagwell K.; Staiger R.W.	(2010)	Nullification/Impairment; Renegotiation; Reciprocity; Most-favoured-nation

Trade	T23	Bown C.P.; McCulloch R.	(2003)	Most-favoured-nation
Trade	T24	Ochieng C.M.O.	(2007)	Reciprocity, Special and differential treatment; Most-favoured-nation; Developmental principles; Sovereign equality
Trade	T25	Shih W.-C.	(2009)	Non-discrimination; Prohibition on quantitative restrictions
Trade	T26	Mitchell A.D.; Heaton D.; Henckels C.	(2016)	Most-favoured-nation; National treatment
Trade	T27	McGee J.; Steffek J.	(2016)	Economic liberalism; Redistributive multilateralism; Social protection; Common heritage of mankind; Common concern of mankind; Common but differentiated responsibilities
Trade	T28	Dröge S.; Trabold H.; Biermann F.; Böhm F.; Brohm R.	(2004)	National treatment; Most-favoured-nation; Destination; Origin
Trade	T29	Elek A.; Findlay C.; Hooper P.; Warren T.	(1999)	Transparency; Non-discrimination; Accession; Review; Comprehensiveness; WTO-consistency; Comparability; Non-discrimination; Transparency; Standstill; Simultaneous start, continuous process and differentiated timetables; Flexibility; Cooperation
Trade	T30	Cottier T.; Echandi R.; Liechti-Mckee R.; Payosova T.; Sieber C.	(2019)	Proportionality
Trade	T31	Ederington J.; McCalman P.	(2003)	Most-favoured-nation
Trade	T32	Lee Y.-S.	(2011)	Most-favoured-nation; Special and differential treatment

12.2 Table A2: Journal Disciplines

Journal Discipline*	Carbon Accounting	Trade Law	Total
Economics, Econometrics and Finance	6	28	34
Social Sciences	7	25	32
Environmental Science	26	5	31
Agricultural and Biological Sciences	6	2	8
Engineering	7	1	8
Energy	6	1	7
Earth and Planetary Sciences	5	0	5
Business, Management and Accounting	2	2	4
Computer Science	3	0	3
Medicine	0	1	1

** Disciplines are those listed for each journal on Scopus, often a handful per journal. Papers often were categorized as more than one discipline (average of ~2.5 disciplines per journal), so this table sums to more than the total number of articles reviewed.*

12.3 Table A3: Methodology and Publication Type

	Carbon Accounting	Trade Law	Total
Methodology			
Theoretical/conceptual	15	30	45
Empirical	8	2	10
Type			
Article	19	24	43
Review	3	5	8
Letter	1	0	1
Book	0	2	2
Book chapter	0	1	1

13 Appendix B: Principles defined and separated from rules

13.1 Table B1 Common-goal principles

Lit ref (Table A1)	Principle name in literature	Literature definition (term search)	Category of goal
Primarily in carbon accounting literature			
C4	Accuracy	The principle of neither over- nor underestimating emissions	Climate change mitigation
C11	Additionality	Demonstrating that the effect of the intervention would not have happened in its absence	Climate change mitigation
C1	Additivity	The sum of national emissions for all countries should equal total global emissions	Climate change mitigation
E1* (via C18)	Completeness	Account for all emissions (via C18, “Biogenic method” rule)	Climate change mitigation

