ICAT Initiative for Climate Action Transparency

# Agriculture Methodology

*Assessing the greenhouse gas impacts of agriculture policies*

ICAT series of
**Assessment Guides**

ghg management institute

# Contributors & Acknowledgments



## Disclaimer



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# How to use the Assessment Guides

This guide is part of a series developed by ICAT to help countries assess the impacts of policies and actions. It is intended to be used in combination with other ICAT assessment guides and can be used in conjunction with other guidance.

## Series of ICAT Assessment Guides

Introduction to the ICAT Assessment Guides

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- Renewable Energy
- Transport Pricing
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# Chapter 1: Introduction

Introduction | Chapter 1

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## 1.1 Purpose and users

### 1.1.1 Purpose of the guide

With the adoption of the Paris Agreement in 2015, governments around the world are increasingly focused on implementing policies and actions that achieve greenhouse gas (GHG) mitigation. The terms policy and action may refer to interventions at various stages along a policy-making continuum, from broad strategies or plans that define high-level objectives or desired outcomes to specific policy instruments to carry out a strategy or achieve desired outcomes.

Agricultural production contributes approximately one quarter of anthropogenic GHG emissions (IPCC, 2014). Countries need to assess and communicate the GHG impacts of policies that affect agricultural activities, including how policies address their international climate change action commitments and the provision of sustainable sources of food for people and income for farming communities. This guide provides methods for assessing the GHG impacts of policies and actions in the Agriculture sector. The methodologies presented are aligned with the *2006 IPCC Guidelines for National GHG Inventories* and its 2019 Refinement and are based on the Policy and Action Standard developed by the World Resource Institute.

This guide is part of the Initiative for Climate Action Transparency (ICAT) series for assessing the impacts of policies and actions. The guide is designed to assess specific mitigation policy instruments, which are interventions taken or mandated by a government and implementation of technologies or practices, known as measures. This guide has been updated to cover additional agricultural emission sources and the most up-to-date Intergovernmental Panel on Climate Change (IPCC) methodologies. It may be used in combination with other ICAT guidance documents to assess GHG, sustainable development, and transformational impacts of various policies and actions. Refer to the *Introduction to the ICAT Assessment Guides* for information on applying guides in combination. For example, agriculture policies may also result in land use changes and impact the forest sector (e.g., restoration of degraded lands) which can be assessed with the ICAT *Forest Methodology*. Furthermore, ICAT *Technical Review Guide* outlines additional steps for enhancing transparency and confidence in the assessment. Refer to the Glossary for definitions of key terms that appear throughout the guide.

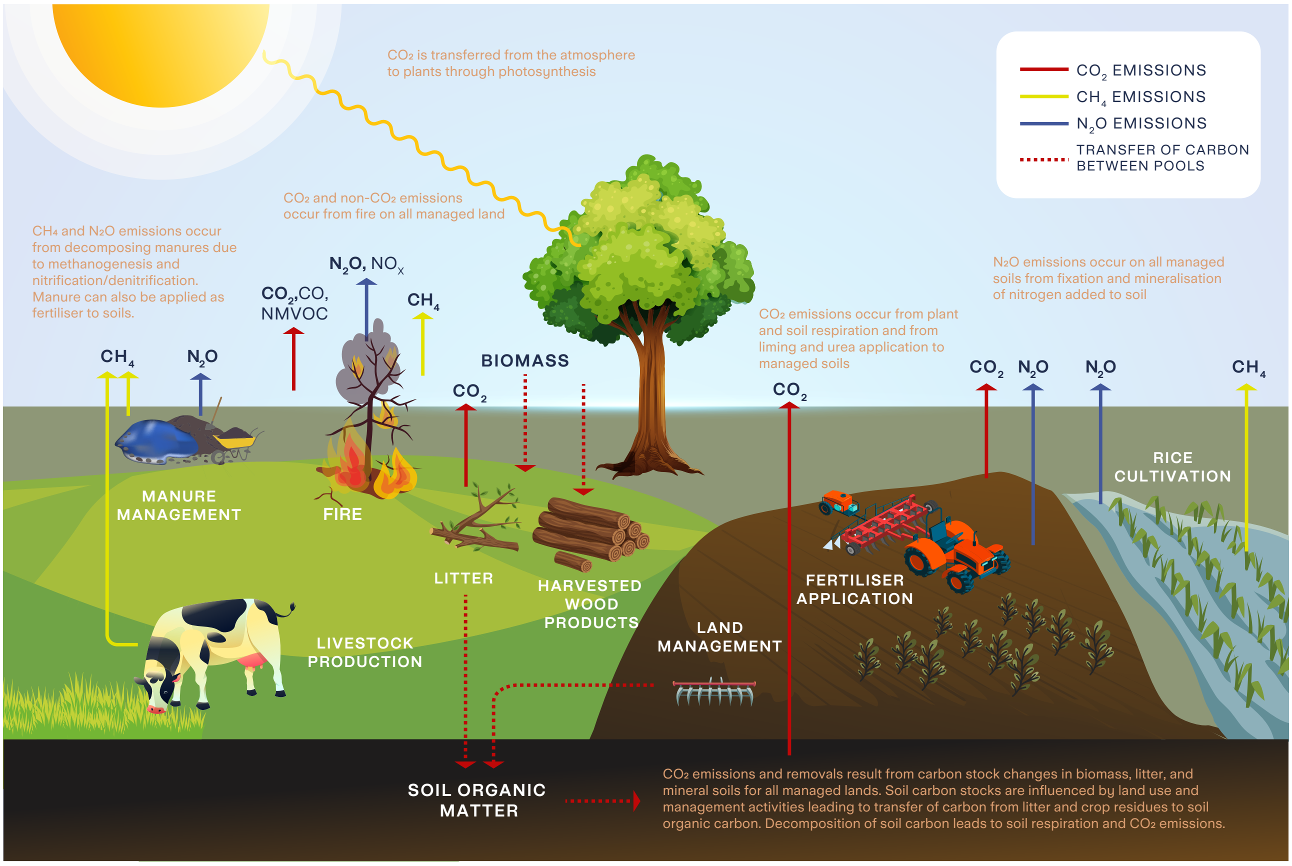
### 1.1.2 Intended users of the guide

The primary intended users of this guide are developing country governments and their partners who are planning and implementing agriculture policies, and/or assessing their GHG impacts in the context of developing and implementing their Nationally Determined Contribution (NDC), national or sub-national low carbon strategies, Nationally Appropriate Mitigation Actions (NAMAs), and other mechanisms. Throughout this guide, the term "user" refers to the entity conducting the policy GHG impact assessment. Users are encouraged to assemble a team, which may include the country's technical experts and GHG inventory compilers to inform and conduct the assessment. The team should also include personnel and stakeholders involved in the design and implementation of agriculture and climate change policies, such as those from relevant government agencies, research institutions, businesses, and non-governmental organisations.

## 1.2 Scope of the guide

Agricultural systems are inherently complex and have a great deal of variability both due to natural events and human-caused interventions. Volume 4 of the IPCC guidelines, Agriculture, Forestry, and other Land Use (AFOLU) presents good practice methodologies for quantifying associated anthropogenic GHG emissions. The different agricultural processes and activities are shown in **Figure 1.1.**

Figure 1.1. **The main GHG emission sources/removals from activities in the Agriculture sector**




Source: Adapted from IPCC 2006 GL, Volume 4, Chapter 1, Figure 1.1. NOx, CO, and NMVOC are noted because they are precursors for the formation of GHGs in the atmosphere

Policies that affect land management or agricultural production practices—for example, improving livestock feed, changing how manure is stored, or applying synthetic and organic fertiliser at different rates—typically lead to changes in GHG fluxes. Agricultural policies may also be linked to changes in land use—for example, converting forest land or wetlands to cropland, taking degraded land out of production to be used as pasture, or installing riparian buffers to prevent erosion. For guidance on estimating GHG emissions or removals resulting from a policy that changes land uses, refer to the ICAT *Forest Methodology*.

This guide provides principles, concepts, and detailed procedures for quantitatively estimating GHG impacts of agricultural policies addressing the following major GHG sources and carbon pools in the Agriculture sector:

- Livestock (enteric fermentation and manure management)
- Fertiliser management
- Soil carbon pools
- Rice cultivation

This guide is applicable to all countries and regions and policies implemented at any level of government (e.g., national, subnational, municipal). It can be applied to policies that are planned, adopted, or implemented, as well as extensions, modifications, or termination of existing policies.

The GHG source and sink categories associated with agricultural activities are defined in Volume 4 of the 2006 IPCC Guidelines. The 2019 Refinement to the 2006 IPCC Guidelines further clarifies methodologies for estimating

GHG emissions. The 2019 Refinement provides updated default emission factors and parameters for the emission sources covered in this guide. Furthermore, emission parameters for livestock are updated to allow differentiation between high- and low-productivity systems and the method to calculate methane emissions from manure has been updated. The essential references will be referred to in this guide as IPCC 2006 GL and 2019 Refinement. The IPCC guidelines on AFOLU deal with the key GHGs: carbon dioxide ($CO_2$), nitrous oxide ($N_2O$), and methane ($CH_4$).

This guide can be used at multiple points in time along a policy design and implementation life cycle, including:

- Before policy implementation to forecast the expected future impacts of a policy, known as ex-ante assessment
- During policy implementation to assess the policy's achieved impacts to date, key performance indicators (KPIs), and expected future impacts
- After policy is implemented to assess what impacts occurred as a result of the policy, known as ex-post assessment

Depending on the user's objectives, the steps related to ex-ante assessment, ex-post assessment, or both can be utilised. The most comprehensive approach is to assess the impact before implementation, regularly during policy implementation, and again after implementation.

At the time of publication, the 2019 Refinement has not been formally adopted by the Conference of the Parties of the United Nations Framework Convention on Climate Change (UNFCCC). However, countries may use the 2019 Refinement if they provide a technical rationale, for example, more appropriately reflecting country circumstances. For the purpose of this guide, the 2019 Refinement is used as it reflects more up-to-date scientific information on methodologies and emission factors.

## 1.3 Overview of guide structure and wayfinding

### 1.3.1 Guide structure

This guide details the steps to follow when conducting a GHG assessment of agriculture policies, as shown in **Figure 1.2**. The guide is organised into three parts:

**Part I: Plan assessment.** Provides fundamental information about GHG assessment and reporting frameworks, assessment planning steps, and how assessment results can be used. Planning for the assessment is covered in Chapter 2.

**Part II: Select and describe policy.** Helps users understand agriculture policy instruments and measures that could be applied in their context, as well as describing the policy activities and outcomes being assessed. Selecting policies is covered in Chapter 3, while guidance on describing the assessed policy is in Chapter 4.

**Part III: Assess policy.** Includes methodological chapters for each major GHG source/sink category. Chapters 5 – 8 demonstrate the assessment methodology.

Each of these parts contains steps the user should follow to assess the GHG impacts of a policy. The guide's conclusion, Chapter 9, provides guidance on how to communicate and report on the assessment.

Figure 1.2. **The assessment process presented in this guide**

**PART I. PLAN ASSESSMENT**

CHAPTER 2
**PLANNING THE AGRICULTURAL POLICY ASSESSMENT**

- Essential definitions, GHG assessment principles, and frameworks
- Stakeholder engagement and participation
- Setting objectives for policy assessment
- Methodological considerations
- Tracking implementation and progress
- Planning technical review

**PART II. SELECT AND DESCRIBE POLICY**

CHAPTER 3
**POLICY SELECTION**

- Review regional emission levels and trends
- Agricultural policies and measures
- Policy prioritisation

CHAPTER 4
**DESCRIBING THE POLICY AND IMPACTS**

- Outline policy activities
- Identify policy intermediate effects
- Identify potential GHG impacts
- Develop a causal chain
- Select policy assessment boundary and period
- Consider other policy synergies and interactions

**PART III. ASSESS POLICY**

CHAPTER 5
**ASSESSING LIVESTOCK POLICY IMPACT**

- Livestock policy description and GHG impacts
- Methodological considerations
- Estimating GHG emissions
- Monitoring policy performance

CHAPTER 6
**ASSESSING FERTILISER POLICY IMPACT**

- Fertiliser policy description and GHG impacts
- Methodological considerations
- Estimating GHG emissions
- Monitoring policy performance

CHAPTER 7
**ASSESSING SOIL CARBON POLICY IMPACT**

- Soil carbon policy description and GHG impacts
- Methodological considerations
- Estimating GHG emissions
- Monitoring policy performance

CHAPTER 8
**ASSESSING RICE CULTIVATION POLICY IMPACT**

- Rice policy description and GHG impacts
- Methodological considerations
- Estimating GHG emissions
- Monitoring policy performance

The guide also includes several supporting components, including:

**Abbreviations, glossary, and references:** References included in the guide, definitions of key terms, and abbreviations used

**Hypothetical country description:** Description and activity data for a hypothetical country used in assessment examples.

**Templates:** Templates for completing assessment.

**Appendix:** Additional guidance for completing assessment.

**Assessment toolkit:** The toolkit provides short descriptions of databases, resources, and tools that can support the policy assessment process. It includes materials that provide input data, emission factors, and other parameters to supplement local data. It also identifies other reference materials to inform the work of measuring, reporting, and verifying (MRV) GHG emissions. This guide collectively refers to these materials as the assessment toolkit. The toolkit is not an exhaustive list of all resources available, but rather a selection of those commonly used. Where other resources exist, especially those that are policy-specific or country-specific, they should also be considered for use. Resources listed in this toolkit are indicated by the tools symbol throughout the guide and hyperlinked for easy navigation.

**Case studies:** Illustrations of application of the methodologies in specific national contexts. As more countries apply the guide, more case studies can be added. Contact ICAT if interested.

Users may select and use the sections or chapters applicable to their needs and purposes.

