Australian Government

Department of Climate Change, Energy, the Environment and Water

DRAFT Greenhouse Gas Emissions Estimation and Reporting Guidelines for Agriculture, Fisheries and Forestry

Methodological Guidance

Chapter 1: General Guidance

Cataloguing data

This publication (and any material sourced from it) should be attributed as: DCCEEW 2025, DRAFT Greenhouse Gas Emissions Estimation and Reporting Guidelines for Agriculture, Fisheries and Forestry - Methodological Guidance, Department of Climate Change, Energy, the Environment and Water, Canberra, February. CC BY 4.0.

This publication is available at dcceew.gov.au.

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Acknowledgements

We thank Environmental Accounting Services for drafting this document, and the Voluntary Greenhouse Gas Estimation and Reporting Standards Reference Group for their valued contributions.

Acknowledgement of Country

We acknowledge the Traditional Owners of Country throughout Australia and recognise their continuing connection to land, waters and culture. We pay our respects to their Elders past and present.

Contents

1 General Guidance

Question Reference 1.1.

As you read the Methodological Guidance, please consider the following questions:

Will the content support you or other users, to collect the appropriate data and undertake emissions estimates?

Could the content be presented in alternative ways to make it more accessible?

Is there fundamental content missing? If so, please outline your suggestions for other material that may be useful.

1.1 Introduction

Understanding the greenhouse gas (GHG) emissions profile of a business is becoming increasingly important for agriculture, fisheries and forestry (AFF) industries. Demand for emissions data is expected to increase, driven by a range of factors including evolving market expectations, and supply chains and financial institutions seeking to monitor progress against voluntary climate commitments. Additionally, some large AFF entities may be required to report under Australia's mandatory climate-related financial disclosures as set out in the *Corporations Act 2001*.

The Australian Government has developed the voluntary GHG Emissions Estimation and Reporting Guidelines for Agriculture, Fisheries and Forestry (the Guidelines) to provide a nationally consistent framework and methods for estimating and reporting GHG emissions and removals from AFF entities.

The Guidelines comprise 2 complementary documents.

- The **Common Requirements Framework** which provides requirements for, and high-level guidance on, establishing boundaries, selecting calculation approaches to estimate GHG emissions and removals, assessing data quality and reporting.
- **Methodological Guidance** (this document) which provides the specific equations, data sources, and calculation protocols needed to estimate emissions in a consistent and verifiable way.

1.2 Purpose of the Guidance

The Methodological Guidance (the Guidance) supports consistent, transparent, and practical estimation and reporting of annual GHG emissions.

Its purpose is to:

- provide methods that are scientifically robust and appropriate for Australian production systems and environments
- reduce variability in reported emissions and removals across GHG calculators
- increase the confidence of producers, advisors, and decision-makers in GHG emissions and removals data.

The Guidance has been designed to:

- align with the Australian National Greenhouse Accounts (NGA) which are used to estimate and track Australia's greenhouse gas emissions[1]. Estimation methods have been adapted for use at the entity level
- build on existing best-practice tools such as the Agriculture Innovation Australia (AIA) Common Accounting Framework Methods and Data Guidance
- align with relevant international standards (e.g. ISO 14064-1:2018, GHG Protocol Corporate and Value Chain (Scope 3) Standards, as well as the Scope 3 Calculation Guidance where practical
- provide a choice of methods so that entities can achieve reliable and consistent estimates aligned with available data and the goals of their inventory.

Through the consistent application of the Guidance, Australian producers will be better positioned to inform emissions reduction strategies and meet GHG reporting requests and requirements.

1.3 Coverage and limitations of the Guidance

Tranche 1 of the Guidance outlines methods for estimation of entity Scope 1 emissions sources associated with Beef, Dairy, Sheep and Cropping activities. It also includes methods for estimation of Scope 2 emissions, and a subset of possible Scope 3 emissions.

The Guidance provide methods for estimating annual Scope 1, 2 and Scope 3 emissions and removals relevant to the following AFF production activities:

- Livestock (beef, dairy, sheep, poultry, pigs and other livestock categories)
- Cropping (grains, legumes, sugar, rice, cotton)
- Horticulture
- Viticulture
- Aquaculture and wild-sea fisheries
- Land Use, Land Use Change and Forestry (LULUCF).

Currently, the Guidance includes estimation methods for a limited subset of Scope 3 categories. Entities will need to assess whether other Scope 3 categories are relevant and material to their inventory. Where applicable, entities may use emission factors from national and international databases to estimate these emissions if required (e.g. Australian Life Cycle Inventory Database, Ecoinvent).

This document does not explain the scientific basis of specific emissions sources and sinks, nor does it repeat foundational inventory design principles or rules outlined in the Common Requirements Framework. However, cross-references are provided to ensure clarity and coherence

For further guidance on the coverage and limitations of the Guidelines, please refer to Section 2.3 of the Common Requirements Framework (CRF).

[1] The agriculture sector methods in the National Inventory Report are currently being updated. The methods provided in the Guidance reflect the most up to date information on the proposed changes and may be revised before publication.

This Guidance is primarily designed for:

- **Producers** who are actively engaged or interested in understanding emissions estimation methods and data collection prioritisation.
- **Advisors, extension officers, and sustainability managers** involved in or supporting emissions reporting.
- **Tool developers** creating or updating GHG emissions calculators.
- **GHG accountants and consultants** working with clients to develop farm level GHG inventories.

To support a broad range of technical and non-technical users, the Guidance uses plain language, includes decision trees and case studies, and emphasises usability.

The methodologies are structured to:

- clearly specify required activity data, emission factors, and their units
- provide guidance on data sources and quality control
- support integration into emissions calculators.

1.4 Using the Guidance

The Guidance adopts a modular approach to support ease of use and flexibility. Estimation modules are structured around specific emission sources and estimation methods, enabling consistent and comprehensive annual emissions reporting. This modular structure allows entities to tailor emissions estimation to their specific reporting boundaries, including mixed production systems, while considering estimation objectives and data availability.

Entities should apply the Guidance using the following stepwise approach:

Step 1. Define organisational and reporting boundaries

Refer to Chapter 5 of the CRF for guidance on establishing boundaries. These boundaries determine which emissions sources and sinks shall be included in the inventory.

Step 2. Identify emissions sources within the reporting boundary (Chapter 2)

Based on the defined reporting boundary and production activities, identify the emissions sources which need to be considered and the relevant estimation modules.

Step 3. Select estimation approach aligned with data availability and inventory goal (Chapters 3-11)

For each identified module, select the estimation approach that best fits the available data and the intended use of the inventory.