C4	Conservative	When completeness, accuracy and precision cannot be achieved, the reported reduction of emissions (and thus the incentives claimed by the country) should not be overestimated, or at least the risk of overestimation should be minimized.	Climate change mitigation
C1	Monotonicity	Countries should not be able to reduce their national carbon footprints in ways that contribute to increased global carbon emissions.	Climate change mitigation
C9	Robustness	The quality of inputs to models affects accuracy, so good quality data should be used.	Climate change mitigation
C1	Sensitivity	It should be responsive to factors that nations can influence, for example the level and composition of their consumption, and their domestic carbon efficiency	Climate change mitigation
E2* (via C12)	Consistency	Derived from implicit principle in an article describing that "Frameworks should be expected to meet consistent and broad boundary definitions." See also Carbon Accounting Practice definition.	Climate change mitigation, Free trade
Primarily in trade law literature			
T29	Accession (non-exclusivity)	Any economy whose government accepts the responsibilities as well as the benefits of following policies compatible with any existing or proposed cooperative arrangements should be able to, and encouraged to, become parties to these arrangements. Existing parties to these cooperative arrangements should be willing to share the information, experience, expertise and technology needed to enable others to adopt the relevant policies.	Free trade
T29	Comprehensiveness	Liberalisation and facilitation process will be comprehensive, addressing all impediments to achieving the long-term goal of free and open trade and investment	Free trade
T29	Cooperation	Economic and technical cooperation contributing to liberalisation and facilitation will be actively pursued	Free trade
T20	Innovation and adaptive management	Precautionary action should not unreasonably interfere with an innovation that promises major benefits until the dangers and benefits of this innovation are well understood	Free trade
T11	Least Restrictive Means	Standards should not be a "disguised restriction" to trade and should attain their	Free trade

		goals in a way that is the least restrictive for trade	
T1 T5 T6 T7 T8 T13 T14 T17 T25 T29 C8	Non-discrimination	A core principle of free trade which states that 'like products' should be treated the same. Specifically, the General Agreement on Tariffs and Trade (GATT 1947:2) states that any advantage, favour, privilege or immunity granted by any contracting party to any product originating in or destined for any other country shall be accorded immediately and unconditionally to the like product originating in or destined for the territories of all other contracting parties	Free trade
T15 T20	Precautionary Principle	In order to protect the environment, where there are threats of serious or irreversible damage, the lack of full scientific certainty shall not be used as a reason for postponing cost-effective measures to prevent environmental degradation.	Climate change mitigation
T30	Proportionality	Assessing the relationship of means and ends, and seeking least intrusive measures.	Free trade
T29	Standstill	Refrain from using measures which would have the effect of increasing levels of protection, thereby ensuring a steady and progressive trade and investment liberalisation and facilitation process.	Free trade
T12	Subsidiarity	What can be done as well or better at a lower level must be done at the lower level.	Free trade
T12 T29	Transparency	Facts, reasoning and policies should be stated and documented in a clear and freely accessible manner. Reasonable prior notice of intended policy changes should be given.	Free trade, Climate change mitigation

**Those labelled E1 and E2 were extracted from terms identified as rules (Appendix B)*

13.2 Table B2: Distributional principles

Lit ref (Table A1)	Principle name in literature	Literature definition (term search)
Primarily in carbon accounting literature		
C7	Capability	The principle of capability demands that the currently most advantaged actors bear the largest quota of mitigation costs because of their greater wealth and capacities
C6 C8 T27	Common but differentiated responsibilities	The global nature of climate change calls for the widest possible cooperation by all countries and their participation in an effective and appropriate international response, in accordance with their common but differentiated responsibilities and respective capabilities and their social and economic conditions
C23	Consumer responsibility	Asserts that the consumer is the ultimate driver of carbon dioxide emissions and should be responsible for the emissions
C13	Equity	Broadly, equitable approaches should acknowledge that some actors need different resources to achieve the same outcome.
C23	Non-differentiated producer responsibility	Developed as a refinement of the shared responsibility principle; it redistributes carbon dioxide emissions along a value chain according to the proportion of profits obtained
C23	Producer responsibility	The producer responsibility principle asserts that the producing country should undertake all the responsibility for the carbon dioxide emissions caused by the production of products and the provision of services within its administrative scope
C23	Shared responsibility	Advocates that both consumers and producers should share the carbon dioxide emission responsibility
Primarily in trade law literature		
T27	Common Concern of Mankind	This recognises a common obligation of all countries to protect the atmosphere by addressing climate change, however with no obligation for countries to share the benefits of using the atmosphere.
T29	Comparability	In this context, comparability of effort; that developing economies will endeavour to ensure the overall comparability of their trade and investment liberalisation and facilitation, taking into account the general level of liberalisation and facilitation already achieved by each developing economy
T24	Developmental Principles	Due to the financial, trade, and development needs of developing countries, developed countries should not seek reciprocity in their trade with developing countries.
T4	Empowerment	The term ‘empowerment’ in this context refers to a process through which marginalised individuals and groups are able to exercise a meaningful level of control over the progressive realisation of their own well-being.
T29	Flexibility	Considering the different levels of economic development and the diverse circumstances in each economy, flexibility will be available in dealing with issues arising from such circumstances in the liberalisation and facilitation process.
T7	Non-reciprocity	Allowing developing country exports duty free access to developed country markets while enabling the developing states to maintain tariff barriers against developed country goods.
T3	Polluter-pays	Externalities are best dealt with by internalizing them; that is, by getting those who harm society to meet the cost.