### 1.3.2 Guide wayfinding

Informational graphics are used throughout the guide to provide further orientation.

| Guide components | Symbol |
|---|---|
| **Key recommendations:** The guide includes a series of key recommendations. These recommendations identify steps that assist users in producing impact assessments based on the principles of relevance, completeness, consistency, transparency, and accuracy. | |
| **Assessment toolkit:** The guide references tools and resources that offer more detailed guidance, databases for agricultural statistics, or other support for estimating parameters for a policy assessment. The toolkit is available in the Toolkit section. | |
| **Templates:** The guide provides users with downloadable templates for completing steps within the assessment. | |
| **Stakeholder engagement:** The assessment team will include staff and subject matter experts. This team will likely engage stakeholders in discussing priorities, identifying key policy activities, and informing other parts of the assessment. This stakeholder engagement process is described in Section 2.2. | |
| **Expert judgement:** Expert judgement is often needed due to lack of quantitative information. Considerations for using expert judgement are described in Section 2.4.1. | |
| **Cross-reference:** When conducting the assessment, sections of this guide or external resources are referenced for ease of navigation. | |

### 1.3.3 Guide alignment and references

Methodologies presented in this guide are based on the IPCC 2006 GL and 2019 Refinement, Volume 4, Agriculture, Forestry and Other Land Use. This guide utilises and adapts IPCC 2006 GL and 2019 Refinement tables, figures, and equations.

This guide also builds upon the World Resources Institute (WRI)'s GHG Protocol *Policy and Action Standard*, which provides general guidance on estimating the GHG impacts of generic policies and actions (Rich, 2014). This guide adapts some of the tables, figures, and text from the *Policy and Action Standard*.

Full list of references is available in the References section.

# Part I

## Chapter 2: Planning the Agricultural Policy Assessment

INTRODUCTION
PART I PLAN ASSESSMENT
PART II SELECT AND DESCRIBE POLICY
PART III ASSESS POLICY
CONCLUSION
HYPOTHETICAL COUNTRY
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CASE STUDIES

# Chapter 2: Planning the Agricultural Policy Assessment

PART I. Plan Assessment | Chapter 2

2.1 Essential definitions, GHG assessment principles, and frameworks | 2.2 Stakeholder engagement and participation | 2.3 Setting objectives for policy assessment | 2.4 Methodological considerations | 2.5 Tracking implementation and progress | 2.6 Planning technical review

This chapter helps users plan, assign responsibilities, and identify resources to assess the GHG impacts of agricultural policies. The resources and time required to carry out an impact assessment will depend on a variety of factors, such as the complexity of the policy being assessed, data availability, and the desired level of accuracy and completeness needed to meet the assessment's objectives. This chapter describes basic concepts including key definitions, assessment principles, reporting frameworks, stakeholder engagement methods, and input data needs.

## 2.1 Essential definitions, GHG assessment principles, and frameworks

### 2.1.1 Agriculture definitions

Before beginning the assessment, it is helpful to define what is deemed as an agriculture activity and consider how agricultural emissions are estimated and reported under the Paris Agreement. Agriculture includes systems that produce crops and livestock and may lead to associated land use changes or land use management approaches to maintain production. Refer to **Figure 1.1** to review the Agriculture sector activities that result in GHG fluxes.

This guide covers the following subset of agricultural categories that have the most significant GHG contributions (FAO, 2021):

- $CH_4$ emissions from livestock
- $CH_4$ and $N_2O$ emissions from manure management systems
- $N_2O$ emissions from all managed soils (focus on synthetic N fertiliser)
- $CO_2$ emissions and removals resulting from carbon (C) stock changes in mineral soils for all managed lands (focus on cropland)
- $CH_4$ emissions from rice cultivation

Other emissions and removals occurring on managed land, but not covered in this guide, include:

- $CO_2$ and non-$CO_2$ emissions from fire on all managed land
- $CO_2$ and $N_2O$ emissions from cultivated organic soils
- $CO_2$ emissions associated with liming and urea application to managed soils
- $CO_2$ and $N_2O$ emissions from managed wetlands, and $CH_4$ emissions from flooded land
- C stock change in biomass, dead organic matter, and associated with harvested wood products

Energy use for operating machinery or manufacture of fertiliser in agricultural production and associated emissions are accounted for under the Energy sector. $N_2O$ emissions from managed soils, when due to application of organic fertiliser derived from biological waste, should be accounted for in coordination with the Waste sector. Other cross-sectoral cases exist and should be noted when conducting policy assessments. For emissions and removals associated with agricultural activities not covered in this guide, refer to 2019 Refinement, Volume 4 and the 2013 Supplement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories: Wetlands.

Under UNFCCC reporting obligations, countries typically report emissions from the Agriculture sector and land use, land-use change, and forestry (LULUCF) sector separately. Therefore, this guide recommends identifying categories of emissions that will be affected by the policy in a manner that matches reporting under UNFCCC refer to Section 2.1.2 and uses methods from the 2019 Refinement, Volume 4 (AFOLU).

### 2.1.2 Reporting frameworks

Under the Paris Agreement, all countries should set long-term strategies (LTSs) to address climate change and shall prepare their Nationally Determined Contributions (NDCs), which are to be updated with increasing ambition every 5 years. The Paris Agreement also established the Enhanced Transparency Framework (ETF), building on previous UNFCCC reporting requirements for countries. Under the ETF, all countries shall submit Biennial Transparency Reports (BTRs) that include information about progress on their mitigation policies and NDC. BTRs unify reporting requirements for all countries and supersede the previous rules for Biennial Reports and Biennial Update Reports while extending flexibility to developing countries that need it in meeting requirements (UNFCCC, 2021c). Countries also shall provide information on mitigation policies for each sector to achieve NDC targets.

For NDCs and BTRs, the information on mitigation actions should be submitted in a Common Tabular Format (CTF), which is outlined in **Table 2.1** (UNFCCC, 2021b, Annex II, Table 6). This guide recommends that countries utilise the same common format to document GHG impact assessment results.

A template is provided to compile and report assessment results, which can be also used for UNFCCC reporting.

Table 2.1. **UNFCCC Common Tabular Format for reporting on mitigation policies and actions**

| UNFCCC mitigation reporting components | Where to find additional information in the guide |
|---|---|
| Name of policy | Chapter 4 |
| Description | Chapter 4 |
| Objectives | Chapter 4 |
| Type of instrument (e.g., regulatory, economic instrument or other) | Chapter 3 |
| Status (e.g., planned, adopted, or implemented) | Chapter 4 |
| Sector(s) affected | Agriculture or LULUCF depending on emission sources impacted by policy |
| Gases affected | Chapter 4 |
| Start year of implementation | Chapter 4 |
| Implementing entity or entities | Chapter 4 |
| Estimates of GHG emission reductions (Gg $CO_2e$) – achieved/expected | Assessment Chapters 5-8, depending on emission sources impacted by policy |

Countries may also provide information on costs, non-GHG mitigation benefits, and how mitigation actions interact with other policies. This guide points users to additional resources that can help conduct additional assessments related to assessing costs and sustainable development goals (SDGs) in the guide's assessment **toolkit**.

Emission reductions associated with mitigation policies and actions are demonstrated relative to baseline scenario emissions. Aggregate changes in national emissions resulting from all policies and actions, as well as other factors, will be captured in a country's GHG inventory. All countries under the Paris Agreement report their GHG inventories using common reporting tables (CRTs), with the agriculture and LULUCF categories disaggregated by GHG type (UNFCCC, 2021a). When conducting the policy assessment, this guide recommends reviewing the CRTs and identifying which source and sink categories will likely be affected by the assessed policy and measures.

### 2.1.3 Assessment quality principles

It is important to be familiar with assessment quality principles, as they underpin and guide the impact assessment process, especially where guidance provides flexibility or expert judgement is utilised. These principles are described below (Rich, 2014).

**Transparency:** Provide clear and complete information for stakeholders to assess the credibility and reliability of the results. Disclose and document all relevant methods, data sources, calculations, assumptions, and uncertainties. Disclose the processes, procedures, and limitations of the assessment in a clear, factual, neutral, and understandable manner with clear documentation. The information should be sufficient to enable a party external to the assessment process to derive the same results if provided with the same source data. Chapter 9 provides a list of recommended information to report to ensure transparency. Refer to the **Templates** section for templates to complete the assessment report.

**Accuracy:** Ensure that the estimated impacts are systematically neither over nor under true values, as far as can be judged, and that uncertainties are reduced as far as practicable. Achieve sufficient accuracy to enable users and stakeholders to make appropriate and informed decisions with reasonable confidence. If accurate data for a given impact category is not currently available, users should strive to improve accuracy over time as better data becomes available.

**Completeness:** Include all significant GHG impacts in the scope of the assessment, including both positive and negative impacts. Disclose and justify any specific exclusions.

**Consistency:** Use assessment approaches, data sources, data collection methods, and calculation methods to allow for meaningful performance tracking over time and ensure that methodologies are not changed without justification.

**Relevance:** Ensure the assessment appropriately reflects the GHG impacts of the policy and serves the decision-making needs of users and stakeholders, both internal and external to the reporting entity. Applying the principle of relevance depends on the objectives of the assessment, broader policy objectives, national circumstances, and stakeholder priorities.

**Comparability:** In addition to the principles above, users should follow the principle of comparability if it is relevant to the assessment objectives, for example, if the objective is to compare multiple policies based on their GHG impacts or to aggregate the results of multiple impact assessments and compare the collective impacts to national goals. Comparability ensures that methods, data sources, assumptions, and reporting formats are such that the estimated impacts of multiple policies can be compared.

Users can also consider conservativeness, which refers to a set of assumptions defined in order to ensure that the mitigation scenario does not overestimate policy performance. The combined principles of "transparency" and "accuracy" dictate that thorough documentation and description of assessment assumptions and conditions used in the quantification of GHG impacts are needed when conducting the policy assessment.

In some reporting or decision-making cases, users shall provide an estimate or description of assessment uncertainty to help interpret results. This could include documentation of the method or approach used to assess uncertainty and/or sensitivity of the results as a function of parameter values or models used. Investigating uncertainty can be helpful in improving assessment methods and data collection processes. This guide does not provide quantitative guidance on estimating uncertainty. Methodological guidance for qualifying or quantifying uncertainty can be found in IPCC 2006 GL Volume 1, Chapter 3, with additional information relevant to policy GHG impact estimation in the Policy and Action Standard, Chapter 12 (Rich, 2014) and *ICAT Technical Review Guide*, available in the guide's assessment **toolkit**.

## 2.2 Stakeholder engagement and participation

The guide recommends integrating stakeholder engagement and participation throughout the policy GHG impact assessment process. In this guide, opportunities for stakeholder engagement and participation are highlighted with the stakeholder engagement symbol.

Stakeholder engagement and participation can help to achieve the following:

- Provide those directly affected by a policy an opportunity to raise concerns to be considered before, during, and after policy implementation
- Raise awareness and understanding of complex issues, facilitating meaningful stakeholder input
- Build trust, collaboration, shared ownership, and support for policies among stakeholder groups, leading to less conflict and smoother implementation
- Address stakeholder perceptions of risks and impacts
- Reduce potential negative impacts and enhance benefits for all stakeholder groups, including the most vulnerable
- Improve the credibility, accuracy, and comprehensiveness of the assessment, drawing on diverse expert, local, and traditional knowledge and practices
- Increase transparency, accountability, legitimacy, and respect for stakeholders' rights
- Enable enhanced ambition and financing by strengthening the effectiveness of policies and the credibility of reporting

A key recommendation of this guide is to identify and engage relevant stakeholders.

Before beginning the assessment process, users should consider how stakeholder engagement can support policy assessment and include relevant activities and associated resources in assessment plans. During the planning phase, the first step is to identify stakeholder groups that may be affected by or may influence the policy and begin engaging them to refine objectives for the assessment. Stakeholders can be individuals, organisations, communities, or any other group of persons. Stakeholders also include national agencies or ministries, regional or local units of government, as well as civil society and private sector organisations. Some typical stakeholders in the Agriculture sector include:

- Farmers and ranchers
- Producer associations
- Non-governmental organisations (NGOs) or civil society organisations
- Communities, indigenous peoples, or marginalised groups that are involved in or are affected by agriculture
- Education and research institutions
- Suppliers of equipment and inputs
- Other companies
- National and subnational government agencies
- Government entities responsible for natural resource and/or agriculture and livestock management
- Financial institutions
- Consumers

Engaging stakeholders builds support for policy implementation (if policy is being planned) or amendments (if the assessment is conducted during policy implementation) and can help identify potential barriers and solutions. Stakeholder engagement is also important after a policy is implemented to evaluate the performance of the policy and whether it needs to be updated and improved. It is also important to provide a mechanism that enables action on issues raised by stakeholders to secure adequate protection of stakeholders' rights related to the impacts of the policy.

It is helpful to use a participatory process to identify a full range of stakeholders and to understand how they may be affected by or influence the policy.

Refer to this guide's assessment toolkit for additional resources on stakeholder engagement, such as the ICAT *Stakeholder Participation Guide*. Furthermore, refer to Appendix B for more information on linkages with the ICAT *Stakeholder Participation Guide*.

## 2.3 Setting objectives for policy assessment

Impact assessments support evidence-based decision-making by enabling policymakers and stakeholders to understand the relationship between policies and expected or achieved GHG impacts. Examples of assessment objectives are presented in **Table 2.2.**

A key recommendation of this guide is to thoughtfully consider the assessment's objectives.

