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Agriculture

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4. Agriculture

The agriculture sector includes the following source categories consistent with the national-level *GHGIA*:

- Enteric fermentation
- Manure management
- Rice cultivation
- Agricultural soil management
- Liming
- Urea fertilization
- Field burning of agricultural residues (FBAR)

More information on national-level emissions and methods is available in Chapter 5 of the latest national-level *GHGIA*.

Methodology

Table 4-1 summarizes the different approaches used to estimate state-level agriculture emissions. Overall, the specific methods used to develop state-level emission estimates for 1990–2024 are consistent with those used in EPA (2024a). For some agriculture categories including livestock enteric fermentation and manure management, rice cultivation, agricultural soil management, and field burning of agricultural residues (FBAR), *GHGIA* state and national-level emission estimates are developed using the same underlying data and methods for portions or all of the time series. In these cases, state-level estimates are not derived by "disaggregating" the national-level *GHGIA* estimate and allocating emissions to individual states. Rather, the national-level *GHGIA* methodology uses geographically-specific activity data to develop estimates that can be aggregated to both the state and national levels as part of the same calculation framework. These instances are noted in Table 4-1 as using the same methods as the national-level *GHGIA* (e.g., see the enteric fermentation cattle disaggregation approach for 1990–2022). This designation indicates that state and national estimates are developed using the same underlying methods. For other categories, national-level *GHGIA* estimates are disaggregated or allocated to individual states using proxy data that are available at subnational spatial scales. Geographic completeness is consistent with the national-level *GHGIA* (see Annex 1).

For users seeking a comprehensive technical understanding of the compilation of *GHGIA by State* emission and sink estimates, this methodology report is best read in conjunction with the corresponding sections of the three references provided in Table 4-2. The *GHGIA by State* emission and sink estimates are compiled to be consistent with the latest national-level *GHGIA* data and largely apply methodologies and data previously published by EPA at the national and state levels. Methodological detail is only included in this document for new sources not included in EPA (2024a). Unless otherwise noted, readers should refer to EPA (2024a) 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. Recalculations at the national-level *GHGIA* that impact state-level estimates are discussed in the national-level *GHGIA* Chapter 5.

Table 4-1: Methodology Summary for State-Level Agriculture Sector GHG Emissions Estimates

Category	Gas	Disaggregation Approach	Changes to 1990–2023 estimates from previously published EPA GHGI by state	Additional Information	Data Appendices
Enteric fermentation (*GHGIA* Section 5.1)	CH_4	*Cattle, swine, sheep:* Enteric fermentation state-level emissions are estimated using a combination of approaches across the time series. **1990–2022:** State-level estimates are developed using the same methods as the national-level *GHGIA*. This approach is consistent with the approach previously applied in EPA (2024a). **2023–2024:** Proxy approach; state-level proportions of national livestock populations are applied to national emissions estimates to disaggregate state emissions estimates. This approach is consistent with the approach used to estimate 2021 state-level emissions applied by EPA (2023). *Goats, mules & asses, American bison, horses:* Enteric fermentation state-level emissions are estimated using a	*Cattle, swine, sheep:* **1990–2023:** No *Goats, mules & asses, American bison:* **1990–2017:** No **2018–2023:** Yes *Horses:* **1990–1991:** Yes **1992–2017:** No **2018–2023:** Yes	No changes were made to the disaggregation methods, and the approach is consistent with that used in EPA (2024a). Additional details on changes to emissions data are included below: *Cattle, swine, sheep:* **2023–2024:** National emissions are estimated with the "Simplified Approach" described in *GHGIA* Section 5.1. *Goats, mules & asses, American bison:* **2018–2023:** Revisions to the time series are due to integration of 2022 USDA Census of Agriculture data (USDA NASS, 2024) into the national-level *GHGIA*. State emissions estimates reflect this change in national emissions estimates. *Horses:* **1990–1991:** Revisions to the time series are due to correcting a national-level *GHGIA* error in the	E-1: State Non-Cattle Populations E-2: State Cattle Populations

Category	Gas	Disaggregation Approach	Changes to 1990–2023 estimates from previously published EPA GHGI by state	Additional Information	Data Appendices
		combination of approaches across the time series. **1990–2017:** State-level emissions estimates are developed using the same methods as the national-level *GHGIA*. This approach is consistent with the approach previously applied in EPA (2024a). **2018–2022:** Proxy approach; state-level proportions of national emissions previously reported in EPA (2024a) are applied to the national-level *GHGIA* emissions to compile state estimates. **2023–2024:** Proxy approach; state-level proportions of national livestock emissions are applied to national-level *GHGIA* estimates to derive state estimates, consistent with the approach used in EPA (2023).		extrapolation method used to back cast populations from the 1992 USDA Census of Agriculture data. State emissions estimates reflect this change in the national emissions estimates. **2018–2023:** Revisions to the time series are due to integration of 2022 USDA Census of Agriculture data (USDA NASS, 2024) into the national-level *GHGIA*. State emissions estimates reflect this change in national emissions estimates.	