Step 4: Collect required data and calculate GHG emissions and removals

Each module includes:

- Step-by-step estimation methods
- Guidance on data requirements and data quality considerations.

Step 5: Ensure transparency and traceability

As modules are applied, it is good practice to document all assumptions, data sources, estimation parameters, and methodological decisions to support transparency.

Case Study 1 gives an example of how to apply the Guidance, including how modules can be mapped to a mixed enterprise system.

Case Study 1 – Application of the Modules in a Mixed System

Entity Description

Silver Meadows Station is a 1500ha property in Western Victoria owned and operated by Fiona and her sister Lauren. In total they have 1050ha of the property under grazing which consists of a flock of 1000 Merino sheep and 200 head of beef cattle for sale to a nearby feedlot for finishing. They also offer agistment to their neighbour, Richard, with 50ha allocated to 20 head of beef.

In good years they grow winter crops including wheat, oats and barley on 300ha. Their parents planted sugar gum managed for wood production throughout the property totalling 100ha over a 5-year period, 20-25 years ago. Fiona and Lauren have been asked to develop a GHG estimate for their bank as they are wanting to incorporate producer specific data into their reporting of financed emissions.

Identifying the Modules

Fiona and Lauren's mixed enterprise needs to consider emissions estimation modules related to pasture-based beef, sheep, and cropping. Sequestration by the sugar gum plantations will be covered by the Land Use, Land Use Change and Forestry module which will be supplied as part of tranche 2 of the Guidelines so is currently excluded from this case study. The relevant emissions modules and sections (see Chapter 2: Implementation Guides) required are outlined below:

Module	Reporting Category	Estimation Module
Enteric fermentation	Scope 1	3.2 and 3.4
Manure management	Scope 1	4.2 and 4.4
Fertiliser use	Scope 1	5.1 – 5.5
Agriculture residue management	Scope 1	6.2 – 6.3
Transport and stationary fuel	Scope 1	8.1 – 8.2
Purchased electricity	Scope 2	10.1
Well-to tank emission from fuel	Scope 3	11.8
Purchased electricity (upsteam)	Scope 3	11.9
Purchased livestock	Scope 3	11.1
Purchased feed and mineral supplements	Scope 3	11.2 – 11.3
Purchased fertiliser	Scope 3	11.4
Purchased herbicides/pesticides	Scope 3	11.5
Purchased lime	Scope 3	11.6
Management of waste	Scope 3	11.10
Purchased services/contractors	Scope 3	11.7

Recording herd movements on Silver Meadows Station is relevant to both cattle owned by Fiona and Lauren and those owned by their neighbour Richard that are on agistment.

If Fiona and Lauren have operational control of the agisted animal (that is, if they are responsible for animal management and performance), they would report enteric fermentation and manure emissions from the agisted stock as their Scope 1 emissions, and Richard would report it as part of his Scope 3 emissions. However, if Richard maintains control of the 20 head of cattle, then the responsibilities for Scope 1 and 3 reporting would be reversed. See Appendix C of the CRF for more information.

1.5 Use of terminology in this document

While use of the Guidelines is voluntary, the Guidance specify requirements that need to be followed to claim compliance with the Guidelines. The following terminology is used:

- 'Shall' indicates what is necessary to meet the minimum requirements of these Guidelines
- 'Should' indicates a recommendation
- 'May' indicates an optional aspect.

1.6 Methods for Estimation

GHG emissions or removals can be estimated in different ways, ranging from simple methods using emission factors or empirical relationships to process-based models and field measurements using highly specialised equipment. The Guidance allows entities to select the calculation method that best aligns with the desired levels of accuracy and data availability.

Calculation methods have been classified according to three Method levels. In general, moving to the higher-level methods improves the accuracy of the estimates and reduces uncertainty. However, the increased complexity and additional data requirements can increase costs and resourcing requirements (**Case Study 1 – Application of the Modules in a Mixed System**

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1. **Method 1** provides the minimum requirement for estimation. It generally applies the emissions factors or empirical relationships from the NGA and requires core site-specific activity data (e.g. head of livestock, tonnes of fertiliser applied). National or regional default values from the NGA are provided for other input parameters

2. **Method 2** is more complex, usually applying the same methodological approach as Method 1 (i.e. the same equations), but requires additional site-specific data. It also includes use of the NGA process-based model FullCAM and the FullCAM-derived SAVCAM tool for LULUCF activities.

3. **Method 3** is most demanding in terms of complexity and data requirements. Method 3 approaches use higher order estimation methods, including sophisticated process-based models (other than FullCAM or SAVCAM) and detailed measurement systems tailored to specific systems, often repeated over time, and driven by high-resolution activity data. The Guidance does not currently provide Method 3 calculation approaches.

The entity should select and use the calculation method(s) that best align with available data and the entity's goal for compiling the GHG inventory. The entity may select different method levels for different sources and sinks. Some sources and sinks may have only one method option available in the Guidance.

It is recommended that Method 2 is adopted where suitable data exists. Method 2 should be considered where mitigation actions or improved management practices are being adopted or verification is needed. When applying Method 2, it is essential to use credible and verifiable sources of entity-specific data. Guidance on data quality requirements for input data sources is provided in relevant modules in Chapters 3 – 11.

The entity shall document the methods applied and any changes in methods since its previous report as per the Reporting requirements set out in Chapter 9 of the CRF.

Table 1.1: Characteristics of data and resulting estimates

Consideration	Method 1	Method 2
Data Source	Some producer level data, but high reliance on default data	High reliance on producer specific data
Accuracy	Low to Moderate	Higher (if properly implemented)
Resource Requirement	Low	Moderate to high
Uncertainty	Higher	Lower (if properly implemented)

1.6.1 Method selection and data collection decisions

Moving from Method 1 to Method 2 may be driven be a range of strategic and operational reasons including:

- **Improved Accuracy and Decision Making:** While Method 1 is designed for simplicity and comparability it can lack precision. Method 2 provides more specific and representative estimates, better reflecting practices, production outcomes, technologies, and emissions more accurately.
- **Compliance and Reporting Requirements:** Certain voluntary or regulatory reporting schemes and frameworks may require more detailed and granular estimates.
- **Risk Management and Corporate Responsibility:** More accurate and representative data can help identify and provide insight into how to mitigate risks associated with significant sources of emissions. Method 2 data can enable more strategic GHG mitigation planning.