Table 2.2 **Policy assessment objectives examples**

| Objectives of assessing impacts before policy implementation (ex-ante) | Objectives of assessing impacts during or after policy implementation (ex-post) |
|---|---|
| **Inform policy selection** by comparing policy options based on their expected future impacts | **Assess policy effectiveness** by determining whether policies are delivering the intended results |
| **Improve policy design and implementation** by understanding the impacts of different design and implementation choices | **Inform future policy design** and decide whether to continue current actions, enhance current actions or implement additional actions |
| **Inform goal setting** by assessing the potential contribution of policy options to national goals, such as NDCs and NAMAs | **Track progress** toward national goals such as NDCs and SDGs and understand the contribution of policies toward achieving them |
| **Project and compare** multiple expected impacts of policies, domestically and/or internationally | **Improve policy implementation** by determining whether policies are being implemented as planned |
| **Access financing** for policies under consideration by demonstrating expected future results | **Report domestically or internationally,** including under the Paris Agreement's enhanced transparency framework, on the impacts of policies to date |
| **Assess administrative capacity** required to implement policy activities and collect associated data for evaluation and reporting | **Meet funder requirements** to report on impacts of policies, if relevant |
| **Assess technical capacity** at the national level to identify technical expertise needs | **Assess the effectiveness of the policy instrument** in operationalising mitigation measures and establishing necessary drivers for mitigation measure adoption |
| **Build support** for additional mitigation measures to be adopted by the decision-makers and farmers | |

This guide also recommends that users begin **engaging stakeholders** during the objective-setting phase so that the objectives of the assessment respond to the needs and interests of stakeholders. Users should also identify the intended audience of the assessment report. Possible audiences include policymakers, the public, NGOs, companies, funders, financial institutions, analysts, research institutions, or other stakeholders affected by or who can influence the policy.

The objective of the assessment should be articulated and documented in the assessment report (assessment report template available in the **Templates** section).

## 2.4 Methodological considerations

This section introduces key assessment concepts. It discusses the types of data needed for the analysis and the complexity of the calculations. It also discusses how to construct a baseline scenario. Finally, it reviews the issue of tracking progress, selecting performance indicators, and ensuring that a system is in place to conduct measurement, reporting, and verification.

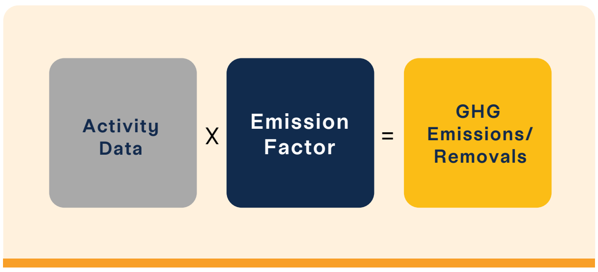
### 2.4.1 Understanding and preparing for data needs

#### Identifying data parameters needed for assessment

Once the assessment objective is determined and stakeholder engagement has begun, the next step is to consider what calculation methods are appropriate and what data on agricultural activities is needed for those methods. Users will need activity data specific to their location and relevant to the mitigation policy being designed or implemented. Activity data is defined as a quantitative measure of a level of activity that results in GHG emissions. An example of activity data is livestock population. Activity data can be multiplied by an emission factor to derive the GHG emissions associated with a process. GHG emission factors are emission rates for a given source per unit of activity. More broadly, these factors can include reference values of soil carbon stock, factors that scale emissions relative to land management methods, and factors that represent emissions of $CH_4$ per head of livestock.

Emission calculations, in their simplest form, are a product of activity data and appropriate emission factors as shown in **Figure 2.1.** Calculations are conducted for each emission category and GHG, and can then be converted to units of carbon dioxide equivalent ($CO_2e$) based on each GHG's global warming potential (GWP). Emissions are calculated for each relevant scenario and point in time.

Figure 2.1. **Emission calculation schematic showing the basic approach to calculating GHG emissions or removals for non-$CO_2$ gases.**




There are additional categorisations or classifications for both activity data and emission factors (not depicted here) that further define these two parameters.

To assess the impacts of policies with a sufficient level of accuracy and completeness that meets the stated objectives of the assessment, it is critical to understand what data and parameters are needed to estimate agricultural emissions and what data parameters will change due to policy activities. Similar datasets are needed to estimate the baseline and policy scenario emissions.

**Table 2.3** provides a list of data types, both activity data and emission factors, users would likely need to conduct the assessment, depending on the activities within their policy. The detailed description of data types and their references are provided in the Technical Supplement available for download. Data parameters particular to policy examples are elaborated in Chapters 5-8.

It is a key recommendation to identify relevant data parameters, i.e., activity data and emission factors, and their associated references, when preparing for the assessment.

Table 2.3. **Data and parameters typically used in estimating agricultural GHG emissions, by source. Default emission factors and parameters refer to values from the 2019 Refinement.**

| Emission source | Data type | Examples of data and parameter |
|---|---|---|
| Livestock – Enteric fermentation and manure | Species categorisation | ▪ Species and subcategories including where relevant high or low productivity |
| | Livestock population | ▪ Average annual population (including sex), calculated from number of animals produced annually, by species and subcategory<br>▪ Birth, death, and slaughter information |
| | Production | ▪ Milk (fat percentage, daily production)<br>▪ Meat<br>▪ Wool<br>▪ Other livestock products (hides, velvet, etc.) |
| | Livestock characterisation | ▪ Weight<br>▪ Breed<br>▪ Physiological state (pregnant, lactating)<br>▪ Growth rate<br>▪ Feeding situation (confined, grazing, pasture, etc.)<br>▪ If working animals, the number of hours worked daily |
| | Feed characterisation | ▪ Proportion, source, and composition of feed supplements<br>▪ Proportion of feed that is digestible (digestible energy) |
| | Emission factor | ▪ IPCC default emission factors, by species and subcategory<br>▪ Country-specific emission factors that have been developed |

Table 2.3. **Data and parameters typically used in estimating agricultural GHG emissions, by source. Default emission factors and parameters refer to values from the 2019 Refinement. (Continued)**

| Emission source | Data type | Examples of data and parameter |
|---|---|---|
| Livestock – Manure management | Manure system characterisation | ▪ Types of manure management systems<br>▪ Proportion of manure managed in each system, by species and subcategory<br>▪ For more accurate estimation, maximum methane producing capacity of excreta, by manure management system, by species and subcategory |
| | Livestock excretion characterisation | ▪ Average excreta per head, by species and subcategory<br>▪ Excretion rates, by species and subcategory |
| | Feed characterisation | ▪ Nitrogen content in feed<br>▪ For more accurate estimation, nitrogen intake and nitrogen retention data |
| | Emission factor | ▪ IPCC default emission factors for direct and indirect $N_2O$ emissions, by species and category<br>▪ Country-specific factors that have been developed |
| Fertiliser management | Land area | ▪ Area of organic soils<br>▪ Area with fertiliser applied |
| | Fertiliser characterisation | ▪ Type(s) of synthetic N fertiliser applied and its N content<br>▪ Method of application<br>▪ Crops or pasture that fertiliser type(s) are applied to<br>▪ Amount of each fertiliser applied |
| | Emission factor | ▪ IPCC default emission factors, by fertiliser type<br>▪ Country-specific emission factors that have been developed |
| | Mitigation mechanisms | ▪ If fertilisers have a slow-release mechanism<br>▪ If an inhibitor to prevent nitrification (and subsequent $N_2O$ emissions) is also applied |
| Soil carbon | Land stratification | ▪ Land use categories<br>▪ Soil types<br>▪ Climate zones<br>▪ Area of land within each land use category and subcategory<br>▪ Land use change between category and subcategory over time |
| | Land management | ▪ Tillage regime<br>▪ Inputs<br>▪ Irrigation/hydrology conditions<br>▪ Grazing intensity<br>▪ Agronomic practices |
| | Land cover | ▪ Vegetation type (e.g., annual, perennial) |
| | Emission factor and parameters | ▪ IPCC default reference soil carbon stocks<br>▪ IPCC default carbon stock change factors for land management (land use, management practices, inputs)<br>▪ Country-specific factors that have been developed |

Table 2.3. **Data and parameters typically used in estimating agricultural GHG emissions, by source. Default emission factors and parameters refer to values from the 2019 Refinement. (Continued)**

| Emission source | Data type | Examples of data and parameter |
|---|---|---|
| **Rice cultivation** | Land area | ▪ Rice area under cultivation<br>▪ Rice area with potential for rice cultivation |
| | Rice cultivar | ▪ Improved cultivar or traditional (e.g., improved cultivar has lower $CH_4$ emission) |
| | Production | ▪ Grain yield, grain rice quality, and subproducts related to rice production |
| | Soil type | ▪ Description (e.g., in relation to clay content) |
| | Water management/ irrigation system | ▪ Continuous flooded<br>▪ Mid-season drainage, multiple drainages<br>▪ Alternate wet and dry system |
| | Rice cultivation management | ▪ Land preparation<br>▪ Sowing system<br>▪ Agronomic practices<br>▪ Harvest system |
| | Fertilisation characterisation | ▪ Type(s) of synthetic N fertiliser applied and its N content<br>▪ Type(s) of organic amendments applied<br>▪ Amount of fertiliser applied<br>▪ Time of fertiliser application |
| | Emission factor | ▪ IPCC default emission factors, by water management system<br>▪ IPCC default emission factor for direct and indirect $N_2O$ emissions, by water management system<br>▪ Country-specific emission factors that have been developed |
| **All sources** | Conversion factors | ▪ GWP of GHGs to $CO_2e$<br>▪ Carbon stock to $CO_2$<br>▪ Nitrogen to $N_2O$<br>▪ Unit conversions |
| | Climate data | ▪ National meteorological data (temperature, precipitation), and regional climate data where emission sources are highly sensitive to temperature (e.g., paddy field, manure) |

When preparing for the assessment, users should identify data types (and their sources) that are relevant to the mitigation measures and begin to compile data needed for the assessment. Food and Agriculture Organization (FAO)'s GHG Data Management tool, found in this guide's assessment **toolkit**, can be used to identify and compile activity data to support the assessment process. Emission factors and some activity data can be obtained from public global databases and resources, such as the IPCC emission factor database (EFDB), the FAO's database, FAOSTAT, the International Fertiliser Association database, IFASTAT, the database of GHG emissions from manure management, DATAMAN, and the World Bank open data. These resources are further described in this guide's assessment **toolkit**.

### Choosing a methodological tier

The complexity of calculations depends on the availability of data which will determine the methodological tiers available for application (IPCC 2006 GL Box 1.1). **Table 2.4** summarises the IPCC's methodological tier structure and outlines trade-offs for their selection. In this guide, in addition to Tier 1 methods, Chapters 5-8 also use Tier 1a and simplified Tier 2 methods. Tier 1a allows disaggregation of emission factors based on system productivity levels when calculating enteric fermentation and manure $CH_4$ emissions from livestock. Simplified Tier 2 approach applies an adjusted emission factor reflecting the country's circumstances while using Tier 1 activity data and methodology. In addition, the Technical Supplement provides an overview of the parameters needed to apply Tier 2 methods. If data is available to derive country-specific values for some parameters, those should be used in the calculations. This guide does not address Tier 3 methods. Users of this guide may rely on Tier 1 methods, as data availability is often a barrier to using Tier 2 and Tier 3 methods. Improving data collection should be an integral part of the ongoing impact assessment process. Limitations to using Tier 1 emission factors are discussed in the IPCC 2006 GL and 2019 Refinement.

For further guidance on Tier 2 and Tier 3 methods, refer to the IPCC 2006 GL in this guide's assessment **toolkit**. For planning purposes, it is helpful to identify the possible methodological tier prior to beginning an impact assessment.

Table 2.4. **IPCC Guidelines tiers and trade-offs and considerations when determining the assessment method.**

| Tier | Methodological description | Trade-offs and considerations |
|---|---|---|
| 1 | Employs default emission factors and default estimation methods, available in IPCC guidelines | Simplest to use, not country-specific; may not be sufficient to capture mitigation efforts of some activities or production efficiency improvements; is generally less accurate than the results under the other tiers |
| 2 | May use the same methodologies as Tier 1, or country-specific methodologies where proven to be more accurate than IPCC methods for the country; applies emission factors and parameters based on country-specific data; should have country-specific land-use and livestock population categories | Requires national data and research results to justify methodological decisions; estimates reflect country-specific agricultural production system characteristics, and climatic / production regions; should be used for key source categories (in terms of contribution to sector emissions) |
| 3 | Employs empirical or process-based estimation models to estimate or predict GHG emissions | More sophisticated and complex, requiring detailed and long-term data, high levels of human and financial resources to develop models and body of science to underpin modelling; provides greater accuracy for estimates and levels of uncertainty |

### Expert judgement

It is likely that assumptions based on expert judgement will be needed to complete an assessment, especially where country-specific (Tier 2) information is not available or requires interpretation. Expert judgement is defined by the IPCC as carefully-considered, well-documented qualitative or quantitative choices, in the absence of unequivocal observational evidence, made by a person or persons who have demonstrable expertise in the given field. The goal is to be as representative of policy circumstances and production systems as possible to increase accuracy. The user leading policy development and assessment should therefore consult with experts in relevant fields.

> Refer to this guide's assessment toolkit for additional resources on expert judgement such as IPCC 2006 GL (Volume 1, Chapter 2, Annex 2A.1).

The IPCC outlines procedures for expert elicitation, including specific guidance on the elicitation process, avoiding biases, producing independent and reliable judgements, and documentation. Sections of the guide where expert judgement might be critical are identified with the **expert judgement** symbol.

To reduce the level of uncertainty associated with expert judgements, users may consult a range of experts to identify possible values for the parameter in question, associated uncertainties, and help select the most suitable value from a range. Expert judgement can be informed or supported through broader **consultations with stakeholders**. Users should document why expert judgement was necessary and the rationale for the value chosen.