T1 T5 T6 T7 T8 T9 T10 T14 T16 T18 T21 T22 T24	Reciprocity	The principle of reciprocity is a General Agreement on Tariffs and Trade (GATT) norm under which one country agrees to reduce its level of protection in return for a reciprocal ‘‘concession’’ from its trading partner. At the broadest level, this principle refers to the ‘‘ideal’’ of mutual changes in trade policy which bring about equal changes in import volumes across trading partners
T7 T24 T32	Special and Differential Treatment	Providing trade preferences for developing countries, where these preferences are consistent for all developing countries but are not extended to developed countries.

13.3 Table B3: Terms best characterised as "rules" that were identified in the carbon accounting literature and related principles

Ref (Table A1)	Term in literature	Literature definition (term search)	Related principles (Tables B1 and B2)
Primarily in carbon accounting literature			
C17	Ability to pay	Applied as a calculation rule for one option of determining net tax burden to evaluate the fairness of a carbon tax. When evaluating with the ability to pay principle, this is defined as the net tax payment divided by per capita income in a region	Broadly relates to determining accomplishment of fairness as a category of distributional principle
C2	Accurate Forest Emissions Accounting	Accounting for the GHG emission reduction potential of forest bioenergy must include the following: A) Forest carbon following biomass harvest for energy production (the forest bioenergy scenario); B) Forest carbon in the absence of demand for bioenergy (the forest baseline scenario); C) Life cycle GHG emissions (upstream fossil fuel emissions) from producing forest bioenergy (excluding GHG combustion emissions); and D) Life cycle GHG emissions (including those from combustion) for the fossil fuel displaced by forest biomass (the reference fossil fuel scenario).	Accuracy
C17	Beneficiary principle	Applied as a calculation rule for one option of determining net tax burden to evaluate the fairness of a carbon tax. When evaluating with the beneficiary principle, this is defined as the net tax payment divided by regional population.	Broadly relates to determining accomplishment of fairness as a category of distributional principle
C18	Biogenic method	Account for all emissions including biogenic CO_2 cycling	Completeness (extracted principle E1)
C21	Biospheric carbon exclusions	That accounting excludes removals resulting from (i) elevated carbon dioxide concentrations above their pre-industrial level; (ii) indirect nitrogen deposition; and (iii) the dynamic effects of age structure resulting from activities and practices before the reference year	Accuracy, Conservativeness
C3 C5 C6 C7 C8 C10 C11 C13 C14	Consumption-based	Accounting for the upstream CO_2 emissions generated to produce a region's final demand; counts the emissions required to produce the goods and services consumed in a country	Consumer responsibility