It is not always possible to collect high quality data for all sources and sinks that need to be included in an inventory. For this reason, data collection efforts should be prioritised. Entities should prioritise data collection efforts for key sources and sinks (those expected to result in higher emissions or removals, or those showing largest change over time) and for parameters that have the greatest influence of emissions (e.g. animal numbers and liveweight gain, or crop production).

Box 1 presents a conceptual decision tree to help guide Method adoption.

Box 1 – Decision making for method selection and data collection

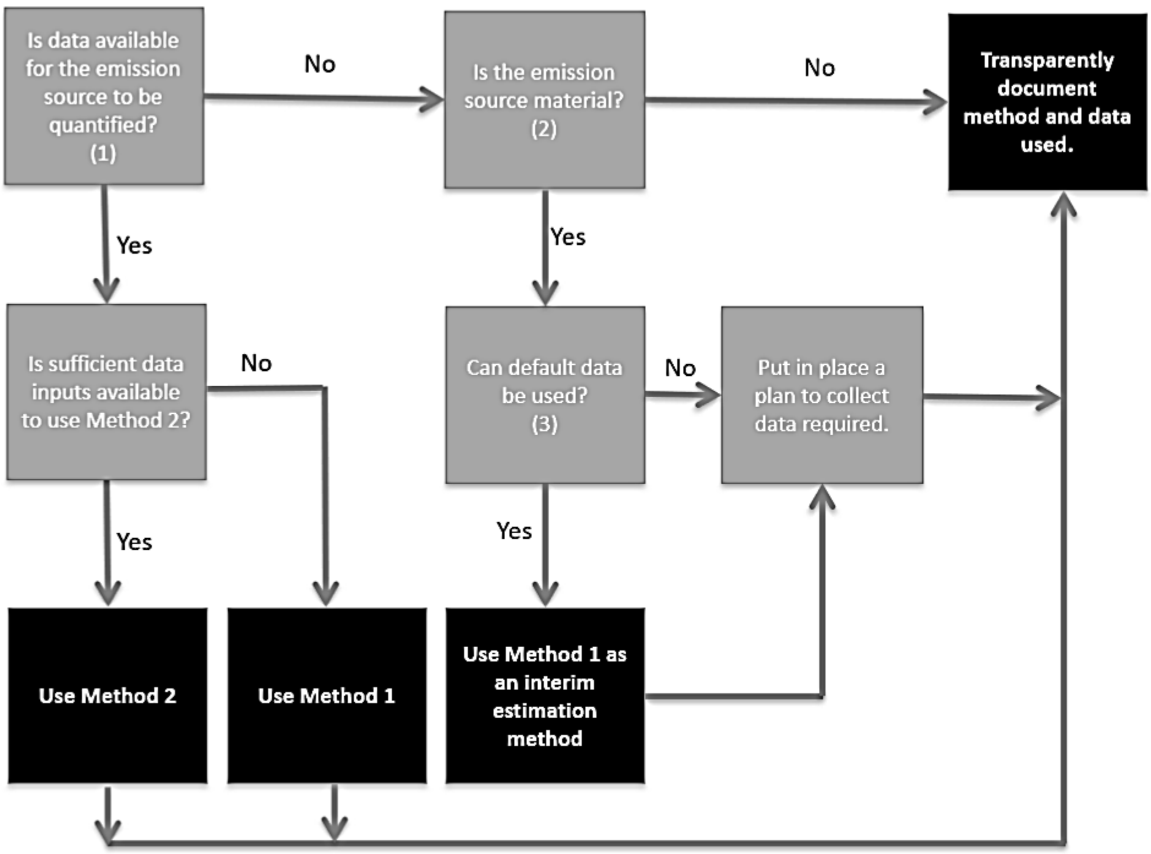


Figure 1.1: Decision making for method selection and data collection

Question 1: Is data available for the emission source to be quantified? Availability of data refers to both data quality considerations (e.g. is there confidence in the data) and time series consistency (e.g. will there be access to the same level of data in subsequent reporting periods). Reliable data sources are needed to have confidence in the estimation of annual emissions and to enable comparison between years.

Question 2: Is the emission source material? Materiality can be an important consideration in decision making related to prioritising resources (e.g. time and money) for data collection. Available resources should be prioritised for data used in Method 2 defined in the relevant modules of the Guidance. Please refer to the CRF for additional guidance on determining materiality.

Question 3: Can default data be used? For emissions sources that are material (significant to the overall inventory) default data should be used over excluding an estimate from the inventory. Data sources can be improved overtime to enable movement from Method 1 to Method 2. Developing estimates with the best available data and Method can provide useful insights for decision making as an alternative to exclusion of the emissions source from quantification.

Case Study 2 – Application of higher Methods

Entity Description

Redridge Herefords is a 2,000-ha mixed enterprise in Southern New South Wales. Joe runs 300 cows for prime beef production and pedigree breeding production. The breeding herd is pasture-based and they finish all animals using a feedlot system. Around 600ha of the property is used for production of canola, wheat, and barley on a rotational cropping system, with a proportion of the yield being kept for feeding and the rest being sold.

Redridge Herefords supplies beef animals to the processor NSW Prime Beef who have offered all producers a bonus if they use specific activity data for scope 1 and 2 estimates. Joe keeps good records on their activities and operations, so he is going to transition to producer-specific Method 2 approaches for his annual GHG inventory.

Identifying the modules requiring higher methodological approaches.

Joe needs to consider a number of emissions estimation modules related to beef and cropping. The Method 2 estimation modules to be adopted by Redridge Herefords are defined below:

Module	Method Required	Higher Methodological Requirement
Enteric fermentation	Method 2	Required to use Method 2 equations and with herd-specific numbers, stay length within finishing system, feed intake and quality information, and production data.
Manure management	Method 2	Required to use Method 2 equations with manure systems proportions, feed intake and quality information, and liveweight gain.
Fertiliser use	Method 2	Required to use Method 2 equations with application records and fertiliser type, including manure and lime applied to soils and rate of application.
Agriculture residue management	Method 2	Required to use Method 2 equations with crop production data.

As there is only one method for Transport and Stationary Fuel Joe adopts Method 1 to estimate these emissions.

As Joe has not purchased any renewable electricity, he uses the Location-based method to estimate his Scope 2 emissions from Purchased Electricity.

Redridge Herefords neighbour, Bob, operates a nearby 1,000 ha sheep breeding enterprise. While he is not yet subject to the same reporting requests, he is aware of the shifting industry requirements and after talking with Joe he voluntarily adopts Method 2 estimation for his annual GHG inventory. During the year, Bob was able to improve the accuracy of his data relating to herd performance, feed efficiency and fertiliser application to move to Method 2 calculations. He found having more accurate data not only improved his GHG estimates, it also highlighted opportunities to improve lambing rates, feed efficiency and animal growth rates within his operation.