### 2.4.2 Baseline types

Estimating the GHG impacts of a policy requires a reference case, or baseline scenario, against which GHG impacts are estimated. The baseline scenario represents what would have happened in the absence of the mitigation policy, i.e., business as usual or emissions without policy. The most likely scenario, in the absence of the policy intervention, should be deemed as the baseline scenario. Baseline emissions and removals are estimated according to the baseline scenario, which includes credible assumptions on land use, land-use changes, livestock, and soil management practices, and the associated GHG emissions and removals that would have occurred, without the implementation of the policy. Estimating a baseline is necessary for the assessment process. A change (reduction or increase) in GHG emissions is the difference between emissions in the baseline scenario and emissions in the policy scenario.

The next step in the planning phase is to consider what kind of baseline the user would use in the assessment and identify information types they will need to construct a baseline scenario. The baseline estimation process differs depending on whether the policy will be implemented in the future (ex-ante) or has already been implemented (ex-post). For ex-ante analysis, the assessment is a forecast of what is expected. For ex-post analysis of an implemented policy, baseline emissions are estimated and actual data is used to estimate emissions for the policy scenario.

When determining the baseline scenario, consider how the sector will or would have developed without the policy. For example:

- What mitigation practices or technologies will or would have been implemented in the absence of the policy?
- Are there existing or planned policies, other than the policy being assessed that would likely have an impact on GHG emissions within the Agriculture sector?

- Are there non-policy drivers (e.g., market trends) or other sectoral trends that should be reflected in the baseline scenario (e.g., improvements in livestock management, exploitation of organic soils, tillage practices)?

The approach applied in this guide is based on the application of drivers that are understood to have a large influence on the GHG emissions and/or carbon stock trends for those sources and sinks relevant to the assessment. Specifically, this approach requires identifying parameters representing these drivers and then making reasonable assumptions as to their most likely values in the absence of the policy. For example, both changes in national population and income per capita could be selected as drivers for emission categories associated with crop or livestock production. Due to global population growth and rising incomes per capita, global agricultural production is expected to grow by 50 percent in the first half of the 21st century to meet the demand for agricultural consumption (Alexandratos & Bruinsma, 2012). National population and income growth will influence most baseline scenarios used in agriculture policy assessment. On the other hand, technological advances leading to more efficient production are likely to increase outputs for constant inputs. Furthermore, shifting diets, and therefore demand, may lead to decreases in emissions and should also be considered when developing baseline scenarios (OECD-FAO, 2022).

Users should evaluate drivers of agricultural production relevant to their national context when considering baseline and policy scenarios as well as factors that may constrain such drivers, for example, labour shortages, limited access to water or other resources, limited access to information or technologies, access to new supply chains, and/or consumer preferences.

Typically, a GHG impact assessment will identify a single baseline scenario that is considered most likely. However, it may be the case that multiple baseline scenario candidates are deemed equally plausible. Users can then consider using multiple baselines, each based on different drivers and other assumptions. This more complex approach produces a range of possible emission reduction scenarios. These assumptions will be informed by **expert judgement** and/or **consultations with stakeholders**.

Depending on the availability and quality of historical and forecast data, different approaches can be used for determining the baseline scenario. **Figures 2.2** through **2.4** illustrate common baseline approaches. The baseline should be estimated for the same period as the period for which GHG impacts of the policy are to be assessed. Examples for determining baseline scenarios and estimating baseline emissions are provided in assessment Chapters 5-8.

Users putting together baseline scenarios can also refer to the United States Environmental Protection Agency (US EPA) for information on a country's projected emissions in agriculture (US EPA, 2012). Appendix D of the US EPA report provides modelled emission projections by country and subsector through 2030. Users can also consult peer-reviewed literature and other reports for information on trends in land use and agricultural productions (Smith et al., 2010; Asian Development Bank, 2021; Jayne et al., 2017; Marengo et al., 2014; OECD-FAO, 2022).

### Constant baseline (base year/base period)

The constant baseline approach (**Figure 2.2**) assumes there will be no change in agricultural practices, the use of technology, animal population, or land use during the assessment period with respect to the situation prior to policy implementation. It represents the simplest approach as only historical data is required. Values from either a base year or an average over a given base period are used as assumptions for the baseline scenario. The base year could be the most recent year data is available, although users should consider whether it represents a typical year (e.g., no droughts or major economic fluctuations). Alternatively, a base period can be selected as an average value from at least three years prior to the start of the policy implementation. The constant baseline approach then assumes these parameters do not change over the assessment period (i.e., the baseline is the continuation of the historical situation). For example, land has not undergone land use changes in the past 20 years, i.e., soil carbon stock is in equilibrium, and land will remain under the same management conditions under the baseline scenario. This baseline approach is the easiest to estimate, but it can produce errors if history is a poor predictor of the future in the context of the assessment.

### Simple trend baseline (extrapolation)

This trend baseline approach (**Figure 2.3**) assumes that agricultural practices, the use of technology, and land use will change relative to the past. This approach typically uses a linear or exponential extrapolation of the historical trend for each assumed driver. Users can employ a statistical regression analysis to estimate trends. To evaluate the quality of the regression, users can utilise statistical parameters such as R-squared, proportion of the variability covered by the fit, and Mean Square Error, difference between observed values and model's prediction. This approach can be easy to implement; however, it can produce errors because it does not consider other policies that are known and expected to cause a deviation from past trends in the sector. Users should collect historical data from five to ten years prior to the implementation of the policy for quantifying parameter trends, such as for livestock population or conversion of land to produce crops. If there is no discernible trend, or main drivers of emissions are expected to remain relatively unchanged, a constant trend line based on historical average may be used (Broekhoff et al., 2013) as described in the Constant Baseline section above.

Figure 2.2. **An example of constant baseline**

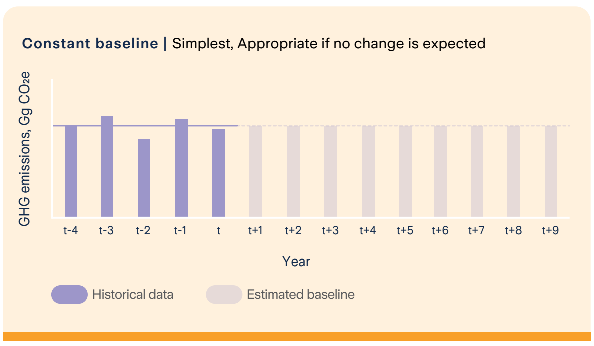
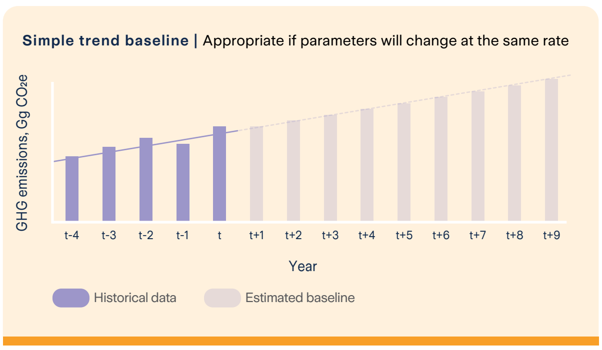



Figure 2.3. **An example of simple trend baseline**



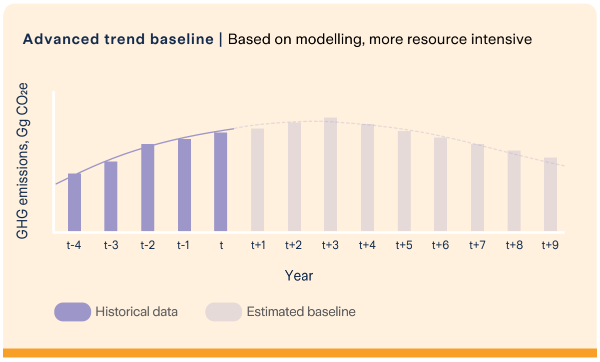
### Advanced trend baseline (modelling)

The advanced trend approach (**Figure 2.4**) models the impact of many interacting factors, including trends in macroeconomic conditions, demographics, and other non-policy drivers. A modelled baseline can be top-down or bottom-up.

**Top-down model:** This approach models how the economy (e.g., macroeconomic and demographic conditions) will impact the Agriculture sector. For example, the approach may model how gross domestic product (GDP) will impact livestock populations or changes in land-use management and then uses GDP forecasts to predict baseline livestock populations.

**Bottom-up model:** This approach models the interaction of key factors on specific mitigation practices, use of technologies, and land use. It can offer a more detailed projection of specific GHG sources and carbon pools. It will likely require detailed data such as livestock census data, including the average daily feed intake per species or specific land management practices. It is suitable for policies that target a specific livestock category (e.g., dairy cows or buffalo for milk production) or a specific land type (e.g., grasslands or croplands).

Figure 2.4. **An example of advanced trend baseline**




Selection of an appropriate model depends on the characteristics of the national circumstances, such as the structure of the economy, population, and level of industrialised, as well as sectoral characteristics. Multiple types of data can be used to develop an advanced trend model, such as sectoral statistics (e.g., crop production by province, livestock census data, feed intake survey data, milk or meat consumption statistics, land-use maps, population, and GDP).

> Refer to this guide's assessment toolkit for references to publicly available datasets on agricultural activity data and emission factors as well as on contextual sector data. Furthermore, Chapters 5-8 discuss references for data relevant to the emissions sources covered in those chapters.

### Choosing an approach

The choice of approach to determine the baseline scenario depends on the users' resources, capacity, access to data, availability of models, and expectations for how national circumstances will or will not change. A constant baseline is the simplest option and may be appropriate when parameters are likely to remain stable over time or the data lacks a clear trend. Advanced trend baseline approaches can take into account various drivers that affect conditions over time. However, more complex baseline prediction models require more data and a deeper understanding of multiple drivers. Users should select a baseline approach that yields the best prediction of the without-policy scenario within the national context, given the constraints on resources and data availability. Users should also consider whether and how to apply a degree of conservativeness in making assumptions and selecting a baseline scenario, where it is important to reduce the likelihood of overestimation of the policy's mitigation impact.

Refer to this guide's assessment toolkit for additional resources on baselines, such as the UNFCCC Compendium on GHG Baselines and Monitoring National-Level Mitigation Actions, the GACMO model, or the ICAT COMPASS toolbox.

Utilising **expert judgement** to inform the development of the baseline is good practice.

## 2.5 Tracking implementation and progress

This section addresses how progress is evaluated as a policy is implemented, including identifying parameters to track, setting up a data management system, and developing a monitoring plan for data collection and management.

### 2.5.1 Selecting key performance indicators

#### Identifying data parameters needed for assessment

While planning the assessment, the next step is to consider the key performance indicators to monitor. A key performance indicator (KPI) is a metric indicating the state or level of a policy's performance (i.e., whether the policy is on track and being implemented as planned). This section provides examples of KPIs.

It is a key recommendation to identify KPIs for tracking policy performance over time. If a mitigation policy is to be included in a country's NDC, the KPIs will be used for NDC implementation tracking and should meet the requirements set in modalities, procedures and guidelines (MPGs) for the transparency framework (UNFCCC, 2018).

To meet the requirements, indicators shall be relevant to the mitigation measures in the NDC, measurable, and utilise consistent methods for evaluation. Furthermore, information shall be provided on indicator reference levels in the baseline scenario, projected levels, and for each reporting year reflecting policy implementation to determine if the policy is performing as expected. Indicators can also reflect mitigation co-benefits of adaptation actions and sustainable development impacts. While KPIs are initially identified during the planning phase, they can be further refined and modified during the assessment process to better capture key parameters that should be monitored to track policy implementation.

**Table 2.5** defines and provides examples of KPIs. Refer to this guide's assessment toolkit for resources on developing policy KPIs such as WRI's working paper on monitoring implementation and effects of GHG mitigation policies (Singh and Vieweg, 2016).

Table 2.5. **KPI examples for policy assessment and monitoring**

| Policy implementation components | Definition | KPI examples |
|---|---|---|
| **Inputs** | Resources that go into implementing a policy | ▪ Budget allocation to agriculture extension service |
| **Activities** | Administrative activities involved in implementing the policy | ▪ Number offered and attendance at agriculture extension training sessions<br>▪ Area of land under each management method<br>▪ Number of farmers enrolled<br>▪ Area managed with new equipment<br>▪ Management data survey response rate |
| **Intermediate effects** | Changes in behaviour, technology, processes or practices | ▪ Rate of livestock weight gain<br>▪ Proportion of land in each land category and how it changes<br>▪ Proportion of land under particular management<br>▪ Fertiliser application rates<br>▪ Average rice grain yield<br>▪ Grain yield per rice cultivar<br>▪ Herd size |
| **GHG impacts** | Changes in GHG emissions by sources or removals by carbon pools that result from the intermediate effects of the policy | ▪ Enteric fermentation emissions per head of livestock<br>▪ Rate of soil carbon sequestration |
| **Non-GHG effects** | Changes in relevant environmental, social or economic conditions that result from the policy | ▪ Rate of agricultural productivity to support food security<br>▪ Water pollution levels from cropland nutrient loss<br>▪ Economic productivity due to technological upgrades in farming practices |

Performance indicators should be clearly defined and, in combination, cover the range of activities under the policy, utilise available data with appropriate quality and timeliness, and allow for comparability between policies. Once identified, they should be included in reporting and monitoring plans.

### 2.5.2 Develop sectoral measurement, reporting, and verification (MRV) for tracking progress

Information on KPIs and parameters needed for GHG inventories and mitigation policy assessments can be dispersed among institutions and governmental agencies. Strong institutional arrangements with clear roles, responsibilities, and data flows play a central role in coordinating MRV. A technical coordinator or coordinating team should oversee the procedures for data collection, analysis, and reporting.

Refer to this guide's assessment toolkit for resources on establishing or improving the institutional arrangements for a robust climate MRV system, in particular the UNFCCC's Toolkit for non-Annex I Parties on establishing and maintaining institutional arrangements.

