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Introduction

UNIVERSITY OF MARYLAND
SCHOOL OF PUBLIC POLICY
CENTER FOR GLOBAL SUSTAINABILITY

Authors

Mausami Desai, William Irving, John Steller, Vincent Camobreco, Jiehong Lou, Ryna Cui, Allen Fawcett, Nate Hultman

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1. Introduction

This report describes the methodologies used by the Center for Global Sustainability (CGS) to disaggregate national-level anthropogenic greenhouse gas (GHG) emissions and sinks to the state level while maintaining consistency with the *Greenhouse Gas Inventory and Analysis for the United States: 1990–2024 (GHGIA)* (Desai et al., 2026). State-level data is available on the *GHGIA* website (https://ghgi.cgs.umd.edu) under the Data and Tools tab. CGS intends to continue publishing the national-level *GHGIA* annually each April, presenting time-series estimates by gas, source or sink, and sector. The complementary state-level estimates, hereafter referred to as the *GHGIA by State*, will also be published annually following the release of the national-level report.

The approaches and specific methods for estimating state-level emissions described in this document are consistent with the national-level *GHGIA*, meaning:

- The methodologies and reporting adhere to good practice as defined by the Intergovernmental Panel on Climate Change and to international standards for transparency, accuracy, completeness, comparability, and consistency.
- The estimates are based on the **same methodologies as the national-level *GHGIA*** and reflect methodological refinements and improvements in the national-level *GHGIA*.
- This report covers the years 1990–2024, consistent with the most recent national-level *GHGIA*.
- The **completeness and geographic disaggregation** of the report are consistent with the national-level *GHGIA*, meaning the state-level estimates cover all anthropogenic sources and sinks, and all seven gases (carbon dioxide [CO_2], methane [CH_4], nitrous oxide [N_2O], hydrofluorocarbons [HFCs], perfluorocarbons [PFCs], sulfur hexafluoride [SF_6], and nitrogen trifluoride [NF_3]). In addition to estimates for states, the report also includes emissions and removals occurring in the District of Columbia, U.S. territories, and tribal lands. See Annex 2 for more information on geographic completeness.
- Estimates are compiled to **avoid double counting** or gaps in GHG emissions coverage between states, ensuring that state totals, when summed, equal totals in the national-level *GHGIA*. This is important for data users, who require consistent, comparable, and complete state data for analyses and other purposes.

Official State Inventories

Many states have compiled or are developing their own state-level GHG inventories on a regular basis (e.g., annual, biennial, etc.). The state inventory data accompanying this methodology report should not be considered the official data of any state government. In addition, for states where an official inventory is available, states may find CGS's *GHGIA by State* useful for comparison and quality assurance and quality control (QA/QC), or as a complement or supplement to existing state efforts. Depending on their circumstances and policy needs, states may also choose to adopt the CGS estimates or activity data as part of their official estimates. See Annex 1 to this report for information on where users can find official state-level data.

This methodology document is organized by inventory reporting sectors[6] and their respective source and sink categories, consistent with the national-level *GHGIA*. For users seeking a comprehensive technical understanding of the compilation of *GHGIA by State* emission and sink estimates, CGS recommends reading this methodology report in conjunction with the corresponding sections of the three key references listed in Table 1-1. The *GHGIA by State* emission and sink estimates are compiled to be consistent with the latest national-level GHG data and largely apply or extend methodologies and data previously published by the U.S. Environmental Protection Agency (EPA). The first version of the EPA state report underwent formal peer review in 2021, in addition to technical review by state experts.[7]

Methodological detail is only included in this document for new sources that were not included in EPA (2024). Unless otherwise noted, readers should refer to EPA (2024) for detailed descriptions of disaggregation methodologies. Where previously published methods remain unchanged, CGS summarizes the disaggregation approaches rather than repeating information from the latest national-level inventory report or the previous state-level methodology report.

Table 1-1: Key References for Data Users

Geographic Scope	Report	Publication Source	Publication Date	What to Read
State	Methodology Report Inventory of U.S. Greenhouse Gas Emissions and Sinks by State: 1990–2022	U.S. Environmental Protection Agency (EPA) (EPA, 2024)	September 2024	The sector and source-category-level "Background," "Methods/Approach" and "Uncertainty" sections
National	Inventory of U.S. Greenhouse Gas Emissions and Sinks 1990–2023	EPA (FOIA Release) (EPA, 2025)	May 2025	The relevant sector/source category-upfront content and "Methodology and Time-Series Consistency" and "Uncertainty" sections as appropriate
National	Greenhouse Gas Inventory and Analysis for the United States: 1990–2024 (*GHGIA*)	Center for Global Sustainability (CGS) (Desai et al., 2026)	April 2026	The source category-level "Methodology," "Recalculation," and "Uncertainty" sections

6 The international reporting guidelines require reporting of GHG emissions and removals across five sectors: energy, IPPU, agriculture, LULUCF, and waste. Find international reporting guidelines at https://unfccc.int/process-and-meetings/transparency-and-reporting/reporting-and-review/reporting-and-review-under-the-paris-agreement/national-inventory-reports

7 See https://www.epa.gov/ghgemissions/us-greenhouse-gas-inventory-state-methodology-report-archive for the peer review and supporting files.