For both Redridge Herefords and their neighbour, a focus on data collection provided value in both sustainability reporting and management decision-making.

1.7 Calculating annual GHG emissions and removals

Entities shall estimate and report emissions and removals for the year in which the emissions or removal activity occurs (e.g. year of fertiliser application or land preparation). That is, management inputs should not be allocated across multiple years.

Box 2 ,3 and 4 provide examples of how this operates for land management activities that may follow multi-year cycles or where production cycles are longer the 12 months.

Box 2: Occasional Emissions Activities

Occasional emissions activities are any GHG emitting practice in agriculture or land management that:

- does not occur every year;
- produces emissions (e.g. CO_2, CH_4, N_2O) when it does occur; and
- is linked to regular land management or production cycles.

Examples of occasional emissions activities

Activity	Typical Frequency	Emissions Type
Lime application (to reduce soil acidity)	Every 2–5 years	CO_2 from carbonate dissolution
Infrequent manure spreading from stockpiled waste	Irregular	N_2O from agricultural soils
Pasture renovation	Irregular	N_2O from agricultural soils

Although some agricultural practices (like liming, manure application, or fertiliser use) may follow multi-year cycles, emissions from these practices should not be allocated across the cycle.

In practice, this requires:

- Tracking the actual timing of occasional activities (e.g. liming events).
- Inclusion of zero emissions for years in which the activity does not occur.

Case Study 3 - Lime Application

Entity Description

Dawnbank is a 3,000ha cropping and sheep entity located just outside of Tardun, Western Australia. Dawnbank is managed by Eamon and his family, who manage a flock of 500 merino sheep with 2000 ha of arable cropping. The sheep flock is a pasture-based system, and the arable enterprise focuses on production of wheat, canola and lupins.

Agricultural lime is applied at intervals between three-five years across both the arable and pasture areas to manage soil acidity. Dawnbank is required to prepare an annual GHG inventory under their bank's sustainability-linked lending arrangement.

Identifying the emission profile

Eamon needs to consider a number of emissions estimation modules related to sheep and cropping to develop his annual emissions as defined below:

Module	Reporting Category	Description
Enteric fermentation	Scope 1	Emissions from sheep
Manure management	Scope 1	Emissions from manure voided to pasture
Fertiliser use	Scope 1	Application of fertilizer, lime and emissions from manure voided to pasture
Crop Residues	Scope 1	Residue breakdown from arable crops
Fuel Use	Scope 1	Emissions from machinery and irrigation
Purchased Electricity	Scope 2	Emissions from Dawnbank operation
Various scope 3 modules	Scope 3	Purchases and management for Dawnbank operation

The occasional application of lime causes an 8% spike in Dawnbanks emissions in the year of application. Eamon wonders if he should spread the GHG impact of liming across the 3 years between application to smooth the emissions across the time period.

In developing an annual GHG estimate, emissions must be reported in the year that the emissions activity occurs and not evenly spread across the intervening three years between lime applications.

The bank requires the GHG inventory for their total financed emissions and is not interested in one producers' data in isolation but rather is focused on their portfolio of producers. Variations in annual emissions on individual basis are evened out across management schedules of all the producers in their portfolio.

Case Study 4 - Longer than 12-month production/lifecycles.

Entity Description

Rivercut Farm is a 1,200ha sugar cane producer located in Northern Queensland, Australia. The producer operates under a continuous ratoon cycle. The average sugar cane crop cycle is typically one plant crop followed by 3-4 ratoon years each of 12-24 months duration.

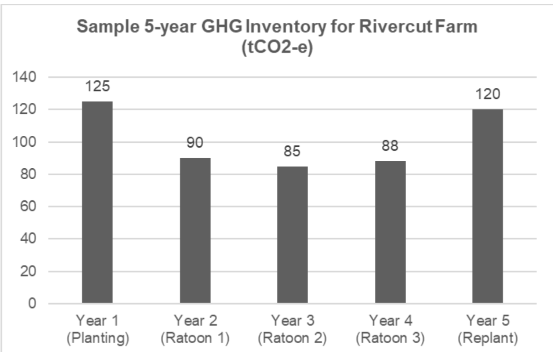
Rivercut Farm sells their sugar cane to a local brewed drinks company; the brewing company requires the producer to produce an annual GHG inventory. Although the production life cycle of sugar cane extends beyond 12 months, Mike must produce an annual GHG inventory report that ensures emissions are reported in the year the activity takes place.

Identifying the impact of extended production or lifecycles

Mike needs to consider a number of emissions estimation modules related to cropping. The impact of longer production or lifecycles for relevant emissions modules to be adopted by Rivercut Farm are defined below:

Module	Reporting Category	Description
Fertiliser use	Scope 1	Various applications depending on growth stage
Soil Management	Scope 1	Lime application once every five years
Crop Residues	Scope 1	Residue breakdown from sugar cane harvest
Fuel Use	Scope 1	Influenced by production stage requirements
Purchased Electricity	Scope 2	Rivercut Farm operation
Various scope 3 modules	Scope 3	Purchases and management practices for Rivercut Farm operation

Rivercut Farms annual GHG inventory doesn’t mirror other arable crops due to certain practices (e.g. land preparation, planting and harvesting occurring non-annually). Despite the multi-year crop cycle, Mike ensures the GHG inventory aligns with the 12-month reporting window.



Temporal allocation of emissions results in yearly variability in emission estimates, with higher emissions in planting years compared to ratoon years. Both Rivercut Farm and the brewing company understand this variability and are both transparent in reporting of annual GHG inventories and consideration of the long-term average emissions and trends in their disclosures.

Rivercut Farm chooses internally to evaluate the GHG emissions of the crop on a 5-year cycle, so that planting vs planting and ratoon vs ratoon years can be compared. This allows Mike to review his emissions over time, isolate key drivers of emissions and account for other annual fluctuations. This approach allows Rivercut Farm to highlight areas of improvement, understand the areas which impact the crops emission portfolio, and isolates emission sources within his control and those outside his control. This knowledge will allow Mike to better communicate with their supply chain.

1.8 Spatial boundary considerations

For some Methods, emissions factors and default parameters vary by location reflecting differences in climate, rainfall, soil type, and management practices. As these variables can significantly influence GHG emissions it is essential that entities apply the correct spatial boundary estimating emissions.