Countries may already have institutional arrangements in place as part of their national climate MRV system. Where this is the case, users can consider adding policy GHG impact assessment to the duties of this national MRV system. Where strong institutional arrangements do not yet exist, users assign the governmental ministries or departments, depending on resources, legal and administrative structures in a country, with appropriate capacity and authority as responsible for monitoring the policy and setting the necessary legal arrangements. Institutional mandates help to strengthen policy procedures and may also help secure funding from the government to ensure the continuity of policy data collection and assessment.

### 2.5.3 Monitoring policy performance

Regardless of the status of a national MRV system, it is a key recommendation that users create a monitoring plan addressing data collection.

A monitoring plan is the system for obtaining, recording, compiling, and analysing data and information necessary for tracking policy KPIs and assessing GHG impacts. Input from stakeholders can be valuable in developing a monitoring plan and selecting KPIs. **Table 2.6** provides an overview of the elements that should be included in the monitoring plan.

Table 2.6. **Monitoring plan informational elements**

| Monitoring plan element | Description |
|---|---|
| **Roles and responsibilities** | Identify the entity or person responsible for monitoring KPIs and parameters and clarify the roles and responsibilities of the personnel conducting the monitoring. |
| **Competencies** | Include information about any required competencies and any training needed to ensure that personnel have the necessary skills for monitoring and impact assessment. |
| **Monitoring methods** | Explain the methods for collecting, processing, storing, and reporting data on monitored parameters. |
| **Monitoring period** | The policy implementation period is the time during which the policy is in effect. The assessment period is the time over which the GHG impacts resulting from the policy are assessed. The monitoring period is the time over which the policy is monitored. At minimum, the monitoring period should include the policy implementation period. Users can have multiple monitoring periods for separate assessment periods. A monitoring period can also include monitoring of relevant activities prior to the implementation of the policy and after the policy implementation period. |
| **Frequency** | KPIs and parameters can be monitored at various frequencies, such as monthly, quarterly, or annually. Determine the appropriate frequency of monitoring based on the needs of decision-makers and stakeholders, cost, and data availability. The frequency of monitoring can be consistent with measurements conducted under the national MRV system. |
| **Collecting and managing data** | Identify the databases, tools, or software systems used for collecting and managing data and other information. |
| **Quality assurance & quality control (QA/QC)** | Define the methods for QA/QC to enhance confidence in the assessment results. Quality assurance is a planned review process conducted by personnel who are not directly involved in the data collection and processing. Quality control is a procedure or routine set of steps that are performed by the personnel compiling the data to ensure the quality of the data. |
| **Record keeping & internal documentation** | Define procedures for clearly documenting data collection processes as well as what data and information are collected. |
| **Continual improvement** | Include a process for improving processes for taking measurements, running surveys, modelling, and analysing data. Continual improvement of monitoring can reduce uncertainty in GHG impact estimates over time. |
| **Financial resources** | Identify the cost of monitoring and sources of funds. |

A monitoring plan should be developed during the policy design phase or soon after the start of policy implementation. If the policy is in a country's NDC, then the monitoring plan should recognise that under the Paris Agreement, countries must provide information necessary to track progress toward achieving their NDC targets (UNFCCC, 2018).

### 2.5.4 Corrective action

A system for monitoring and tracking policy implementation allows decision-makers to take corrective action when KPIs show unsatisfactory progress. The ability to identify when corrective action is needed is essential to the country's ability to achieve its NDC target and combat climate change.

## 2.6 Planning technical review

Prior to initiating the policy assessment process, consider whether a technical review will be pursued. A review process can inform future improvements in the impact assessment. Independent review also increases the transparency and confidence of the policy assessment. Specific objectives of the technical review may include:

- Facilitating learning and continual improvement
- Improving selection, design, and implementation of policies through a more rigorous understanding of their impacts
- Increasing transparency and confidence in reported impacts of policies, including under the Paris Agreement's enhanced transparency framework
- Demonstrating results to donor agencies or financial institutions that provide funding or financing for policies
- Consistent assessment of a single policy over time
- Comparability of reported impacts of different policies

Technical review is conducted after the assessment is complete.

Refer to this guide's assessment toolkit for additional resources on technical review, such as the ICAT Technical Review Guide. Furthermore, refer to Appendix B for an overview of technical review types and to help inform the approach selection.

# Part II

Chapter 3: Policy Selection
Chapter 4: Describing the Policy and Impacts

INTRODUCTION
PART I PLAN ASSESSMENT
PART II SELECT AND DESCRIBE POLICY
PART III ASSESS POLICY
CONCLUSION
HYPOTHETICAL COUNTRY
TEMPLATES & APPENDIX
TOOLKIT
CASE STUDIES

# Chapter 3: Policy Selection

PART II. Select and Describe Policy | Chapter 3 | Chapter 4

3.1 Review regional emission levels and trends | 3.2 Agricultural policies and measures | 3.3 Policy prioritisation

Policies addressing agricultural production and land management present opportunities for countries to reduce GHG emissions, enhance carbon stocks, and meet their commitments under the Paris Agreement. After reviewing the planning phase described in Part I of this guide, the user should be familiar with basic concepts supporting the assessment process. The user can now start considering mitigation approaches applicable to various agricultural systems and determine which specific policy or policies will be assessed. Policies are instruments that enable or incentivise the implementation of practices or technologies that impact GHG emissions. Measures are the practices and/or technologies that reduce emissions.

This chapter provides guidance on selecting an agricultural policy to assess, which can be a planned policy or one that has already been implemented. To identify agricultural policies that may be selected for the assessment, the user can review common agricultural mitigation measures and policy instruments, as well as regional trends in agricultural emissions.

## 3.1 Review regional emission levels and trends

In the policy selection phase of the assessment, the first step is to review trends in agricultural production and emissions at the global and national levels.

Agricultural emissions in 2019 reached 10.2 billion tonnes of $CO_2e$, accounting for approximately 20 percent of global GHG emissions (FAO, 2021). These estimates include emissions from agricultural production activities and land use change associated with agriculture, excluding energy consumption. Emissions from land use change decreased by 25 percent due to decreases in deforestation. Contrary to this, emissions from agricultural production activities grew by 10 percent (FAO, 2021). Agricultural production emissions are projected to grow further due to increasing food demand (Dickie et al., 2014). In 2019, of the $CO_2e$ generated through agricultural production, emissions from enteric fermentation were the largest contributor at 28 percent of total emissions. Emissions from manure management comprised 13 percent, while emissions from fertilisers on agricultural soils were 6 percent. Emissions from rice reached 7 percent (FAO, 2021).

Regional agricultural GHG emission trends between 2000 and 2019 are shown in **Figure 3.1**. While emissions in North America and Asia remained relatively stable, they have increased in Africa by 30 percent and decreased in Latin America by over 20 percent. Decreased emissions in Latin America are primarily due to a decrease in deforestation and emissions associated with conversion of forest land compared to 2000 levels. Europe and Oceania also saw decreases in emissions. Such regional trends indicate the general direction of agricultural emissions. This guide recommends that the user identifies national emission levels and trends to inform policy analysis.

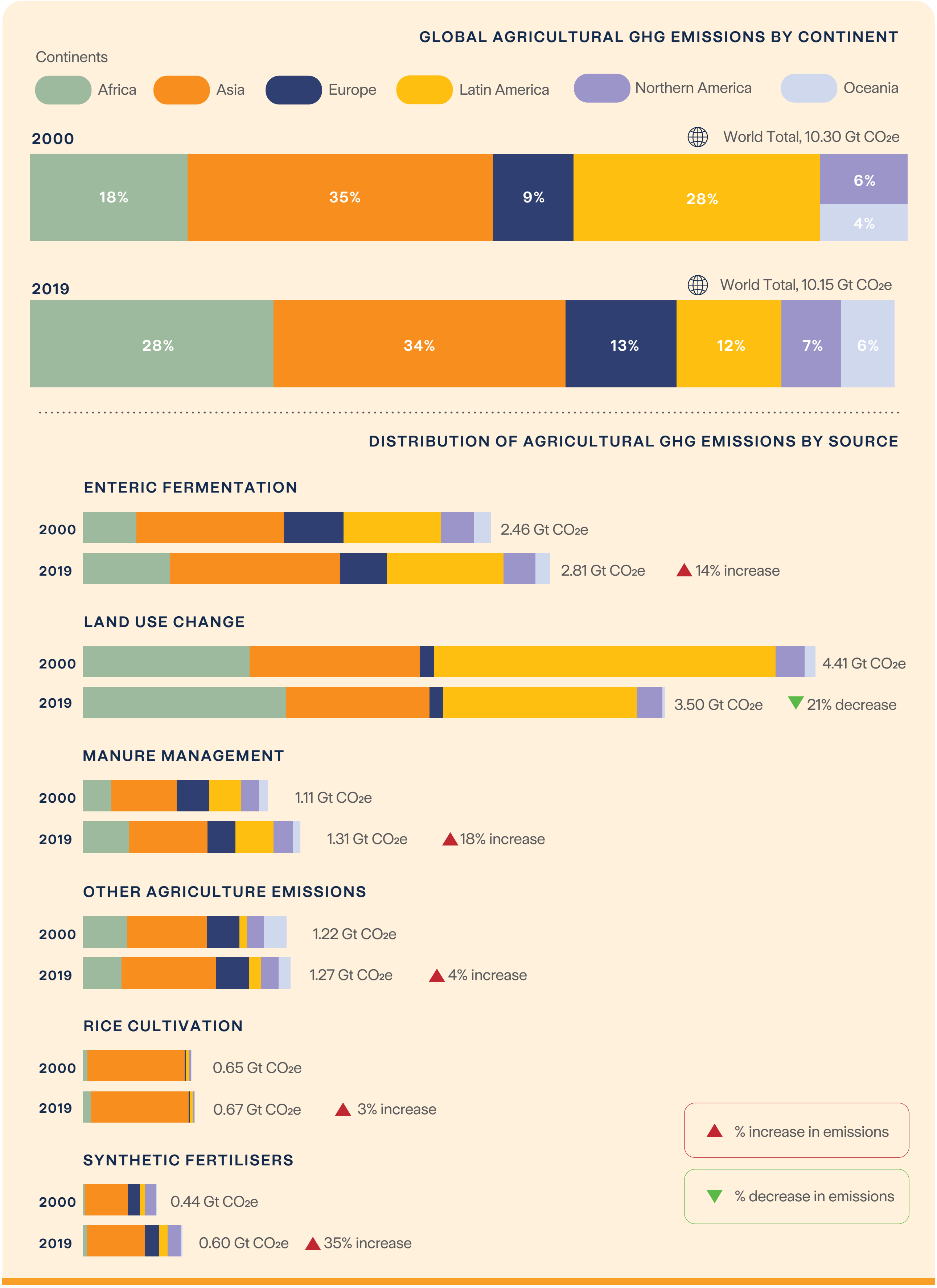
Refer to the FAO's database, FAOSTAT, in this guide's assessment toolkit, for country-specific emissions data.

There are also regional differences in sources of emissions. **Figure 3.1** shows past and current distribution of emission sources for different regions.

Analysis of the potential for mitigation from enteric fermentation point to areas with pasture-based production systems, in particular Brazil and India (Dickie et al., 2014). Fertiliser management measures are relevant globally, although would have an especially significant impact in regions with highly industrialised agricultural systems and areas with high rates of industrialised growth because they are associated with nitrogen fertiliser overuse (USA, China, European Union, and India account for ~80 percent of $N_2O$ emissions from soils). Similarly, hotspots for manure management interventions occur in areas with highly industrialised livestock or rapidly industrialised systems (Dickie et al., 2014). The importance of manure management in less intensive systems should not be overlooked, and this guide provides an example of such an intervention in Chapter 5.

Opportunities to improve soil carbon storage can be found across the globe, but challenges with data availability make it hard to quantify and prioritise. Carbon management measures could be targeted to areas where they have synergistic effects with other policy priorities or areas with low soil carbon and high needs for food security and poverty reduction, such as Sub-Saharan Africa.

Figure 3.1. **Distribution of global agricultural GHG emissions, by continent**




Source: FAOSTAT

Asia represents the biggest opportunities for mitigation related to rice cultivation as 90 percent of the global production occurs there. In particular, water management practices are applicable to areas with high levels of irrigated production such as Pakistan, Sri Lanka, Vietnam, China, Taiwan, Japan, and South Korea (Dickie et al., 2014).

**Table 3.1** provides an overview of mitigation measures and their applicability in different regions. The measures are described in more detail in Section 3.2.