Differences Between CGS and Official State GHG Data

CGS's *GHGIA by State* data may differ from inventories developed independently by state governments. These differences can arise for several reasons and do not necessarily indicate that one set of estimates is more accurate or "correct" than another. Consistent with EPA's state GHG data, CGS clearly describes its coverage, methodologies, and accounting approaches to help users understand these differences. CGS's estimates are intended to complement and supplement existing state data. Potential differences between CGS and official state estimates are summarized in Table 1-2.

Table 1-2: Potential Differences Between Official State GHG Inventories and CGS Estimates

Area	Potential Differences
Organization of sectors	CGS has organized estimates by sector and their respective source and sink categories, consistent with the national-level *GHGIA* and with international reporting guidelines. Standardization of sectors in international reporting allows countries to compare data and supports cooperation on climate action. States may use alternate organization of data for presenting emissions and sinks, such as economic sectors, rather than IPCC sectors. Some states may use IPCC sectors as the basis of their inventory, but allocate categories differently across sectors, such as reporting some IPPU categories in the energy sector (e.g., SF_6 from electrical transmission and distribution). Comparability also depends on similar coverage. The completeness and geographic disaggregation of the estimates are consistent with the national-level *GHGIA*, meaning in addition to estimates for states, the methods also address emissions and removals occurring in the District of Columbia, U.S. territories, and tribal lands. ***Note:*** The data accompanying this document also presents estimates using economic sectors, consistent with U.S. energy data conventions (electric power industry, industry, agriculture, commercial, and residential sectors).
Methods and data	As a starting point, CGS generally used either the same methods or methods based on those used to compile the national-level estimates. In some cases, CGS used different methodologies, activity and/or proxy data, and emissions factors to disaggregate national emissions to each state. States may apply the same methods but use different sources of activity data. For example, states may have access to the latest facility-level information through state reporting programs.

Area	Potential Differences
Accounting approaches	States may have adopted different accounting decisions that differ from those adopted for international reporting (e.g., use of different category definitions and emission scopes consistent with state laws and regulations). CGS uses geographic state boundaries to allocate emissions consistent with the international methodological framework for national reporting.[8] This means CGS focuses on emissions that occur within geographic state boundaries ("Scope 1"), whereas some states include emissions that are caused by activity within their borders but which actually occur in other states ("Scope 2 or 3"). In this example, some states include emissions from imported electricity or electricity production that occurs outside state boundaries. States may also use consumption-based accounting approaches, which include emissions resulting from the consumption of goods and services regardless of where they occur. Other possible accounting differences include the approach to estimating transportation, cross-border aviation and marine emissions, or treatment of biogenic CO_2. For example, CGS does not include biogenic CO_2 emissions in state energy sector totals because, in accordance with IPCC methodological guidelines, CO_2 emissions and removals due to the harvesting, combustion, and growth of biomass are included in the carbon stock changes of the relevant land use category of the LULUCF sector where the biomass originates. Including these emissions in both energy sector and LULUCF totals would result in double counting.[9] Users of *GHGIA by State* should take care to review and understand differences in accounting approaches to ensure that any comparisons of estimates are based on an equivalent or an apples-to-apples comparison of estimates.
Time series	CGS has developed state-level estimates for 1990–2024 consistent with the national-level *GHGIA* published in April 2026 and with current international reporting requirements. States may estimate emissions and sinks over a different time period based on state goals, designation of different base years, legislation, and available state data. Some states may not estimate back to 1990 and instead include only more recent years. Other states may have previously published estimates for earlier years but have not recalculated or otherwise updated these estimates in more recent publications despite changes in methods, activity data, or emissions factors. Similarly, new emissions sources may be added in recent years to improve completeness of the inventory, but those sources may be excluded or not estimated in earlier years of the time series (due to lack of data).
Global warming potentials (GWPs)	States may use different metrics for CO_2 equivalency of non-CO_2 gases, such as different values for GWPs. Consistent with the national-level *GHGIA*, CGS is using 100-year GWPs from IPCC's Fifth Assessment Report (AR5) to calculate CO_2 equivalency of non-CO_2 state-level emissions, as required for international reporting of annual national inventories (IPCC, 2014). This requirement ensures that national GHG inventories reported across nations are comparable.