C15 C17 C20			
C12	Development and use of fine-scale emission factors for agricultural inputs	Tier 3 emission factors are needed for a diverse range of inputs and soil amendments. This is an important step toward correcting underlying assumptions of tier 1 emission factors, capturing differences in farming systems, increasing accuracy of emission factors, and reducing uncertainties of agricultural system carbon footprint estimation and comparison.	Accuracy
C13	Equal per capita	Emissions for countries are allocated on a basis of equal amounts of emissions per person	Common but differentiated responsibilities
C16	Forward-looking credits	Records anticipated changes in value	Does not appear relevant to other identified principles
C13	Grandfathering	Emissions allocations are assigned in a way that permits current higher emitters to continue on existing trajectories for a time	Capability, Common but differentiated responsibilities
C13	Historical responsibility	Emissions allocations are assigned in a way that requires historical high emitters to reduce faster	Polluter pays, Common but differentiated responsibilities
C15 C20	Income-based	Emissions enabled by primary inputs are often referred to as "income-based CO_2 emissions", which include all the emissions generated downstream in the supply chain until delivery to final demand and can help to identify critical primary suppliers for supply-side emission reduction policymaking	Capability, Producer responsibility, Consumer responsibility
C12	Incorporation of soil emissions and sequestration	The potential importance and the current difficulty in measuring soil greenhouse gas fluxes argues for a concerted development of consistent methods and models that utilize site-specific information	Accuracy, Completeness (extracted principle E1), Consistency (extracted principle E2)
C6	One-factor-each-time	The 'one-factor-each-time' principle implies that in decomposition, changing only one factor's value from year 0 to year T at a time while holding all other factors' value unchanged, which therefore captures the impact of the factor being changed	Consistency (extracted principle E2), Accuracy
C22	Optimality	The release of carbon is penalized by a tax and carbon capture is subsidized	Proportionality, Polluter pays
C3 C5 C6 C7 C8	Production-based	The direct CO_2 generated in the production process within borders (counted in a country's emissions account under Kyoto)	Producer responsibility

C10 C11 C13 C14 C15 C17 C20			
C19	Reality principle	Report emissions and removals when and where they actually occur	Supports Polluter Pays, Accuracy, Sensitivity, Relevance, Minimum Regulatory burden and Subsidiarity
C9 C20	Residence principle	Emission accounts follow the so-called residence principle – that is, address the activities undertaken by the residents of a country, independent from where these take place	Polluter pays
C5	Robustness measured by input-output consistency	Using this perspective, emissions associated with exports are included but those associated with imports are excluded from the national account. Upstream resources used in the production of goods are attributed to the producer, not the consumer of those goods	Robustness, Producer responsibility
C18	Simplified method	Assume that the net balance of carbon taken up by biomass is neutral over the short-term and hence there is no requirement to include this carbon in the calculation	Minimum regulatory burden
C16 C18	Stock method	Account for the quantity of carbon that is moved to and maintained in the non-atmospheric pool	Accuracy
C9 C20	Territory principle	Emissions are counted as defined by a territory boundary	Polluter pays
C12	Use of consistent broad agricultural system boundaries	Frameworks should be expected to meet consistent and broad boundary definitions	Consistency (extracted principle E2), Accuracy, Completeness (extracted principle E1)
C14 C20	Value-added accounting	Methods for CO_2 accounting should account for carbon emissions embodied in the value-added chain, and a CO_2 accounting method based on value-added should be established	Producer responsibility, Consumer responsibility
Primarily in trade law literature			
T2	Coercion	Coercion influences human rights behaviour by changing actors' calculations of the price of adopting certain behaviours over others	This rule is not supported by any of the identified principles.
T9	Conciliation	Conciliation is the idea that countries should try to settle disputes on their own whenever possible, through bilateral	Minimum regulatory burden, Non-discrimination