Table 3.1. **Mitigation opportunities by region**

| | Measure Type | Geographic opportunities |
|---|---|---|
| **Livestock – Enteric fermentation** | Feed management | Areas with medium- to low- productivity systems, with market-oriented herds, e.g., Latin America, Asia/Indian subcontinent |
| | Diet formulation | Areas with medium- to low- productivity systems, with market-oriented herds, e.g., Latin America, Asia/Indian subcontinent |
| | Rumen manipulation | Areas with high-productivity livestock systems, e.g., European Union, USA, Canada, Australia, New Zealand |
| | Animal husbandry | Areas with medium- to low- productivity systems, with market-oriented herds, e.g., Latin America, Asia/Indian subcontinent |
| **Livestock – Manure management** | Manure storage, covers and other handling practices | Areas with medium- to low- productivity systems, with market-oriented herds, e.g., Latin America, Asia/Indian subcontinent |
| | Application of nitrification or urease inhibitors to stored manure or to urine patches | Areas with primarily pasture-based systems |
| | Grazing practices to manage livestock manure deposition | Areas with large tracts of grazing land, e.g., Brazil, China, Mongolia, Kenya, Ethiopia |
| | Anaerobic digestion | Areas with highly intensive systems, e.g., European Union, USA, China, India |
| **Fertiliser management** | Optimising nitrogen fertiliser application | To reduce overuse – areas with highly industrialised or rapidly growing systems, e.g., European Union, US, China, India<br>To improve fertility and prevent overuse/inefficiency – areas with degraded lands, e.g., Sub-Saharan Africa |
| | Using slow or controlled-released nitrogen fertilisers or nitrification inhibitors | Areas with highly industrialised systems, e.g., European Union, USA |

Table 3.1. **Mitigation opportunities by region (Continued)**

| | Measure Type | Geographic opportunities |
|---|---|---|
| Soil carbon | Residue management and tillage | Applicable across all regions |
| | Restoration of degraded lands/land cover(use) change | Areas where food security is not expected to be compromised |
| | Agronomic improvements | Applicable across all regions |
| | Pasture management | Areas with overgrazed/degraded lands, e.g., Sub-Saharan Africa, Eurasia<br>Areas with large tracts of grazing land, e.g., Brazil, China, Mongolia, Kenya, Ethiopia |
| Rice cultivation | Management of water | Applicable in areas with rice production primarily Asia, in particular countries with high areas of irrigated rice production systems (over 75%), e.g., Vietnam, Pakistan, Sri Lanka, Taiwan, Japan, South Korea |
| | Organic matter management strategies | Applicable in areas with rice production primarily Asia, in particular China |
| | Rice cultivar | Applicable in areas with rice production primarily Asia |
| | Fertilisers or amendments | Applicable in areas with rice production primarily Asia, in particular China |
| | Seeding methodology | Applicable in areas with rice production primarily Asia |
| | Rotational management | Applicable in areas with rice production primarily Asia |

## 3.2 Agricultural policies and measures

This section reviews common Agriculture sector GHG mitigation measures, policy instruments, and financing mechanisms.

### 3.2.1 Mitigation practices or technologies

This guide can be used to assess a range of practices or technologies in the Agriculture sector that reduce GHG emissions from livestock enteric fermentation and manure management, fertiliser use, rice cultivation, and enhance removals in soil carbon. This section provides an overview of common mitigation practices and technologies in the Agriculture sector and will help the user identify which Agriculture sector policies are the most impactful on GHG emissions. Users should also recognise that agricultural systems involve linkages between different emission sources (see **Figure 1.1** to review agricultural processes), which means that there are often interactions between policies.

A marginal abatement cost curve represents the relationship between the cost of different mitigation options and the total amount of GHG reduced (Bockel et al., 2012). Estimating the abatement cost can gauge the cost-effectiveness of the policy. Abatement cost is determined by dividing the resulting net cost of the policy by the potential emission reductions of implementing the policy (USD/t$CO_2$e) relative to the baseline scenario. Some mitigation policies may present zero or negative costs (i.e., produce financial savings), and therefore present strong cases for ready adoption and implementation. Cost-effectiveness might change as technologies mature, and while some technologies might not be profitable in the conventional sense, they might be interesting for financial institutions dedicated to combating climate change when exhibiting a high mitigation potential or are seen as a key action for transforming a specific practice.

A list of Agriculture sector mitigation measures along with their typical mitigation potential and abatement costs are provided in **Table 3.2**. The typical mitigation potential and abatement cost values are taken from published literature and should be viewed as indicative. Values for a specific country and policy may differ due to local circumstances. An overview of each measure, including enabling conditions, interactions, cost considerations, and literature references is presented in the sections following the table.

Table 3.2. **Overview of mitigation measures, their mitigation potential, and average abatement costs for emission sources covered by this guide**

| | Measure type | Mitigation potential | Average abatement cost |
|---|---|---|---|
| **Livestock – Enteric fermentation** | Feed management | Average reduction of 12% of product-based emissions *(Arndt et al., 2022)* | Moderate:~50-100 USD/ $tCO_2e$ *(Ahmed et al., 2020; Harmsen, 2019)* |
| | Diet formulation | Average reduction of 18% of product-based emissions and 12% of daily $CH_4$ emissions *(Arndt et al., 2022)* | Moderate: ~50-100 USD/ $tCO_2e$ *(Ahmed et al, 2020; Harmsen, 2019; Day et al., 2019)* |
| | Rumen manipulation | Average reduction of 32% and 13% of product-based emissions and 35% and 17% of daily $CH_4$ emissions, for $CH_4$ inhibitors and electron sinks, respectively *(Arndt et al., 2022)* | Moderate: ~50-100 USD/ $tCO_2e$ (*Ahmed et al., 2020)* |
| | Animal husbandry | For absolute emission reductions (daily $CH_4$), literature suggests a reduction of ~10% per day for genetic improvements and ~17% for improvements to animal health *(Arndt et al., 2022)* | Cost-neutral or cost-beneficial: ~ < 0 USD/ $tCO_2e$ *(Ahmed et al., 2020; Harmsen, 2019)* |
| **Livestock – Manure management** | Manure storage, covers and other handling practices | Depends significantly on management, as well as the type of cover and unique system circumstances | Low: ~1-50 USD/$tCO_2e$ *(Day et al., 2019)* |
| | Application of nitrification or urease inhibitors to stored manure or to urine patches | Depend on nitrifiers in the microbial community | Published estimates not available |
| | Grazing practices to manage livestock manure deposition | Reducing wet season grazing can reduce direct and indirect $N_2O$ emissions by 10-12% *(De Klein, Eckard, 2008; Van der Weerden et al., 2017)* | Low: ~1-50 USD/$tCO_2e$ *(Ahmed et al., 2020)* |
| | Anaerobic digestion | 60-80% of the $CH_4$ emissions that would have occurred from manure otherwise. Estimates of the mitigation potential of smaller-scale systems are more complex but one study estimate is a 23-53% reduction *(Andeweg and Reisinger, 2014; Dhingra et al., 2011)* | Moderate: ~50-100 USD/ $tCO_2e$ (*Ahmed et al., 2020)* |

Table 3.2. **Overview of mitigation measures, their mitigation potential, and average abatement costs for emission sources covered by this guide (Continued)**

| | Measure type | Mitigation potential | Average abatement cost |
|---|---|---|---|
| **Fertiliser management** | Optimising fertiliser application; type, amount, rate, timing and delivery | Variable, depending on region, system, and strategy, depends on the quantity of fertiliser replaced and what it is replaced with, and then subsequently on the system it is applied to | Cost-neutral or cost-beneficial: ~ < 0 USD/ $tCO_2e$<br>If type of fertiliser is changed, costs may increase to ~1-50 USD/ $tCO_2e$, however, still remain in the low category *(Ahmed et al., 2020)* |
| | Using slow or controlled-released fertilisers or nitrification inhibitors | Variable | Published estimates not available |
| **Soil carbon** | Residue management and tillage | Varies across different climate zones – average reduction of 0.70 $tCO_2$/ha/yr in warm moist regions, 0.51 $tCO_2$/ha/yr in cool moist regions, 0.33 $tCO_2$/ha/yr in warm dry regions, and 0.15 $tCO_2$/ha/yr in cool dry regions *(Smith et al., 2007)* | Cost-neutral or cost-beneficial: ~ < 0 USD/ $tCO_2e$ *(Ahmed et al., 2020)* |
| | Restoration of degraded lands/land cover(use) change | Ranges from 3.5 $tCO_2e$/ha/yr to 5.4 $tCO_2e$/ha/yr depending on climate zone and practice type *(Smith et al., 2007)* | Variable depending on restoration option |
| | Agronomic improvements | Varies across different climate zones but is especially notable in moist climates. Average reduction is 0.88 $tCO_2$/ha/yr in moist regions, and 0.29 $tCO_2$/ha/yr in regions with dry climate zones. The average estimate for $N_2O$ emissions reductions is an additional 0.1 $tCO_2e$/ha/yr *(Smith et al., 2007)* | Low: ~1-50 USD/$tCO_2e$ *(McKinsey & Company, 2009)* |
| | Pasture management | Varies across different climate zones but is especially notable in moist climates. Average reduction is 0.81 $tCO_2$/ha/yr in moist regions, and 0.11 $tCO_2$/ha/yr in regions with dry climate zones *(Smith et al., 2007)* | Moderate: ~50-100 USD/ $tCO_2e$ *(Laporte et al., 2021)* |

Table 3.2. **Overview of mitigation measures, their mitigation potential, and average abatement costs for emission sources covered by this guide (Continued)**

| | Measure type | Mitigation potential | Average abatement cost |
|---|---|---|---|
| **Rice cultivation** | Management of water | Methane emission reduction ranges for intermittent irrigation (15-54%), mid-season drainage (27-64%), and alternate wet and dry system (48-93%). Emissions of $N_2O$ during intermittent irrigation periods strongly depend on the level of water soil saturation *(Katayanagi et al., 2012; Hussain et al., 2015; Chirinda et al., 2018)* | Cost-neutral or cost-beneficial: ~ < 0 USD/ $tCO_2e$ *(Ahmed et al., 2020)* |
| | Organic matter management strategies | Early straw incorporation at the start of the winter fallow recorded an 11% emission reduction as compared with that of conventional straw incorporation method during spring. Surface retention of straw may decrease $CH_4$ and $N_2O$ emissions by 69% and 81%, respectively, as compared to that of straw incorporation *(Sander et al., 2014)* | Low: ~1-50 USD/$tCO_2e$ *(Magdoff, 2004)* |
| | Rice cultivar | A large variation of emission rates relative to standard cultivar (IR64) emissions, from 0.64 to 2.51, depending on water management and climate conditions *(Yagi et al., 2020)* | Low: ~1-50 USD/$tCO_2e$ *(Sapkota, 2019)* |
| | Nitrogen fertilisers or organic amendments management | Mitigation potential is variable, depending on fertiliser type, water management, and strategy | Low: ~1-50 USD/$tCO_2e$ *(Ahmed et al., 2020)* |
| | Seeding methodology | Reduction in emissions for direct seeding ranges from 53%-60% *(Pathak et al., 2012; Corton et al., 2000; Wassmann et al., 2004; Hube et al., 2021)* | Cost-neutral or cost-beneficial: ~ < 0 USD/ $tCO_2e$ *(Ahmed et al., 2020)* |
| | Rotational management | Variable, depending on climate and crop rotations utilised | Low: ~1-50 USD/$tCO_2e$ *(Rosenberg et al., 2022)* |

### Livestock mitigation measures – enteric fermentation

**Feed management:** One of the most promising mitigation options globally to reduce enteric $CH_4$ emissions are increasing feeding level and forage quality leading to improved digestibility and improved production efficiency (Arndt et al., 2022; Smith et al., 2021; Hristov et al., 2013). For example, feed quality can be improved by decreasing grass maturity or optimising temperature at the time of feed harvest for higher sugar content.

**Applicability:** Measure is applicable in pasture-based and mixed ruminant systems.
**Mitigation potential:** The average emission reduction is 12 percent per unit of production (range 9 to 17 percent) (Arndt et al., 2022).
**Enabling conditions and barriers:** Feed management measures typically result in a financial benefit from increased animal productivity. Implementation requires knowledge and understanding of feed quality and animal needs and suitable conditions for growing sufficient quantity and quality of feed. Some strategies may be costly and therefore impact profitability, creating a barrier to implementation. Some measures require further investment (in new technologies and practices) and most require knowledge transfer and training. Pasture and grazing management practice gains are greatest in overgrazed pastures and unimproved grassland with low yield. Industry involvement to support transfer of knowledge from other regions and to develop suitable customised grazing schemes can foster the adoption of improved practices. Grassland management can be complex due to cultural, social, economic, or regulatory pressures compounded by some land tenure systems.
**Emission trade-offs and synergies:** Care is needed to not reduce the fibre digestibility of animal diets, which has implications for manure $CH_4$. In some instances, feed management measures may increase indirect emissions off-farm (outside the scope of this guidance but should be considered in policy implementation) due to the production of fertilisers required to improve feed quality. Feed management implementation also relies on regional supply chains and can involve interactions with regional food security where (human) food and (animal) feed compete.
**Cost considerations:** Abatement costs are within a moderate range (~50-100 USD/ $tCO_2e$). Optimum feed will depend on local availability and circumstances (Ahmed et al., 2020; Harmsen, 2019).

**Diet formulation:** One of the most promising mitigation options globally for pasture-based systems is the inclusion of tanniferous forages, plants high in tannins such as birdsfoot trefoil, to reduce enteric $CH_4$ emissions by reducing methanogenesis in the rumen (Arndt et al. 2022). Tannins decrease fibre digestibility and bind to nitrogen in the rumen, in the digestive tract, and in treated manure. In feedlot and mixed systems, diet formulation measures include modification of feed to improve animal nutrition and health, for example, the addition of oils and fats, oilseeds, or by-products from grain processing, and changing feeding frequency.

**Applicability:** Measure is applicable in all ruminant systems (pasture-based, feedlot, and mixed).
**Mitigation potential:** Inclusion of tanniferous forages for dairy cattle has an average reduction potential of 18 percent (range 8 to 26 percent) per unit of milk production or a reduction potential of 12 percent (range 7 to 16 percent) in terms of absolute daily $CH_4$ emissions (Arndt et al., 2022).
Enabling conditions and barriers: Dietary management measures typically result in a financial benefit from increased animal productivity. They require knowledge and understanding of dietary needs and there may be issues of palatability of new diets for some animals. Some diets require more investment (in new technologies and management practices) as well as knowledge transfer and training. There would be concerns if the measure alters milk constituents that conflict with market requirements or expectations.
Trade-offs and synergies: Decreased fibre digestibility could potentially have implications for $CH_4$ generated from manure (Arndt et al., 2022). In contrast, tannins and tanniferous compounds bind to nitrogen,

which can lead to reduced N excretion in urine and reduce ammonia and $N_2O$ emissions. Implementation also relies on regional supply chains and can involve interactions with regional food security where (human) food and (animal) feed compete.
**Cost considerations:** With abatement cost in the moderate range (~50-100 USD/$tCO_2e$), diet formulation may have a larger emission reduction potential, with higher implementation costs than feed management (Ahmed et al., 2020; Harmsen, 2019, Day et al., 2022).