Category	Gas	Disaggregation Approach	Changes to 1990–2023 estimates from previously published EPA GHGI by state	Additional Information	Data Appendices
Manure management (*GHGIA* Section 5.2)	CH_4 N_2O	*Cattle, swine, sheep:* Manure management state-level emissions are estimated using a combination of approaches across the time series. **1990–2022:** State-level estimates are developed using the same methods as the national-level *GHGIA*. **2023–2024:** Proxy approach; state-level proportions of national livestock manure management emissions applied to 2023–2024 national emission estimates to disaggregate state estimates, consistent with approach used in EPA (2023). *Goats, mules & asses, American bison, horses:* Manure management state-level emissions are estimated using a combination of approaches across the time series.	*Cattle, swine, sheep:* **1990–2023:** No *Goats, mules & asses, American bison, horses:* **1990–2017:** No **2018–2023:** Yes *Horses:* **1990–1991:** Yes **1992–2017:** No **2018–2023:** Yes *Poultry:* **1990–2023:** No	No changes were made to the disaggregation methods, and the approach is consistent with that used in EPA (2024a). See enteric fermentation row above for details regarding revisions to livestock population data for goats, mules & asses, American bison, and horses. State manure management emissions estimates reflect changes in the enteric fermentation estimates for these livestock categories given shared activity data between enteric fermentation and manure management.	

Category	Gas	Disaggregation Approach	Changes to 1990–2023 estimates from previously published EPA GHGI by state	Additional Information	Data Appendices
		1990–2017: State-level emissions estimates are developed using the same methods as the national-level *GHGIA*. **2018–2022:** Proxy approach; state-level proportions of national emissions previously reported in EPA (2024a) are applied to national-level *GHGIA* emissions to compile state-level estimates. **2023–2024:** Proxy approach; state-level proportions of national livestock manure management emissions applied to 2023–2024 national emission estimates to disaggregate state estimates, consistent with the approach used in EPA (2023). *Poultry:* Manure management state-level emissions are estimated using a combination of approaches across the time series.			

Category	Gas	Disaggregation Approach	Changes to 1990–2023 estimates from previously published EPA GHGI by state	Additional Information	Data Appendices
		1990–2022: State-level estimates are developed using the same methods as the national-level *GHGIA*. **2023–2024:** State-level proportions of national poultry populations are applied to national emissions estimates to disaggregate state estimates, consistent with the approach used in EPA (2023).			
Rice cultivation (*GHGIA* Section 5.3)	CH_4	State-level emissions are estimated using a combination of approaches across the time series. **1990–2020:** State-level emissions are estimated using the same method as the national-level *GHGIA*, utilizing prior runs of the Daycent model. **2021–2024:** Proxy approach; national-level *GHGIA* estimates are allocated to states based on each state's average share of national rice cultivation CH_4 emissions over the last three years for which state-level Daycent outputs were available (2018–2020).	**1990–2020:** No **2021–2023:** Yes	No changes were made to the disaggregation methods, and the approach is consistent with that used in EPA (2024a). **2021–2023:** Revisions to the time series are due to updates to the national *GHGIA* forecasting approach for the years beyond the available Daycent model outputs (see *GHGIA* Box 5-1 and Section 5.3). These national-level changes are reflected in state-level emissions estimates.	E-3 Rice Area Planted Data

Category	Gas	Disaggregation Approach	Changes to 1990–2023 estimates from previously published EPA GHGI by state	Additional Information	Data Appendices
Agricultural soil management (*GHGIA* Section 5.4)	N_2O	State-level emissions are estimated using a combination of approaches across the time series. **1990–2020:** State-level emissions are estimated using the same methods as the national-level *GHGIA*, utilizing prior runs of the Daycent model. **2021–2024:** National-level *GHGIA* emissions estimates were allocated to states based on each state's average share of national agricultural soil N_2O emissions over the last three years for which state-level Daycent outputs were available (2018–2020).	**1990–2020:** No **2021–2023:** Yes	No changes were made to the disaggregation methods, and the approach is consistent with that used in EPA (2024a). **2021–2023:** Revisions to the time-series are due to updates to the national *GHGIA* forecasting approach for the years beyond the available Daycent model outputs (see *GHGIA* Box 5-1 and Section 5.4). These national-level changes are reflected in state-level emissions estimates.	
Liming *(GHGIA* Section 5.5)	CO_2	State-level emissions are estimated using a combination of approaches across the time series. **1990–2023:** State-level emissions are estimated using the same methods as the national-level *GHGIA*, utilizing state-level crushed stone data from the U.S. Geological Survey (USGS).	Yes	No changes were made to the disaggregation methods, and the approach is consistent with that used in EPA (2024a). **2022–2023:** Revisions to the time series are due to integration of updated USGS data for the years 2022 and 2023 into the national-level *GHGIA*	E-4: Crushed Limestone/ Dolomite Used for Agricultural Purposes