		negotiations, instead of invoking the formal mechanisms of the DSP	
T29	Cooperation	Economic and technical cooperation contributing to liberalisation and facilitation will be actively pursued	Minimum regulatory burden, Non-discrimination
T28	Destination	That goods should be taxed in the country of consumption	Consumer responsibility (trade equivalent)
T17	Discriminatory protection	Provides different levels of protection depending upon where the firm is located	Special and Differential Treatment, Developmental Principles, Common but differentiated responsibilities. Contrary to Non-discrimination
T19	Like products	Trade disputes will often involve an examination of whether the products in question are in competition with one another. The most common term used for this test is to ask whether they are 'like products' — that is, to ask whether products are sufficiently similar for consumers to see them as substitutable — and thus whether they are subject to the rules of the World Trade Organization (WTO) and General Agreement on Tariffs and Trade (GATT)	A definition underpinning non-discrimination
T12	Market access	Nations would prohibit their citizen/residents from impairing access to markets by artificial private, as well as public, restraints	A rule to implement Non-discrimination
T18 T22 T23 T24 T26 T28 T31 T32	Most favoured nation	Requires each member of GATT to offer market access on non-discriminatory terms to all other members of GATT; the non-discrimination requirement under the Article 1 GATT setting forth the MFN principle	A rule to implement Non-discrimination
T11 T18 T26 T28	National Treatment	The products of the territory of any contracting party imported into the territory of any other contracting party shall be accorded treatment no less favourable than that accorded to like products of national origin in respect of all laws, regulations and requirements affecting their internal sale, offering for sale, purchase, transportation, distribution or use'	A rule to implement Non-discrimination
T11	Mutual Recognition	If differences between products legally sold in two member countries arise, the presumption is that they both achieve the same legitimate goals. The EU rules require that "any product imported from	Minimum regulatory burden, Non-discrimination

		another Member State must in principle be admitted into the territory of the importing Member State if it has been lawfully produced, that is conforms to rules and processes of manufacture that are customarily and traditionally accepted in the exporting country, and is marketed in the territory of the latter".	
T8 T22	Nullification / impairment	When a government takes some action that nullifies or impairs a previous concession made to some trading partner, that partner has a potentially legitimate basis from which to file a complaint, even if no violation of GATT/WTO rules is alleged.	Non-discrimination, Minimum regulatory burden
T28	Origin	That products be taxed in the country of production.	Producer responsibility (trade equivalent)
T25	Prohibition on Quantitative Restrictions	WTO Members are prohibited, in principle, from imposing measures that prohibit or restrict both import and export of their goods	Non-discrimination, Least trade restrictive means
T22	Renegotiation	The GATT/WTO explicitly provides for renegotiation. This is true both within a multilateral round of negotiation, and it is also true outside of multilateral rounds	Non-discrimination, Minimum regulatory burden, Flexibility
T29	Review	WTO members should endeavour to respond positively to constructive suggestions from other economies for improving the consistency of existing or proposed cooperative arrangements with the guiding principles	Non-discrimination
T24	Sovereign Equality	Predicated on the assumption that nation states have identical abilities	An assumption that underpins Reciprocity and Non-Discrimination
T29	Simultaneous start, Continuous Process and Differentiated Timetables	APEC economies will begin simultaneously and without delay the process of liberalisation, facilitation and cooperation with each member economy contributing continuously and significantly to achieve the long-term goal of free and open trade and investment	Non-discrimination, Minimum regulatory burden, Reciprocity
T29	WTO-consistency	The liberalisation and facilitation measures undertaken in the context of the APEC Action Agenda will be WTO-consistent.	Non-discrimination

13.4 Table B4: Ideologies and moral philosophies

Ref (Table A1)	Term	Definition
Primarily in trade law literature		

T27	Economic Liberalism	The ongoing commodification and marketization of goods and services in a society
T27	Redistributive Multilateralism	International market activity was embedded within international society by differentiation of obligations and international transfers of wealth from developed to developing countries
T27	Social protection	The opposite of economic liberalism. It posits that certain things – such as labour, natural resources and money, cannot be commodified without risking the foundation of the market society.

14 Appendix C: Principles from carbon accounting practice

14.1 Principles identified

14.1.1 Transparency

The IPCC Guidelines call for **transparency** regarding clear documentation that would allow individuals and groups not involved in initial accounting to understand how it was compiled and to determine whether it meets good practice requirements. The ISO and GHG Protocol definitions are both consistent with this. The ISO definition is most succinct, simply calling for disclosure of sufficient and appropriate information to allow intended users to make decisions (ISO 14064-1 and ISO 14064-2). ISO 14067 is broader, requiring that all relevant issues are addressed and documented in an open and comprehensive manner.