**Rumen manipulation:** One of the most promising mitigation options globally is $CH_4$ inhibitors and electron sinks that alter $CH_4$ production pathways during enteric fermentation. Other rumen manipulation measures include additives (e.g., amino acids, enzymes, galactooligosaccharides, ionophores, organic acids, probiotics, and secondary plant compounds), defaunation and manipulation of rumen archaea and bacteria.

**Applicability:** Measure is applicable in ruminant feedlots and mixed systems.
**Mitigation potential:** For $CH_4$ inhibitors and electron sinks, respectively, the average reduction potential is 32 percent and 13 percent per unit of milk production or 35 percent and 17 percent in terms of absolute daily $CH_4$ emissions (Arndt et al., 2022).
**Enabling conditions and barriers:** Increasing animal productivity provides a financial incentive to farmers, and the underlying goal of rumen manipulation is to increase feed efficiency and reduce energy losses from enteric fermentation. Demonstrating the profitability of rumen manipulation is therefore key to the adoption of this measure. Implementation barriers include high development costs, regulatory hurdles, the development time to commercial availability, and a lack of applicability in pasture-based systems. Consumer perceptions of products produced using rumen modification methods may also present a market barrier.
**Trade-offs and synergies:** Production of inhibitors or other additives could increase indirect emissions off-farm (outside the scope of this guide but should be considered in policy implementation). The emissions from the production or import of these substances, however, will likely be small compared to emission reductions. However, considering where emissions are being generated (i.e., off-shore) is important for public communications.
**Cost considerations:** Abatement costs are likely to be in the moderate range (~50-100 USD/$tCO_2e$) (Arndt et al., 2022).

**Animal husbandry:** Improving animal genetics (breeding selection for low residual feed intake or low enteric $CH_4$ emitters) and improved health and reproductive capacity can result in fewer emissions (i.e., increasing herd efficiency). By eliminating the less productive members of a herd without decreasing production, the total amount of manure produced can potentially also be reduced.

**Applicability:** Measure is applicable in all ruminant systems (pasture-based, feedlot, and mixed).
**Mitigation potential:** For absolute emission reductions (daily $CH_4$), the literature suggests a reduction of ~10 percent for genetic improvements and ~17 percent for improvements to animal health (Arndt et al., 2022). There is little data on per unit of production emission reductions for genetic management strategies.
**Enabling conditions and barriers**:
With respect to improving herd health and reproductive capacity, targeted education can support uptake by farmers. Demonstrating the profitability of healthier animals and better herd structure (i.e., reducing the number of unproductive animals) is key for adoption. There may be upfront costs for disease control and eradication as well as for industry and farmer education on the benefits of reducing or eradicating diseases. A barrier to improving animal genetics may be the upfront costs for research and development into superior breeds. Also, the availability of rapid rumen microbiome analysis techniques is needed to advance research on low-emitting breeds (Budel et al., 2022). Breeders

also need incentives to include emission mitigation traits as priorities in their breeding programmes (Andeweg and Reisinger, 2014).
**Trade-offs and synergies:** Improving animal health and genetics can have a feedback effect through elimination of less productive animals in the herd, thereby leading to less overall manure and related $CH_4$ emissions (Hristov et al., 2013).
**Cost considerations:** The abatement cost of this measure is typically in the cost-neutral or cost-beneficial range (~ < 0 USD/t$CO_2$e), but breeding research and development may be required (Ahmed et al., 2020; Harmsen, 2019).

### Livestock mitigation measures – manure management

Mitigating manure emissions is complex due to the risk of emissions leakage (i.e., when reducing source causes another emission source to increase). As discussed in the enteric fermentation measures section, feed and diet management measures will affect the composition of manure and total nitrogen excreted (in dung and urine) available for transformation into $NH_3$ and $N_2O$. Further, increasing herd efficiency via improved animal health and reproductive capacity also results in decreasing manure emissions, by reducing the unproductive part of the herd and thus the total amount of manure produced., For example:

- Storing manure with a low water content may reduce $CH_4$ emissions (due to lower rates of methanogenesis) but may increase $N_2O$ emissions due to incomplete denitrification to $N_2$.

- A measure that reduces the amount of $NH_3$ volatilised during manure handling, treatment, and storage may then increase the amount of N that is available to generate downstream $N_2O$ and $NH_3$ emissions when manure is later applied to soils as fertiliser.

- Dietary management strategies that manipulate dietary N to reduce manure $N_2O$ and $NH_3$ emissions may decrease dietary protein concentration which can then increase $CH_4$ production by decreasing the amount of fermentable carbohydrates in the diet (Hristov et al., 2013).

In sum, the mitigation potential of manure management measures should not be considered in isolation.

This guide does not discuss feed strategies as measures of mitigating manure emissions because their primary objective is a reduction in enteric fermentation emissions. The trade-offs for manure emissions are noted in the previous section.

**Manure storage covers and other handling practices:** The largest source of manure management emissions ($CH_4$, $NH_3$, and $N_2O$) occurs in the form of $NH_3$ and $CH_4$ during the storage period (Hristov et al., 2013). Therefore, reducing time spent in storage, particularly in anaerobic conditions, can be an effective measure.

Use of permeable (natural crusts where solid content is high, straw, wood chips, oil layers, expanded clay, wood), semi-permeable, and sealed plastic manure covers are also mitigation measures for reducing $CH_4$ and $NH_3$ emissions. Their effect on $N_2O$ emissions, however, is highly variable.

**Applicability:** Measure is applicable to all managed manure systems (i.e., intensive systems).
**Mitigation potential:** The effectiveness of manure storage practices depends significantly on the type of cover and on operational storage conditions.
**Enabling conditions and barriers:** Awareness and training are required to foster this measure, especially for smallholder farmers. Increase in labour may pose a significant barrier to adoption. Some new equipment may be needed to implement new storage or cover practices.
**Trade-offs and synergies:** Depending on the specific manure storage practice, all or some combination of $N_2O$, $NH_3$, and $CH_4$ may be reduced. There is also potential to increase indirect $N_2O$ emissions if the manure is later applied to poorly drained or wet

soils. Limitations with other manure handling practices including the following:

- The type of animal housing can indirectly effect manure $NH_3$ and $CH_4$ emissions (Hristov et al., 2013). For example, housing determines whether manure can be collected and stored for anaerobic digestion (for larger production systems) or whether manure is managed as a slurry, stacked, or in deep litter systems (in smaller production systems). Housing systems used by smallholder farmers tend to use concrete floors which have fewer options for storage and treatment of manure than raised slatted floors, which tend to be used in larger operations.
- Adding acid to liquid manure reduces $NH_3$ volatilisation, which leads to $N_2O$ emissions (Harper et al., 2004; Lee et al., 2011), but this practice requires costly infrastructure.
- Composting manure increases nutrient availability and thus potential emissions; therefore, it is not recommended for inclusion in manure policies.
- Compaction of manure to mitigate emissions does not yet have sufficient evidence to determine its net effects.
- According to research on mechanical separation of the liquid and solid portion of manure, this practice has an uncertain effect on emissions. Separating and preventing the solid portion of manure from undergoing anaerobic storage, theoretically, should reduce emissions, but the $CH_4$-producing capacity of the remaining liquid proportion is also altered in the process (Dinuccio et al., 2008).
- Application of manure as fertiliser results in direct and indirect $N_2O$ emissions from soils. See the following section on nutrient mitigation measures.

**Cost considerations:** Mitigation measures related to improved storage typically have low abatement costs (~1-50 USD/t$CO_2$e) and low investment costs, as they mostly require changes in practices as well as capacity building for small farmers (Day et al., 2022).

**Application of nitrification or urease inhibitors to stored manure, urine patches, or via naturally occurring biological nitrification inhibitory compounds in plants on pasture:** Direct application of synthetic nitrification inhibitors (SNI) to urine patches or managed manure can reduce $N_2O$ emissions by inhibiting soil nitrification. A growing body of research also supports the use of plant-induced biological nitrification inhibition (BNI) to reduce soil nitrification in pasture-based livestock systems (de Klein et al., 2022). The most widely used SNIs are dicyandiamide (DCD) and nitrapyrin. For BNIs, research has explored the subtropical plants, wheat, sorghum, maize, rice, grasses (e.g., *Brachiaria humidicola* (Subbarao and Searchinger, 2021) and *Elymus grass* (Li et al., 2022)), and plantain (Judson et al., 2019). Urease inhibitors are appropriate for systems where they can be applied to urine before it is mixed with soil or faeces.

**Applicability:** Measure is applicable in all pasture-based systems and systems with managed manure.
**Mitigation potential:** $N_2O$ emission reductions through BNI depend on nitrifiers in the microbial community.
**Enabling conditions and barriers:** SNI measures can be costly to apply but useful for intensive pasture-based systems. More research is needed, but methods of pasture application and targeting urine patches are being explored (Chibuike et al., 2022; Giltrap et al., 2022). Use on pastures may face regulatory barriers due to concerns about residues in food products. Use of BNIs may face fewer regulatory and public perception barriers.
**Trade-offs and synergies:** Interactions are complex, as SNIs and BNIs reduce direct $N_2O$ emissions but may increase $NH_3$ accumulation and consequent emissions from volatilisation, leaching, and runoff (Hristov et al., 2013). There is potential to increase $N_2O$ emissions if manure is applied to poorly drained or wet soils. Some inhibitors may cause eco-toxicity.
**Cost considerations:** Technology is in development and may have high implementation costs; no cost estimates are available at this time.

**Grazing practices to manage livestock manure deposition:** Practices that restrict grazing can reduce $N_2O$ emissions. Reducing wet season grazing (due to the relationship with soil moisture for both nitrification and denitrification processes) and managing grazing intensity can both reduce compaction of soil and maintain soil aeration, thereby preventing excess $N_2O$ generation.

**Applicability**: Measure is applicable in pasture-based (extensive) ruminant systems. Mitigation potential: Limiting wet season grazing can reduce direct and indirect $N_2O$ emissions by 10-12 percent (de Klein and Eckard, 2008; van der Weerden et al., 2017).
**Enabling conditions and barriers:** General awareness and education are required. Tailored training programmes may be necessary for smallholder farmers.
**Trade-offs and synergies:** Reducing the amount of time animals spend on pasture, for example during the wet season, increases the amount of time they spend elsewhere and may have trade-offs on emissions from housing manure management. Managed grazing can also lead to improved pasture and increased soil carbon sequestration.
**Cost considerations:** Abatement costs are low (~1-50 USD/t$CO_2$e). Potential pasture improvements may offset some upfront costs (Ahmed et al., 2020).

**Anaerobic digestion:** Larger-scale commercial anaerobic digestors capture $CH_4$ as a biogas from manure which can then be used to meet the energy requirements of a farm. Small-scale digestors (6 – 10m$^3$) have been used as a means of improving sanitary conditions in developing country smallholder farm operations due to their ability to manage both livestock and human waste (Bond and Templeton, 2011; Jiang et al., 2011). However, if operated without sufficient care, digesters can have $CH_4$ leakage losses of up to 40 percent of captured emissions and may negate their benefit entirely (Smith et al., 2021).

**Applicability**: Measure is applicable in intensive livestock and poultry systems with managed manure. Specifically, this measure is applicable where 1) average temperatures are sufficiently warm (≤15°C) to be able to generate biogas, 2) technology and human resource requirements for the establishment and management of a digestor system will not present barriers, and 3) the type of livestock system is considered intensive and of a large enough size to operate at scale in keeping with the necessary investment in new equipment.
**Mitigation potential:** Efficient biogas systems avoid up to 60–80 percent of the $CH_4$ emissions that would have occurred from manure otherwise (Andeweg and Reisinger, 2014). Mitigation potential of smaller-scale systems is more uncertain, but one study estimated a 23–53 percent reduction (Dhingra et al., 2011).
**Enabling conditions and barriers:** For larger-scale systems, uncertainty in the economic return from equipment investments can hinder adoption. (Hristov et al., 2013). Anaerobic digestors require continuous water supply and high investment outlays, which often call for government subsidies or other financial incentives (Ndambi et al., 2019). Proper maintenance and knowledge of both small and larger-scale digestors are crucial to prevent $CH_4$ leakage (Smith et al., 2021).
**Trade-offs and synergies:** Anaerobic digestion has minimal trade-offs if managed effectively and leakages are avoided. A co-benefit of anaerobic digestion is the enhanced nutrient availability in digestate compared to untreated manure when applied as fertiliser.
**Cost considerations:** Moderate abatement cost (~50-100 USD/t$CO_2$e) with feasibility highly dependent on farm size and access to investment resources (Ahmed et al., 2020).

### Fertiliser/nutrient management mitigation measures

Emissions of $N_2O$ from agricultural soils can be reduced through measures that optimise the use of fertilisers applied to crops or pastures. Fertilisers may be synthetic or organic (e.g., manure or compost). There are direct and indirect $N_2O$ emissions, the latter via N leaching and ammonia volatilisation, that need to be accounted for.

**Optimising fertiliser application; type, amount, rate, timing, and delivery:** Urea and ammonium-based fertilisers have been found to produce less $N_2O$ compared to nitrate-based fertiliser per unit of N supplied to the soil/plants due to the latter providing a more readily available mineral N pool for denitrification (e.g., Eckard et al., 2003, Kuikman et al., 2006). Therefore, avoiding nitrate fertilisers and opting for urea and nitrogen fertilisers reduces $N_2O$ emissions.