8 See Volume 1, Chapter 8, Section 8.2.1, on Coverage, available online at https://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/1_Volume1/V1_8_Ch8_Reporting_Guidance.pdf. Per the 2006 IPCC Guidelines, national inventories include GHG emissions and removals taking place within national territory and offshore areas over which the country has jurisdiction with some minor exceptions. For example, one exception is "CO_2 emissions from road vehicles should be attributed to the country where the fuel is sold to the end user."

9 See Q2-10 of Frequently Asked Questions on general guidance and other inventory issues: https://www.ipcc-nggip.iges.or.jp/faq/faq.html.

Institutional Arrangements

In preparing the state-level inventory, CGS uses many of the same data arrangements used to compile the national-level *GHGIA* (see Chapter 1. Introduction of the *GHGIA*).

Methodology

Consistent with EPA (2024), three different approaches are applied to disaggregate national estimates to the state level, as described in Table 1-3. CGS ensures consistency with the *GHGIA* by either applying the same methods used to compile national estimates or using methods that are based on those used to compile national estimates.

Within each sector's documentation, CGS has provided a methodology summary table indicating the approach used to disaggregate national estimates to the state level. CGS has also prepared data appendices to provide underlying data and/or relevant proxy information, where possible, to estimate emissions and sinks.

Table 1-3: Disaggregation Approaches

Disaggregation Approach	Description
Use same method as national-level *GHGIA*	The national-level *GHGIA* methods are applied directly at state or finer levels. For example, estimates of forest land remaining forest land and of lands converted to forest land are built from existing data sets that already disaggregate to the state level (see Chapter 5, Table 5.1), and where national estimates reflect aggregation of data estimated at subnational or substate scale. Another example using this approach is state-level fossil fuel combustion estimates, where state energy use data from the U.S. Energy Information Administration (EIA) are used to estimate state-level emissions, i.e., state-level energy use is based on the same basic data sources used to estimate national-level fossil fuel combustion emissions (see Chapter 2, Table 2.1).
Use proxy/indicator data	Estimates are disaggregated from national-level *GHGIA* estimates using geographic proxies or other indicators (e.g., population, production capacity, GHGRP). This approach is applied for categories where it was not possible to apply the same method used for the national-level *GHGIA* (i.e., because state-level data were not available or were incomplete). For example, this approach is used to estimate state-level emissions from other process uses of carbonates (see Chapter 3, Table 3.1) where state-level population is used as a proxy to allocate national emissions. A key factor in this approach is evaluating how well emissions correlate with proxies, and where multiple options exist, how to choose among them.

Disaggregation Approach	Description
Hybrid (e.g., combination of both approaches)	Under this approach, state-level estimates apply a combination of approaches over the time series due to limitations or changes in availability of state-specific data for each year. For example, some estimates may use facility-specific data from EPA's GHGRP, which began collecting data in 2010, as a basis for national- and state-level estimates. For these categories, CGS may use the same method for 2010–2024, while using a proxy approach for earlier years of the time series to estimate state-level emissions, employing IPCC good practice guidance techniques to ensure consistency over the time series to the extent possible.[10] For example, this approach is used to estimate state-level CO_2 and PFC emissions from aluminum production (see Chapter 3, Table 3.1).

Changes from EPA (2024)

CGS follows IPCC good practice by recalculating and revising national-level estimates as better methods and/or data become available. This approach reduces uncertainties over time and improves inventory quality by increasing transparency, completeness, consistency, and overall usefulness. CGS applies the same good practices to state-level estimates. In general, when methodological changes are implemented, the time series in the previous report (i.e., 1990–2023) is recalculated to reflect the change. Note that the most common reason for recalculating national GHG emissions estimates is to incorporate updated statistical data, and changes may impact only recent years of the time series.

Changes or updates made to state-level data are presented within each sector in upfront tables (e.g., 2-2, 3-2, etc.). Although compiled by different organizations, changes to state GHG data between CGS's *GHGIA* report and the previous estimates published by EPA (2025) covering 1990–2023 are considered recalculations and noted within the methodology summary tables. The "Additional Information" column tables indicate reasons for revisions, e.g., whether changes are due to refinements in the national-level *GHGIA* methods and data, including new categories, and/or due to an update that refined the approach and data used to disaggregate national estimates to the state level.