14.1.2 Completeness

The IPCC Guidelines further call for **completeness**, i.e., "that estimates are reported for all relevant categories of sources and sinks, and gases", in addition to making recommendations on completeness of geographic scope of inventories. The ISO and all seven GHG Protocol standards that we reviewed are consistent with this definition, emphasising the need to count all emissions within the chosen boundary and to disclose and justify any exclusions (consistent across all three ISO standards and all seven GHG Protocol standards reviewed).

14.1.3 Consistency

The IPCC Guidelines require reporting entities to use **consistent** methodologies that allow for meaningful comparison of emissions over time, and document changes to data, inventory, boundary, methods, and other factors over time. The ISO 14064-1 and 14064-2 and GHG Protocol definitions are consistent with this. Consistency in ISO 14067 differs from the other practice documents, in that it requires assumptions to be applied consistently throughout a given study and does not refer to changes across time.

14.1.4 Comparability

The IPCC guidelines call for GHG inventories to be reported in a way that is **comparable** to inventories of other countries. This term appears in the GHG Protocol only in the Policy and Action standard, where it is specified as optional. In the GHG Protocol, comparability focuses on ensuring common methodologies to support comparison of changes resulting from policies or other actions; it largely captures the same concerns as the IPCC definition. This term does not appear in the ISO definitions, though ISO 14067 introduces the notion of coherence.

14.1.5 Coherence

Coherence, introduced in ISO 14067 but not appearing in the other two ISO standards reviewed, appears closely related to comparability and requires the use of internationally recognised 'methodologies, standards and guidance documents' to 'enhance comparability' within product categories.

14.1.6 Accuracy

The IPCC Guidelines call for **accuracy**, i.e., the inventory should contain neither underestimates nor overestimates so far as can be judged. The GHG Protocol definition is consistent with this, while the ISO definition is less precise in requiring reporters to reduce bias as far as is practical, in all three ISO standards reviewed.

14.1.7 Relevance

The GHG protocol's corporate accounting and reporting standard requires that the inventory "appropriately reflects GHG emissions of the company and serves the decision-making needs of users" (in all seven of the standards reviewed, see e.g., the Corporate Standard). This is somewhat distinct from the use of relevance in ISO standards ISO 14064-1, 14064-2, and 14067, which state that the GHG sources, sinks, reservoirs, data, and methodologies should be selected appropriate to the needs of the intended user.

14.1.8 Conservativeness

The terminology of conservativeness appears in only one of the seven GHG Protocol standards reviewed (the Project Standard). It requires that GHG reductions should not be overestimated. Conservative does not appear in the IPCC guidelines or in ISO standards 14064-1 and 14067, but does appear in ISO 14064-2 in a means consistent with academic literature and GHG Protocol, i.e., that when completeness, accuracy and precision cannot be achieved, the risk of overestimation of emissions reductions should be minimized.

14.2 Rules identified

14.2.1 *Avoidance of double-counting*

ISO 14067 adds the term "avoidance of double counting", which can be considered as a rule that applies the principle of accuracy.

14.2.2 Priority of Scientific Approach

ISO 14067 introduces the notion that priority should be given to the **scientific approach** to decision-making within product emissions accounting. When addressing allocation dilemmas, for example, preference should be given to 'natural science' to determine the appropriate emissions allocation. Where a scientific approach is unachievable, 'social and economic sciences' and 'international conventions' may be considered.

14.2.3 Specific Life Cycle Analysis Principles (x3)

In addition to the above, ISO 14067 introduces the **life cycle perspective** and identifies 2 further rules/approaches relevant to the life cycle analysis methodology. First, ISO 14067 defines the **relative approach and functional or declared unit**. This rule holds that a life cycle analysis will be relevant if it is structured around a functional unit. Second, the **iterative approach** describes the four phases of LCA - a practical requirement intended to serve accuracy and consistency.