1.8.1 Application across multiple spatial boundaries

When an entity's operations span multiple states, regions, or climate zones, and the Guidance provides location-specific emission factors or data, the following approach must be applied:

- stratify activities across regions—even within a single property or organisational boundary
- apply location-specific emission factors or default parameters as required
- document and transparently disclose all methodological assumptions.

The stratification approach requires completion of the following steps:

1. Define the activity data metric (e.g., hectares, head of livestock, or hours of equipment use)
2. Allocate the activity data metric to the stratified region or zone.
3. Apply the appropriate location-specific emission factor or parameter to estimate the total emissions from each stratum.
4. If detailed sub-entity or paddock-level data is unavailable, to match the activity to the geographic area (i.e. the production occurring in respective regions), then use a proportional allocation method. For example, if 30% of the property lies in one region, and 70% in another, allocate activity data accordingly and apply the relevant region-specific emission factors.
5. Sum emissions across all strata to calculate the total emissions estimate.

Using a single emission factor for the entire area, based on the region with the majority of activity, can lead to biased results if emission factors differ significantly across regions. A stratified approach aligns with the principle of completeness and ensures that all material sources are accounted for. Additionally, third-party verifiers typically expect regional disaggregation when emission factors vary materially.

However, applying a single emission factor may be acceptable when:

- The region in question represents a small proportion (typically less than 5–10%) of the total activity area, and
- The emission factors across regions are similar, such that the impact on total emissions is immaterial

In such cases, the assumption must be clearly documented and justified as a simplification.

1.8.2 Leaching, climate and rainfall zones

DCCEEW is working to prepare spatial layers to support the assessment for these zones. Once available, more guidance will be provided on use of these layers.

If entities are required to apply Modules 4-6 (Manure management, Fertiliser and Residue Management) they shall identify the relevant climate zone, rainfall zone, and leaching zone in which their operations are located. Table 1.2 summarises the classifications that exist for each zone.

Table 1.2: Climate and Rainfall zone classifications and definitions

Zone	Classification	Definition				
		MAT	MAP	Frost days per year	Elevation	MAP:PET
Climate zone	Tropical montane	> 18 °C	N/A	≤ 7	>1000 m	N/A
	Tropical wet	> 18 °C	> 2000 mm	≤ 7	≤ 1000 m	N/A
	Tropical moist	> 18 °C	1000 mm < MAP ≤ 2000 mm	≤ 7	≤ 1000 m	N/A
	Tropical dry	> 18 °C	> 1000 mm	≤ 7	≤ 1000 m	N/A
	Warm temperate moist	10 °C < MAT ≤ 18 °C	N/A	> 7	N/A	>1
	Warm temperate dry	10 °C < MAT ≤ 18 °C	N/A	> 7	N/A	≤1
	Cool temperate moist	0 °C < MAT ≤ 10 °C	N/A	> 7	N/A	>1
	Cool temperate dry	0 °C < MAT ≤ 10 °C	N/A	> 7	N/A	≤1
Rainfall zone	High rainfall	Annual rainfall > 600m				
	Low rainfall	Annual rainfall ≤ 600m				
Leaching zone	Leaching occurs	$\sum(rain) > \sum(ET_0) + soil\ water\ holding\ capacity$				
	Leaching does not occur	$\sum(rain) \leq \sum(ET_0) + soil\ water\ holding\ capacity$				

Note: MAT = mean annual temperature, MAP = mean annual precipitation, PET = potential evapotranspiration.

Climate Zone

The climate zone shall be selected based on the mean annual temperature, mean annual precipitation, annual frost days, elevation, and the ratio of precipitation to evapotranspiration.

A spatial dataset of climate zones across Australia should be referred to, to determine the relevant climate zone for use in the emission estimation.

Rainfall Zone

Rainfall zones are split into two levels: high rainfall and low rainfall. The threshold between the two zones is an annual rainfall of 600 mm. All areas of receiving more than 600mm of rain in the reporting year are classified as the high rainfall zone, those areas below 600mm are classified as low rainfall.

Rainfall data from the year of reporting can be used. It is recommended to use rainfall data collected directly on-site, where this is done reliably and accurately, or use data from a local weather station.

Leaching Zone

Areas are subject to leaching (i.e., in the leaching zone) when either of the following occurs:

- the annual precipitation exceeds the sum of evapotranspiration and soil water holding capacity, or
- the land is irrigated (except drip irrigation).

Climate data should be used when $\sum(\text{rain}) > \sum(ET_0)$ + soil water holding capacity for any non-irrigated enterprises, to determine whether they are located in a leaching zone. Climate data for rainfall, evapotranspiration and soil water accumulation can be sourced from the following resources;

- eWater Toolkit[2]
- TERN[3]
- Department of Primary Industries and Regional Development[4]

[2] eWater Toolkit climate dataset is available at: https://toolkit.ewater.org.au/Tools/Category-Climate
[3] TERN actual evapotranspiration dataset is available at: https://portal.tern.org.au/metadata/TERN/9fefa68b-dbed-4c20-88db-a9429fb4ba97
[4] Department of Primary Industries and Regional Development water tool is available at: https://www.dpird.wa.gov.au/online-tools/rain-and-irrigation-calculators/soil-water-tool/

1.9 Herd flow and liveweight estimation

When estimating livestock emissions, the accuracy of reported stock numbers and their liveweight (LW) and liveweight gain (LWG) during the reporting period, can significantly influence the greenhouse gas estimates. Two methods are presented to reflect situations where such data is collected by producers in varying temporal scales.

The following data shall be available under Method 1:

- Stock numbers for each livestock class within the entity at the first and last month of the reporting period and/or at the point of birth, death, purchase, or sale of the livestock class.

The following data shall be available under Method 2:

- Stock numbers for each livestock class within the entity at the first and last month of the reporting period and/or at the point of birth, death, purchase, or sale of the livestock class, and
- liveweight and liveweight gain for each livestock class within the entity at the month of data collection.

For both Method 1 and Method 2, livestock numbers are assumed to be constant between data entry points. For Method 1, the numbers of livestock are estimated seasonally to align with default liveweights and liveweight gain values (see Chapter 3 Sections 3.2.1.1, 3.3.1.1 and 3.4.1.1, and Chapter 4 Sections 4.2.1.1, 4.3.1.1 and 4.4.1.1, Method 1 for liveweight and liveweight gain). Livestock numbers shall be rounded up if seasonal estimates do not produce a whole number.