Category	Gas	Disaggregation Approach	Changes to 1990–2023 estimates from previously published EPA GHGI by state	Additional Information	Data Appendices
		2024: State-level emissions are estimated based on each state's share of national limestone and dolomite consumption for agricultural purposes for the year 2023.		(see *GHGIA* Section 5.5). These national-level changes are reflected in state-level emissions estimates.	
Urea (*GHGIA* Section 5.6)	CO_2	National-level *GHGIA* emissions estimates were disaggregated to the state level based on each state's share of national urea consumption. The national-level *GHGIA* incorporated a new source of activity data from the International Fertilizer Association (IFA) for the 1990–2024 time series. State-level urea consumption was estimated by applying state shares calculated from the previously reported activity data to the updated national activity data.	Yes	No changes were made to the disaggregation methods, and the approach is consistent with that used in EPA (2024a). **1990–2023:** Revisions to the time series are due to integration of updated IFA fertilizer activity data to the national-level *GHGIA*. This change is reflected in state-level emissions estimates.	E-5: Urea Fertilizer Consumption Data

Category	Gas	Disaggregation Approach	Changes to 1990–2023 estimates from previously published EPA GHGI by state	Additional Information	Data Appendices
FBAR (*GHGIA* Section 5.7)	CH_4 N_2O	State-level emissions are estimated using a combination of approaches across the time series. *Sugarcane:* **1990–2020:** State-level emissions are estimated using the same methods as the national-level *GHGIA*, utilizing state-level crop data. **2021–2024:** National-level *GHGIA* sugarcane estimates were allocated to states based on each state's average share of national sugarcane emissions over the last three years for which state-level estimates were available (2018–2020). *All other crops:* **1990–2014:** State-level emissions are estimated using the same methods as the national-level *GHGIA*, utilizing state-level crop data.	*Sugarcane:* **1990–2020:** No **2021–2023:** Yes *All other crops:* **1990–2014:** No **2015–2023:** Yes	No changes were made to the disaggregation methods, and the approach is consistent with that used in EPA (2024a). *Sugarcane:* **2021–2023:** Revisions to the time series are due to updates to the national *GHGIA* forecasting approach for the years beyond the available state-level outputs (see *GHGIA* Box 5-1 and Section 5.7). These national-level changes are reflected in state-level emissions estimates. *All other crops:* **2015–2023:** Revisions to the time series are due to updates to the national-level *GHGIA*	

Category	Gas	Disaggregation Approach	Changes to 1990–2023 estimates from previously published EPA GHGI by state	Additional Information	Data Appendices
		2015–2024: National-level *GHGIA* emissions estimates were allocated to states based on each state's average share of national emissions over the last three years for which state-level estimates were available (2018–2020), by crop type and gas.		forecasting approach for the years beyond the available state-level outputs (see *GHGIA* Box 5-1 and Section 5.7). These national-level changes are reflected in state-level emissions estimates.	

Table 4-2: 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	EPA (2024a)	September 2024	Chapter 1 (Introduction) and Chapter 4 (Agriculture) sector/ source-level "Background", "Methods/Approach" and "Uncertainty"
National	Inventory of U.S. Greenhouse Gas Emissions and Sinks 1990–2023	EPA (2025)	May 2025 (FOIA Release)	Chapter 5 (Agriculture) *source category-level upfront discussion and "Methodology* and Time-Series Consistency" and "Uncertainty" sections as appropriate
National	Greenhouse Gas Inventory and Analysis for the United States: 1990–2024 (*GHGIA*)	CGS (Desai et al., 2026)	April 2026	Chapter 5 (Agriculture) source category-level "Methods," "Recalculation," and "Uncertainty" sections as appropriate, and "Future Areas for Improvement"

Methodology for newly added sources

No new sources were added to the agriculture sector for this current report.

Comparison to national totals

The sum of state totals aligns with the national-level *GHGIA*. Quality control procedures were implemented to review changes to the time series and confirm that agriculture source estimates sum to national estimates. Issues identified during these checks were addressed, and errors were corrected (e.g., computational formula errors, transcription errors, etc.).

Future areas of improvement

Areas for improving state-level agriculture emissions estimates are the same as those presented in Section 5.1 of the national-level *GHGIA* (Desai et al., 2026), including improvement of geographic completeness, given that many state-level agriculture category estimates utilize the same methodological approach as the national-level *GHGIA*. Some state-level planned improvements for agriculture include:

- Revising proxied state-level enteric fermentation and manure management estimates in the latter part of the time series to be consistent with the national estimation methodologies for the entire time series.
- Consider a new agricultural soil management modeling framework that leverages publicly available cropland spatial data and management information.

- Updating the FBAR methodology to incorporate a more comprehensive burned area estimation framework coupled with crop yield information provided by USDA NASS.

References

The references listed below only include new references used for compiling and updating the current *GHGIA by State*. Full citations for all references relevant to compiling national-level Agriculture estimates are found at the end of Chapter 5 (Agriculture) of the national-level *GHGIA* (2026) and its Annexes 5.14–5.16. The national-level *GHGIA* is available online at https://ghgi.cgs.umd.edu/.

General

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Enteric Fermentation and Manure Management

EPA (U.S. Environmental Protection Agency). (2024b). *Inventory of U.S. greenhouse gas emissions and sinks: 1990–2022* (EPA 430-R-24-004). https://www.epa.gov/ghgemissions/inventory-us-greenhouse-gas-emissions-and-sinks-1990-2022

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