15 Appendix D: Principles Consolidation

The tables in the current appendix (Appendix D) list all the unique principles that were identified from the systematic review of the carbon accounting and trade law literatures (see Appendix B) and from carbon accounting practice (see Appendix C).

Column 1 of the tables identifies the principle using the consistent name from Appendices A and B. Column 2 provides a definition for the context of public embedded emissions accounting design. Column 3 in table D1.1 explains the relationship of the principle to other identified principles.

15.1 D1: Common-goal principles

15.1.1 D1.1: Climate change mitigation common goals principles defined with relevance to public embedded emissions accounting

Principle name in literature	**Definition/relevance to public embedded emissions accounting**	**Relationship to other principles**
Accuracy*	True embedded emissions should neither be under-estimated or over-estimated.	Least restrictive means principle provides a limitation/caveat.
Additionality	Demonstrating that the effect of the intervention would not have happened in its absence.	A special case of accuracy
Additivity	The sum of emissions from accounting modules along a supply chain should equal total supply chain embedded emissions. This implies emissions are neither excluded nor double counted.	Accuracy and Monotonicity imply additivity. Also embedded emissions systems are not yet aiming to cover whole supply chains.
Completeness	All emissions within a defined boundary are included.	Subsumed within Accuracy.
Conservativeness*	Where further accuracy cannot reasonably be achieved, assumptions, default values and alternative methods should be chosen such that the risk of reported emissions (removal) being an underestimate (overestimate) of the true values is minimised.	Provides a principle to compromise between Accuracy and Least restrictive means
Consistency	Emissions accounting systems, boundaries and methods should provide consistency over time. Changes should be documented.	Change documentation is subsumed under Transparency.
Comparability/Coherence	Like methods and boundaries should be used to calculate embedded emissions for like products and processes.	Subsumed in Non-discrimination
Innovation and adaptive management	‘Precautionary action should not unreasonably interfere with an innovation that promises major benefits until the dangers and benefits of this innovation are well understood’	A special case of the Least Restrictive Means.
Monotonicity*	Embedded emissions accounting systems should not allow actors to decrease their reported emissions in a	Supports the principles of Relevance and Accuracy. Subsumes Standstill efficiency principle.

	way that may increase overall emissions.	
Precautionary Principle	Where sufficient accuracy is not possible for new products and processes, conservative assumptions must be applied.	A special case of Monotonicity and Conservativeness
Relevance*	Embedded emissions accounting systems should be designed to support the needs of the intended uses and users.	Subsumes Sensitivity
Robustness	Robust estimates are generally understood not to be sensitive to reasonable alternative methodologies or to the failure of assumptions on which the estimates are based.	Covered by Accuracy, Monotonicity and Non-discrimination
Sensitivity	Actors should be responsible for accounting for products or processes over which they have control.	Covered by Relevance and Subsidiarity.
Transparency*	Information should be provided sufficient to allow stakeholders to assess robustness and reliability.	Least Restrictive Means principle provides a limitation/caveat.

*Principles with an * are identified as the minimum set necessary to capture the broader set of principles across tables D.1.1 and D.1.2.*

15.1.2 D1.2: Free trade common goals principles defined with relevance to public embedded emissions accounting

Accession (non-exclusivity)	(i) Any economy whose government accepts the responsibilities as well as the benefits of following policies compatible with any existing or proposed cooperative arrangements should be able to, and encouraged to, become parties to these arrangements. (ii) Existing parties to these cooperative arrangements should be willing to share the information, experience, expertise and technology needed to enable others to adopt the relevant policies.	Implied by Non-discrimination
Comprehensiveness	The APEC liberalisation and facilitation process will be comprehensive, addressing all impediments to achieving the long-term goal of free and open trade and investment.	Not directly relevant to embedded emissions accounting
Equitable treatment	Fairer trade connotes a more level playing field of equal opportunity, as when bilateral trade agreements benefit the subjects of such treaties through ``preferred" or ``most-favoured-nation" treatment	Synonymous with Non-discrimination
Innovation and adaptive management	'Precautionary action should not unreasonably interfere with an innovation that promises major benefits until the dangers and benefits of this innovation are well understood'	A special case of Least Restrictive Means
Least Restrictive Means*	Embedded emissions accounting systems should be designed to meet the requirements of their intended use in the least trade restrictive means possible.	