For Method 2, where liveweight for different livestock classes is available at multiple points throughout the year, liveweight and liveweight gain will be linearly estimated between data points based on the number of days between liveweight measurements (see Chapter 3 Sections 3.2.1.2, 3.3.1.2 and 3.4.1.2, and Chapter 4 Sections 4.2.1.2, 4.3.1.2 and 4.4.1.2, Method 2 for liveweight gain).

Producers can use a combination of default liveweights for some livestock classes and their own liveweight data (a mix of Method 1 and Method 2). See Chapter 3, Sections 3.2.1.2, 3.3.1.2 and 3.4.1.2, and Chapter 4, Sections 4.2.1.2, 4.3.1.2 and 4.4.1.2, Method 2 for liveweight.

It is assumed stock counts and liveweights are reported at the 1st of the month. Specifically, if liveweights are reported in consecutive months it will be assumed 28, 29, 30 or 31 days are between these measurements depending on the months of data collected.

Method 2 can easily be modified to the annual period required for reporting (calendar or financial). Guidance on prioritising data collection provided in Section 1.6.1 applies when considering increasing the frequency of recording and reporting of livestock numbers and liveweight data.

Case Study 5 – Herd Flow (minimum data option)

Entity A

Redbrook Station is a 1,000-ha beef breeding property located in Northern Queensland. Redbrook runs 200 breeding cows in a spring calving system, and sells the calves as weaners the following winter, in August. The station is completing its annual GHG inventory, and has limited monthly stock numbers due to the extensive nature of the operation. Redbrook's annual GHG inventory is estimated and reported on a financial year basis from 1 July to 30 June, and they have a stock count of each livestock class in July.

Redbrook sold all bull and heifer calves in August to a beef finishing property. The producer recorded no additional sales, births or deaths in the other livestock classes for August and as such livestock numbers are assumed to stay the same.

Table 1.3: Example minimum input data requirements for GHG emissions estimation: July – August

Numbers on hand			
Livestock Class		**Jul**	**Aug**
Cows >3 year	Head	200	200
Breeding Bulls	Head	7	7
Bull calves	**Head**	**98**	**0**
Heifer calves	**Head**	**102**	**0**

Redbrook starts calving in November and finishes calving in March. Calving numbers are difficult to track per month due to the extensive nature of the operation. The producer rounds up all cattle at the end of the calving season in March, and counts all livestock. All calves born in the period are attributed to March as actual number of births per month are unknown. Any unproductive stock also leaves Redbrook in March. The updated stock numbers are recorded for March; no other sales or deaths were recorded from August to February so numbers are assumed to stay the same between recording events.

Table 1.4: Example minimum input data requirements for GHG emissions estimation: July – March

Numbers on hand													
Livestock Class		**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**
Cows >3 year	Head	200	200							**195**			
Breeding Bulls	Head	7	7							**6**			
Bull calves	Head	98	0							**95**			
Heifer calves	Head	102	0							**100**			

Redbrook was not able to recount livestock again before the end of the inventory period in June, but no additional births, deaths or sales were recorded, so the producer assumes the closing stock numbers match the most recent stock count from March.

As only the Method 1 data is available these livestock numbers are translated into seasonal categories to allow seasonal defaults for live weight (LW) and liveweight gain (LWG) to be applied (Method 1). This is demonstrated in Table 1.5. It is assumed the numbers of animals remains constant between stock counts the number of cows>3 years in spring and summer is 200 or each season and the number of breeding bulls stays constant at 7. In Autumn calves are born and counted and their numbers are assumed to stay constant at 95 and 100 respectively for this season. Another stock count of cows and bulls is performed at this time and the new values are used for autumn. As winter crosses the reporting period and there are different stock counts for each class a weighted average is calculated across the values recorded in the winter months and this number is reported for winter.

For example:

Number of Cows > 3 years in Winter = (200 x 31) + (200 x 31) + (195 x 30) / (31 + 31 + 30) = **198**

Number of Breeding Bulls in Winter = (7 x 31) + (7 x 31) + (6 x 30) / (31 + 31 + 30) = **7**

Number of Bull Calves in Winter = (98 x 31) + (0 x 31) + (95 x 30) / (31 + 31 + 30) = **64**

Number of Heifer Calves = (102 x 31) + (0 x 31) + (100 x 30) / (31 + 31 + 30) = **67**

Table 1.5 demonstrates Seasonal defaults for live weight (LW) and liveweight gain (LWG) can be added based on producer location. Redbrook is located in a moderate/high region of Queensland, so those values found in Chapter 12; Appendix Table 12.1.1.2 and 12.1.1.4.

Table 1.5: Complete translation of minimal data requirements to Method 1 emission estimation parameters

Values as used in calculations					
Livestock Class		**Spring** **Sept-Nov**	**Summer** **Dec-Feb**	**Autumn** **Mar-May**	**Winter** **June-Aug**
Cows >3 year	Head	200	200	195	198
	LW (kg)	467	477	471	484
	LWG (kg/day)	-0.19	0.63	0.04	-0.02
Breeding Bulls	Head	7	7	6	7
	LW (kg)	674	669	685	692
	LWG (kg/day)	-0.19	0.19	0.13	-0.06
Bull calves	Head	0	0	95	64
	LW (kg)	-	-	172	241
	LWG (kg/day)	-	-	0.7	0.32
Heifer calves	Head	0	0	100	67
	LW (kg)	-	-	172	208
	LWG (kg/day)	-	-	0.52	0.25

Case Study 6 – Herd Flow (detailed data option)

Entity B

Cloveline Sheep Farm is a 1,000-ha self-replacing Merino enterprise in Tasmania. Cloverline runs 2,200 breeding ewes, supported by rams and replacement ewe lambs, with lambing occurring in late winter, early spring (August-September). The producer keeps detailed monthly stock records, tracking head counts, births, sales and deaths, supported by regular weigh-ins at weaning, pre-joining, and drafting.

The producer is completing its annual GHG inventory, and has chosen to use their more detailed data for stock numbers and liveweights in the creation of a more specific GHG emissions estimation. The producer took a stock count and weighed all livestock before the beginning of lambing in July.

Cloveline counts as they are born, and assigns total number of lambs and average lamb weight per livestock class to August as the majority of lambing takes place in this month. There were no recorded deaths or sales for other livestock classes, so numbers are assumed to remain the same, the ewes and rams were not weighed again.