Quality Assurance/Quality Control (QA/QC)

CGS implemented QC procedures during the compilation process to support quality, transparency, and integrity of the *GHGIA by State*. CGS implemented general QC procedures adapted from the national-level *GHGIA* to ensure that data processing and application of methods could easily identify and correct errors (i.e., data/unit transcription, computation, recalculation, and trend checks). Finally, CGS compared the sum of state GHG emission and sink estimates to national emission and sink estimates by gas, category, IPCC sector, and economic sector, for consistency with the national-level *GHGIA.*

10 See Volume 1, Chapter 5: Time Series Consistency from 2006 IPCC Guidelines for National Greenhouse Gas Inventories at https://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/1_Volume1/V1_5_Ch5_Timeseries.pdf.

For quality assurance or review**,** CGS welcomes feedback on this methodology report and the accompanying 1990–2024 state GHG data. Responses to comments received by **November 16, 2026,** will be published with the next methodology report along with an explanation of how CGS addressed comments. Comments received after this date will also be considered as input for preparing future reports. Feedback can be submitted to ghgi@umd.edu. See also Future Areas for Improvement below.

Uncertainty

CGS has not quantified state-specific or category-level uncertainties for the activity data and other parameters used to estimate state-level emissions and removals but has provided qualitative information on how uncertainties compare to those in the national-level *GHGIA.* The uncertainties of state-level emissions estimates are generally expected to be comparable to or higher than the uncertainties of national-level emissions estimates for the reasons listed below. As with the national-level *GHGIA*, the state-level uncertainty estimates for any given source or sink category may change as the understanding of the uncertainty associated with the underlying data parameters and methodologies improves.

- First, where state GHG data is based on the same methodology, uncertainty is expected to be comparable to quantified uncertainty estimates in the national-level *GHGIA*. For example, in the agriculture and LULUCF sectors, uncertainty in state-level emissions estimates is expected to be similar to the uncertainty associated with national estimates since national estimates are developed from emissions estimated at higher resolution spatial scales.
- Second, for cases where proxy approaches are needed to disaggregate national estimates, CGS expects the uncertainty in state-level emissions to be larger than that associated with national estimates as the assumptions involved in the use of proxies contributed additional uncertainty to reported estimates. For example, where total U.S. production is multiplied by an emissions factor to obtain total national-level emissions, but production capacity rather than production is used to allocate the U.S. emissions to facilities and states, variation in each facility's capacity utilization in relation to actual production will not be reflected in the estimates, increasing their uncertainty.
- Third, for some categories where state-level emissions are estimated using the same facility-based methods as are used for national-level emissions (i.e., where same method is used), state-level uncertainties will generally be higher than national-level uncertainties (in percentage terms), assuming the uncertainties in the estimates for each facility and state are independent of each other.
- In instances where hybrid approaches are implemented to disaggregate state-level estimates, uncertainty in reported estimates may be similar or higher in the segments of the time series depending on which portions of the time series employ a proxy and which segments apply the same methods as the national-level *GHGIA*.

For more information on uncertainties with national-level GHG estimates, see Section 1.7 of the Introduction chapter to the national-level *GHGIA*. Category-specific uncertainties for national estimates are discussed qualitatively in the category-specific methodological discussions across the national-level *GHGIA* report, and quantitative estimates are summarized at the end of each sectoral chapter.

Future Areas of Improvement

CGS has outlined areas for improving future annual publications of these data at the sector level. These improvement areas are additional to improvements identified in the national-level *GHGIA*. From a cross-cutting perspective, CGS plans to prioritize the following improvements:

- Publishing key category analyses for each state.
- Implementing additional QA/QC through analysis and comparisons of *GHGIA by State* data with estimates recently published in official state inventories.

References

Desai, M., Camobreco, V., Hedger, T., Irving, W., Rewcastle, K., Steller, J., Barbieri, L., Weitz, M., Murumkar, T., Fawcett, A., Lou, J., Cui, R., & Hultman, N. (2026). *Greenhouse gas inventory and analysis for the united states: 1990-2024*. Center for Global Sustainability, University of Maryland, College Park. https://doi.org/10.13016/g1xw-qftw

Intergovernmental Panel on Climate Change (Ed.). (2014). Climate change 2013 – the physical science basis: Working group I contribution to the fifth assessment report of the intergovernmental panel on climate change (1st ed.). Cambridge University Press. https://doi.org/10.1017/CBO9781107415324

U.S. Environmental Protection Agency. (2024). Methodology report for inventory of U.S. greenhouse gas emissions and sinks by state: 1990–2022. EPA-430-R-24-006. https://www.epa.gov/ghgemissions/methodology-report-inventory-us-greenhouse-gas-emissions-and-sinks-state-1990-2022

U.S. Environmental Protection Agency. (2025). *Inventory of U.S. greenhouse gas emissions and sinks: 1990–2023.* EPA 430-R-25-003. [Unpublished annual report released via Freedom of Information Act Request]