Non-discrimination*	Embedded emissions accounting systems should not generate explicit or implicit advantage or disadvantage for like products, where “like” includes true emissions impacts.	
Proportionality	Embedded emissions accounting systems should be designed to meet the requirements of their intended use in the least trade restrictive means possible.	Essentially the same as Least Restrictive Means
Standstill	Refrain from using measures which would have the effect of increasing levels of protection, thereby ensuring a steady and progressive trade and investment liberalisation and facilitation process.	Is the trade version of the principle of Monotonicity (i.e., component measures should not act counter to the overarching goal)
Subsidiarity*	Data collection and accounting should be conducted at the lowest level of aggregation and control that is consistent with meeting its intended use.	Supports Polluter Pays, Minimum regulatory burden, Accuracy, Sensitivity, and Relevance

*Principles with an * are identified as the minimum set necessary to capture the broader set of principles across tables D.1.1 and D.1.2.*

15.2 **D2: Distributional principles defined with relevance to public embedded emissions accounting. CDR and SDT are the current best compromises for carbon accounting and trade law respectively.**

Principle name in literature	**Definition/relevance to public embedded emissions accounting**
Ability to pay principle	Accounting burden should consider ability to pay.
Capability	Most advantaged actors bear the largest accounting burden because of their greater wealth (in terms of welfare levels) and capacities (in terms of institutions, technology, infrastructures, and skills).
Common but differentiated responsibilities (CDR)	Jurisdictions should contribute to development and implementation of an international system of embedded emissions accounting in accordance with their common but differentiated responsibilities and respective capabilities and their social and economic conditions.
Common Concern of Mankind	This recognised a common obligation of all countries to protect contribute to embedded emissions accounting, however with no obligation for countries to share the benefits of using the atmosphere.
Comparability	Countries should endeavour to ensure the overall comparability of their efforts to develop and implement embedded emissions accounting frameworks, taking into account prior investment and efforts.
Consumer responsibility	Asserts that the consumer is the ultimate driver of carbon dioxide emissions and should be responsible for knowing the embedded emissions of what they consume.
Developmental Principles	(i) due to financial, trade, and development needs of developing countries, developed countries should not seek reciprocity in their interactions with developing countries and (ii) in order for North–South collaborative governance to accommodate these needs, there needs to be 'additional' flexibility or explicit de jure SDT provisions for developing countries
Empowerment	The term 'empowerment' refers here to a process through which marginalised individuals and groups are able to exercise a meaningful level of control over the progressive realisation of their own well-being
Equity	Equity recognises that different groups need different resources (or burdens) to each the same outcome
Flexibility	Considering the different levels of economic development and the diverse circumstances, flexibility will be available in dealing with issues arising from embedded emissions accounting frameworks.
Non-differentiated producer responsibility	The NDPR principle redistributes responsibility for emissions accounting along a value chain according to the proportion of profits obtained.
Non-reciprocity	Developed countries should not demand equal investments in embedded emissions accounting from lower income countries.
Polluter-pays	Responsibility for emissions accounting lies at the point of emissions.
Producer responsibility	The producer responsibility principle asserts that the producing country should undertake all the responsibility for the embedded emissions accounting for production steps within their territory.
Reciprocity	Countries will provide market access and information quality equivalent to that provided to them by their trading partners.
Shared responsibility	Advocates that both consumers and producers should share the burden of embedded emissions accounting

Special and Differential Treatment (SDT)	Providing special concession for developing countries, where these concessions are consistent for all developing countries but are not extended to developed countries

*Principles with an * are identified as the minimum set necessary to capture the broader set of principles.*