Table 1.6: Example detailed data input for more specific GHG emissions estimation: July – August

Numbers on hand			
Livestock Class		**Jul**	**Aug**
Ewes	Head	2200	**2200**
	LW (kg)	60	**-**
Rams	Head	40	**40**
	LW (kg)	70	**-**
Maidens	Head	250	**250**
	LW (kg)	50	**-**
Ewe lambs	Head	0	**1000**
	LW (kg)	-	**15**
Male lambs	Head	0	**1000**
	LW (kg)	-	**15**

The producer proceeds to count and weigh the livestock at different times throughout the year in line with various operational events. The information is stored in stock records; an example entry is demonstrated in Table 1.12.

Table 1.7: Demonstrating example livestock stock record entry: September – June

September	-
October	2200 ewes average 55kg – sold 50 ewes
November	40 Rams averaging 70kg – sold 10 rams
December	250 maidens averaging 55kg – sold 5 maidens 1000 ewe lambs averaging 35kg – sold 500 ewe lambs 100 male lambs averaging 35kg – sold 750 male lambs
Jan	-
Feb	250 male lambs averaging 40kg
March	2150 ewes averaging 60kg – sold 450 ewes 30 rams averaging 70kg – brought 10 rams 250 male lambs averaging 40kg – sold 250 male lambs
April	-
May	-
June	1700 ewes averaging 65kg 40 rams averaging 65kg 245 maidens averaging 60kg – 5 maidens sold 250 ewe lambs averaging 50kg

This information can be translated into the detailed data input table as demonstrated in Table 1.13. All deaths, births and sales are recorded in the livestock stock records, so numbers between recording events are assumed to remain unchanged. Counting and weighting events are bolded in Table 1.8 to demonstrate when livestock numbers have changed based on farm records.

Table 1.8: Example detailed data input for more specific GHG emissions estimation

		Numbers on hand each month											
Livestock Class		**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**
Ewes	Head	2200	2200	2200	**2150**	2150	2150	2150	2150	**1700**	1700	1700	**1700**
	LW (kg)	60	-	-	**55**	-	-	-	-	**60**	-	-	**65**
Rams	Head	40	40	40	40	**30**	30	30	30	**40**	40	40	**40**
	LW (kg)	70	-	-	-	**70**	-	-	-	**70**	-	-	**65**
Maidens	Head	250	250	250	250	250	**245**	245	245	245	245	245	**240**
	LW (kg)	50	-	-	-	-	**55**	-	-	-	-	-	**60**
Ewe lambs	Head	0	1000	1000	1000	1000	**500**	500	500	500	500	500	**250**
	LW (kg)	-	15	-	-	-	**35**	-	-	-	-	-	**50**
Male lambs	Head	0	1000	1000	1000	1000	**250**	250	**250**	**0**	0	0	0
	LW (kg)	-	15	-	-	-	**35**	-	**40**	**0**	-	-	-

Liveweight gain is assumed to have occurred linearly between data entry points.

For example, the weight gain between October and March for breeding ewes is calculated by:

Average weight gain per day= (60-55)/(30+31+30+28+30) = 0.03

Average weight for November = 55 + (30 x 0.03) = 56

Table 1.9 demonstrates the more detailed data on stock numbers and liveweights held by Cloveline farm is translated to create a more specific data which will allow for more specific GHG emission estimate.

Table 1.9: Translation of more detailed input data to Method 2 emission estimation parameters

	Numbers as used in calculations including specific weights												
Livestock Class		**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**
	Days	31	31	30	31	30	31	31	28*	31	30	31	30
Ewes	Head	2200	2200	2200	2150	2150	2150	2150	2150	1700	1700	1700	1700
	LW (kg)	60	**58**	**56**	55	**56**	**57**	**58**	**59**	60	**61**	**63**	65
	LWG (kg/day)	**-0.05**	**-0.05**	**-0.05**	**-0.03**	**0.03**	**0.03**	**0.03**	**0.03**	**0.03**	**0.05**	**0.05**	**0.00**
Rams	Head	40	40	40	40	30	30	30	30	40	40	40	40
	LW (kg)	70	**70**	**70**	**70**	70	**70**	**70**	**70**	70	**68**	**66**	65
	LWG (kg/day)	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**-0.05**	**-0.05**	**-0.05**
Maidens	Head	250	250	250	250	250	245	245	245	245	245	245	240
	LW (kg)	50	**51**	**52**	**53**	**54**	55	**56**	**57**	**57**	**58**	**59**	60
	LWG (kg/day)	**0.03**	**0.03**	**0.03**	**0.03**	**0.03**	**0.03**	**0.03**	**0.03**	**0.03**	**0.03**	**0.03**	**0.03**
Ewe lambs	Head	0	1000	1000	1000	1000	500	500	500	500	500	500	250
	LW (kg)	-	15	**20**	**25**	**30**	35	**38**	**40**	**42**	**45**	**47**	50
	LWG (kg/day)	**-**	**-**	**0.16**	**0.16**	**0.16**	**0.08**	**0.08**	**0.08**	**0.08**	**0.08**	**0.08**	**0.00**
Male lambs	Head	0	1000	1000	1000	1000	250	250	250	0	0	0	0
	LW (kg)	-	15	**20**	**25**	**30**	35	**38**	40	-	-	-	-
	LWG (kg/day)	**-**	**-**	**0.16**	**0.16**	**0.16**	**0.08**	**0.08**	**0.08**	**-**	**-**	**-**	**-**

*Number of days to be adjusted if reporting period is a leap year

Case Study 7 – 18-month Herd Flow

Entity C

Mountview Farm is a beef farm in Northern Queensland which buys weaner steers for finishing. The producer buys all weaners in April, keeps them for 18 months until finishing and sells them the following October. The producer only has livestock numbers and weights from point of purchase and point of sale, but is required to conduct a 12-month GHG inventory for their processor.

Mountview can use a detailed data input option as they can use the livestock numbers and weight information from point of purchase and point of sale to create a detailed data input table. The producer has the following information from their purchase and sales records.

- Purchase record = 1200 steers averaging 180kg (April Year 1)
- Sale record = 1195 steers averaging 528kg (October Year 2)

The producer decides to conduct the 12-month inventory assessment from April year 1 to April in year 2. The producer does not have reliable records for the 5 deaths which occurred so the stock records remain constant from the purchase until the sale month. The liveweight is assumed to have occurred linearly.

For example, the weight gain between October and March for breeding ewes is calculated by:

Average weight gain per day= (528-180)/(30+ 31+ 30+ 31+ 31+ 30+ 31+ 30+ 31+ 31+ 28+ 31+ 30 + 31+ 30+ 31+ 31+ 30) = 0.635

Average weight for May = 180 + (30 x 0.635) = 199

Table 1.10: Linear application of livestock numbers and weights over an 18-month period

			Year 1														**Year 2**					
			Apr	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**		**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**
		Days	30	31	30	31	31	30	31	30	31	31	*28	31	30		31	30	31	31	30	31
Livestock Class	Steers **<1**	Head	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	Steers **>1**	1200	1200	1200	1200	1200	1195
		LW (kg)	180	199	218	237	257	277	296	315	334	354	374	392	411		430	450	469	489	508	528

*Number of days to be adjusted if reporting period is a leap year

The producer takes the data specific to the 12-month assessment period chosen for the inventory and adds liveweight gain, which is assumed to have occurred linearly. Table 1.11 demonstrates how the stock numbers and liveweights held by Mountview farm from two points in time, are translated to create specific data which will allow Method 2 herd flow approach to be applied.

Table 1.11: Translation of 18-month data into a 12-month inventory aligned detailed input data for Method 2 emission estimation parameters

Numbers as used in calculations including specific weights															
			Apr	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**
		Days	30	31	30	31	31	30	31	30	31	31	*28	31	30
Livestock Class	Steers <1	Head	1200	1199	1199	1199	1198	1198	1198	1198	1197	1197	1197	1196	1196
		LW (kg)	180	199	218	237	257	277	296	315	334	354	374	392	411
		LWG (kg/day)	**0.635**	**0.635**	**0.635**	**0.635**	**0.635**	**0.635**	**0.635**	**0.635**	**0.635**	**0.635**	**0.635**	**0.635**	**0.635**

*Number of days to be adjusted if reporting period is a leap year

1.10 Frequently Asked Questions

This section covers some of the concepts in the Case studies but in a different format to accommodate different user needs. Suggestions of other FAQs to include are welcome.

1. What's the difference between Method 1 and Method 2?

- Method 1: Uses default data (like national averages) with some basic records from producers. Easier and quicker, but less precise.
- Method 2: Uses your own detailed records (like livestock weights or fertiliser amounts). More accurate, could be required for reporting or to show the benefits of your management practices.

See Section 1.6 for more guidance

2. Do I need to use Method 2 straight away?
Not necessarily. Start with Method 1 if you don't have detailed data. Move towards Method 2 over time, especially for major emission sources or if required by banks, buyers, or certification schemes. See Box 1 for more guidance.

3. I run both livestock and cropping – how do I account for everything?
You'll need to apply the modules for each relevant activity (e.g. enteric fermentation, manure management, fertiliser use, crop residues, fuel use). Together they give a complete GHG estimate. See Case Study 1 for more guidance

4. I have solar panels. How does this renewable energy get included in my estimates?

Unlike grid supplied power, renewable energy produced on-site produces zero emissions. In other words, the emissions factor applied to a kilowatt hour of renewable energy is 0. The impact of renewable energy on your GHG estimates comes from a lowering of the total kilowatt hours you draw from the grid which has an emissions factor greater than 0.

Any renewable energy that is generated on your site but sold off-site shall not be reflected in inventory totals. Inclusion of renewable energy will impact scope 2 purchased electricity, and scope 3 upstream emissions of electricity within the inventory assessment.

See Chapter 10 and 11 for estimation methods for scope 2 and 3 electricity.

5. How do I account for emissions from lime application in one year that affects yield in subsequent years?

Agricultural activities vary over a set period of years, such that activities (and corresponding GHG fluxes) in one year differ from those in other years within the same cycle. According to the GHG Protocol guidelines activities that do not occur every year, such as liming, should be reported for in the year the activity takes place. This means if lime is applied once every three years, all emissions associated with that lime application should be reported in the year of application, not spread evenly across the three years. The rationale is to maintain transparency, accuracy, and temporal integrity of the emissions data. In practice, this requires reporters to track the actual timing of occasional activities (e.g. liming events) and include zero emissions for years in which no liming occurs. If desired for communication purposes (e.g. reporting commodity-based emissions intensities), emissions may be analysed as a multi-year average, but this must not replace annual accounting.

See Section 1.6.1 , Box 2 and Case Studies 3 and 4 for more context and guidance.

6. What sort of records do I need to keep for reporting?

At minimum, for a livestock enterprise you need:

- Stock numbers (by class) at key times in the year.
- Amounts of fertiliser, lime, and chemicals used.
- Fuel and electricity use.
- Any purchases like livestock or inputs.

At minimum, for a non-livestock enterprise you need:

- Area and production of crop
- Amounts of fertiliser, lime, and chemicals used.
- Fuel and electricity use.
- Any purchased inputs.

The more accurate your records, the better your estimate. Refer to Section 1.6 and Data Tables in relevant Modules for more guidance open sources of data and guidance on Quality Assurance and Quality Control.

1.11 Key terms

Accuracy represents the degree to which an estimate reflects the true value of the quantity being measured. In practice, it's about how close your GHG estimates are to the actual emissions or removals. It depends on both the correctness of the methods and the quality of the input data.

Agistment is an arrangement between a stock owner and the owner of a short-term supplier of feed. Agistments are typically defined for a shorter period of time than pasture or grazing leases.

Annual is defined as a 12-month period, either a calendar or financial year, or other specified 12-month period which is relevant to the operations under consideration.

Carbon dioxide equivalent (CO_2e) is a standard unit for comparing emissions of different greenhouse gases by expressing them as the amount of CO_2 that would have the same warming effect over a set period (usually 100 years).

Default data is readily available based on national statistics or emission factors and additional parameters to provide an option for estimation where more specific data is not available.

Greenhouse gas (GHG) are gases that absorb and emit radiation causing the greenhouse effect. These gases include carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), and certain fluorinated gases. GHGs differ in their potency as a GHG and their atmospheric lifetime.

Liveweight (LW) is the average liveweight for each stock class at a defined point in time.

Liveweight gain (LWG) is the average weight gain per day.

Supply Chain is the network of systems involved in producing a product or service, from extraction of raw materials, through to the final customer.

Materiality in the context of greenhouse gas inventories refers to the significance of emission sources or categories, determining which ones are important enough to warrant inclusion and detailed tracking. By applying a materiality threshold, often a specific percentage of total emissions, resources can be focused on the most impactful aspects of a GHG inventory, ensuring that significant data, errors, or omissions that could influence user decisions are identified and addressed.

Methods are the procedures for measurement and estimation of GHG emissions and removals. Higher level methods are generally considered to be more accurate.

Reporting entity is the entity responsible for developing the greenhouse gas estimate and may be selecting various methods based on assessing availability of data.

Value Chain is the process or activities which a company adds value to a product or service, at any point in the supply chain.