The timing and placement of fertiliser affect emissions because it can minimise the amount of fertiliser needed to produce a successful crop. However, in many parts of the world, the amount of fertiliser applied will need to increase rather than decrease because current crop nutrient needs are not being met. However, in some regions producers apply a 'buffer' of extra fertiliser as a form of yield insurance, and, in these situations, reductions in fertiliser use are possible. Due to the relationship between $N_2O$ emissions, soil moisture, and temperature, adjusting fertiliser application timing (e.g., from autumn to spring or avoiding wet seasons) can be an effective measure to reduce $N_2O$ emissions. Adjusting the timing of application to a few weeks after planting has also been shown to reduce $N_2O$ emissions. Splitting the application of fertiliser or using other measures such as drip feeding the N supply may also be an option. Applying nitrogen as close as possible to the roots of plants can reduce $N_2O$ emissions due to better plant N uptake, but is not as effective as altering the amount of fertiliser applied.

**Applicability**: Measure is applicable in all agronomy production systems.
**Mitigation potential:** Variable, depending on region, system, and strategy.
**Enabling conditions and barriers:** Implementation requires knowledge and monitoring of crop nutrient needs. Measures such as split applications of fertiliser require sufficient human resources. Regions that do not yet have access to required technologies for a given method of fertiliser application will need access to new equipment and training.
**Trade-offs and synergies:** Reducing the amount of N fertiliser used may reduce crop/pasture yields. Furthermore, changing fertiliser management is associated with higher labour costs and increased technical capacity needs.
**Cost considerations:** Fertiliser management can be cost-neutral or cost-beneficial (~ < 0 USD/$tCO_2e$) as reduction of fertiliser input can entail cost savings if crop yields are unaffected. In the longer term, the measure can also improve soil quality. If the type of fertiliser is changed, costs may increase to ~1-50 USD/$tCO_2e$. (Ahmed et al., 2020; McKinsey & Company, 2009).

**Using slow or controlled-released fertilisers or nitrification inhibitors:** Slow-release fertilisers reduce the amount of N available for direct $N_2O$ emissions from soils and encourage greater N use efficiency by plants. Nitrification inhibitors slow the microbial conversion of $NH_3$ to other forms of N that are precursors for $N_2O$.

**Applicability**: Measure is applicable in all agronomy production systems with access to controlled-release fertilisers where cost is not prohibitive.
**Mitigation potential:** Variable, depending on region, soils, application, and other factors.
Enabling conditions and barriers: Controlled-release fertilisers and inhibitors are not widely available and can be expensive compared to traditional fast-release fertilisers. It is anticipated that the cost of nitrification inhibitors will decrease over time and in some countries a significant proportion of urea sold already contains inhibitors.
**Trade-offs and synergies:** For nitrification inhibitors, the mechanism is the same as nitrification inhibitors applied to manure and urine patches discussed in livestock

mitigation measures. In summary, inhibitors decrease direct $N_2O$ emissions but may increase $NH_3$ accumulation.
**Cost considerations:** Technology is not yet widely available, published estimates of abatement cost are not available.

### Soil carbon mitigation measures

Measures aimed at increasing soil carbon stocks are limited by the saturation limits of soils to store further carbon, leading to a typical slowdown in the rate of sequestration over the timeframe of policy implementation. Furthermore, reversals of carbon storage can result from natural or anthropogenic disturbances, such as when land is tilled or land under perennial cover is cultivated for annual crops. Care should be taken to manage risk of reversals and increase awareness of the benefits of long-term soil health benefits. Another consideration for implementing soil carbon measures is the cost of soil carbon measurements and the high uncertainty in those measurements.

**Residue management and tillage:** This measure includes improving agricultural residue management through mulching, avoiding residue burning, and switching to reduced till or no-till. Reducing soil disturbance tends to result in soil carbon gains due to decreased erosion and decomposition. Retaining plant residues that are precursors to soil organic matter also helps increase soil carbon stocks.

**Applicability**: Measure is applicable in all annual cropping systems.
**Mitigation potential range:** Mitigation potential varies across different climate zones – mean reduction from these practices is estimated to be 0.70 $tCO_2$/ha/yr in warm moist regions, 0.51 $tCO_2$/ha/yr in cool moist regions, 0.33 $tCO_2$/ha/yr in warm dry regions, and 0.15 $tCO_2$/ha/yr in cool dry regions (Smith et al., 2007).
**Enabling conditions and barriers:** In most cases, switching to reduced or no-till practices has no significant technological barriers. Some practices require less or no machinery compared to conventional tillage. The adoption of reduced tillage practices can be enabled through education and increased awareness. A challenge related to this measure is the re-release of carbon if management is not maintained and instead more intensive tillage occurs.
**Trade-offs and synergies:** Reduced tillage can reduce $CO_2$ emissions associated with energy use as well as $N_2O$ emissions from land. This measure can also improve soil quality and reduce water pollution. Maintaining crop residues can enhance water-holding capacity, thereby improving resilience to drought conditions.
**Cost considerations:** Abatement costs are neutral or cost-beneficial (~ < 0 USD/$tCO_2e$) due to savings through decreased use of tillage labour and machinery (Ahmed et al., 2020).

**Restoration of degraded lands/land cover(use) change:** This measure includes a wide range of options that typically result in a change in cropping system or land use type (e.g., terracing, contour strips, adding grassed waterways, and buffer strips). This measure results in increasing soil stability and reduced erosion with some of the land no longer being cultivated. When cropland is degraded, it may also warrant conversion to native vegetation. Soil carbon storage can increase with native and/or more productive species growing on the land and reduced soil disturbance. Fertility can be improved through the addition of soil amendments.

**Applicability**: Measure is applicable in all agronomic systems.
**Mitigation potential range:** Mitigation potential may range from 3.45 $tCO_2e$/ha/yr to 5.36 $tCO_2e$/ha/yr depending on climate zone and restoration option. These estimates consider increases in soil carbon stocks as well as $N_2O$ and $CH_4$ emission reduction (Smith et al., 2007).
**Enabling conditions and barriers:** Mitigation via restoration of degraded lands is well-suited for areas with low or declining agricultural fertility. Increased technical and financial support is critical to enable producers to adopt soil health practices to their systems and mitigate risk of losing production area or yield during the

restoration period.
**Trade-offs and synergies:** $N_2O$ emissions can increase when nutrients are applied to improve fertility of lands remaining in agricultural production. Land taken out of production can negatively impact area available food production. Habitat and biodiversity benefits can be associated with re-vegetation, restoration of land, as well as higher or more stable yields when fertility of degraded land is improved.
**Cost considerations:** Implementation costs can vary widely depending on the restoration option. Globally, economic losses from land degradation could reach USD 23 trillion by 2050 (UNCCD, 2018).

**Agronomic improvements:** This measure includes diversifying/extending crop rotations, increasing the use of perennial crops, and planting cover crops. These practices increase carbon residues on the land and thereby more carbon stored in the soil. Rotations with legume crops also reduce external fertiliser inputs and associated $N_2O$ emissions.

**Applicability**: Measure is applicable in all agronomic systems.
**Mitigation potential range:** Mitigation potential varies across different climate zones but is especially notable in moist climates. Mean reduction from agronomic improvements is estimated to be 0.88 $tCO_2$/ha/yr in moist regions, and 0.29 $tCO_2$/ha/yr in regions with dry climate zones (Smith et al., 2007). The mean estimate for $N_2O$ emissions reductions is an additional 0.1 $tCO_2e$/ha/yr.
**Enabling conditions and barriers:** Increased technical assistance is critical to enable producers to adopt new agronomic practices. Developing markets for perennial crops and/or cover crops will support adoption.
**Trade-offs and synergies:** This measure improves soil quality and reduces water pollution. Economic benefits associated with improved yields are also likely. Agronomic practices are often coupled with nutrient management, which has an impact on $N_2O$ emissions. Improved soil health as well as enhanced water holding capacity improving resilience to drought conditions.
**Cost considerations:** Low abatement cost (~1-50 USD/$tCO_2e$) as changes in planting practices do not generally require higher inputs or capital expenditures (McKinsey & Company, 2009).

**Pasture management:** For land remaining grassland, this measure includes managing grazing intensity (i.e., how much time livestock spend in one area) and selecting grass species with higher productivity. Grazing intensity, frequency, and duration influence the growth rate and composition of grass species, which affects soil carbon storage. Reseeding pasture with more productive grasses can also enhance carbon storage. As described in preceding sections, pasture management can play a role in measures related to livestock such as feed management and grazing practices to manage livestock manure deposition.

**Applicability**: Measure is applicable in pasture-based systems.
**Mitigation potential range:** Mitigation potential varies across different climate zones but is especially notable in moist climates. Mean reduction from pasture management is estimated to be 0.81 $tCO_2$/ha/yr in moist regions, and 0.11 $tCO_2$/ha/yr in regions with dry climate zones (Smith et al., 2007).
**Enabling conditions and barriers:** Regulation is likely to foster better pasture management. Regulations that prevent grassland burning and overgrazing of lands, such as land access fees, can be coupled with financial incentives for fencing and technical support for producers.
**Trade-offs and synergies:** Managing grazing intensity has direct effects on $CH_4$ emissions from livestock if the number of animals changes. Manure from livestock can also influence $N_2O$ emissions, potentially increasing if fertiliser input levels go up or decreasing if legume species are introduced. Improved pastures enhance livestock productivity and food security, reduce desertification, and improve habitat.
**Cost considerations:** Moderate abatement cost range (~50-100 USD/$tCO_2e$) has been reported for this measure, with new grass and cover crops in the lower end and rotational grazing in the of the range (Laporte et al.; 2021).

### Rice cultivation mitigation measures

**Management of water:** Methane is influenced by the irrigation system used since methanogenesis is associated with the condition of soil flooding during the rice plant development. This measure includes the application of intermittent irrigation, a seasonal drainage system, or an Alternate Wet and Dry (AWD) system. There are several water management alternatives to continuous flood irrigation that can be adopted under different soil and climate conditions.

**Applicability**: Measure is applicable in low-land irrigated flooded rice cultivation systems.
**Mitigation potential range:** The mitigation potential for $CH_4$ emissions for intermittent irrigation is 15–54 percent, mid-season drainage 27–64 percent, and AWD 48–93 percent (Katayanagi et al., 2012; Hussain, et al., 2015; Chirinda et al., 2018). Several studies conducted in Latin American countries have reported a decrease in $CH_4$ emissions from AWD by 55-70 percent compared with intermittent irrigation (Tarlera et al., 2016; Moterle et al., 2013). The few studies conducted in LAC corroborate with studies conducted in other regions (Hussain et al., 2015; Minamikawa and Sakai, 2006; Shiratori et al., 2007; Hube et al., 2021).
**Enabling conditions and barriers:** Drainage or intermittent water use means that special attention must be paid to supplying the water requirements of the rice plant to avoid compromising the productive potential of the crop (Hussain et al., 2015). These irrigation systems may not be available in all cases due to local conditions. Management of water levels requires a precise control of water. For example, intermittent drying or soil drainage is not feasible on terraced rice fields because drying may cause water losses from soil cracking. More importantly, to promote the adoption of AWD, infrastructure and training are needed for water delivery and control by farmers (Lampayan et al., 2015).
**Trade-offs and synergies:** AWD, in which fields are drained and re-flooded one or more times during the growing season, can be an attractive mitigation option due to resulting water savings (Epule et al., 2011). It can decrease irrigation water use by 60 percent while maintaining or improving yields (Richards and Sander, 2014). However, AWD can increase $N_2O$ emissions. One study by LaHue et al. (2016) showed that AWD reduced growing-season $CH_4$ emissions by 60–87 percent, as compared to continuously flooded rice fields, and maintained low annual $N_2O$ emissions. Water management reduces costs of water and fuel for irrigation pumps (LaHue et al., 2016; Tarlera et al., 2016; Kim et al., 2014; Johnson-Beebout et al., 2009, Cai et al., 1997; Zou et al., 2005; Hou et al., 2012).
**Cost considerations:** Cost-neutral or cost-beneficial (~ < 0 USD/t$CO_2$e) as implementation typically does not have significant costs (Ahmed et al., 2020).

**Organic matter management:** This measure includes optimising regimes for incorporating straw and/or manure and removing straw from the system. Growing many crops produces large quantities of straw/residues that are typically left in the field (Khaliq et al., 2013). Significant $CH_4$ is generated under flooded conditions from the decomposition of rice straw because this decay favours the growth of methanogenic bacteria (Schütz et al.; 1989; Yagi and Minami, 1990; Sass et al., 1991; Naser et al., 2007; Xu and Hosen, 2010; Ma et al., 2009; Zhang et al., 2011; Denier Van der Gon and Neue, 1994; Khosa et al., 2010). Managing the timing and conditions of straw management can reduce $CH_4$ emissions.

**Applicability**: Measure is applicable in all rice cultivation systems.
**Mitigation potential range:** In rice fields, the surface retention of straw may decrease $CH_4$ and $N_2O$ emissions by 69 percent and 81 percent respectively, compared to straw incorporation. In Asia, early straw incorporation at the start of winter fallow recorded an 11 percent decrease in GHG emissions compared with the conventional straw incorporation method during spring. The practice of incorporating rice residues immediately after harvest, with aerobic decomposition of residues occurring before soil flooding (for the next crop), reduced $CH_4$ emissions by 2.5 to 5 times and improves nutrient cycling (Sander et al., 2014). The

removal or reduction of rice straw from the previous crop, including straw burning management and soil drying in the fallow season, can also reduce emissions.

**Enabling conditions and barriers**: Early incorporation in wintertime can be difficult because of weather conditions. Farmers may use straw as animal feed delaying the time when straw can be incorporated.

**Trade-offs and synergies:** While burning of straw ensures quick seedbed preparation for farmers and avoids N immobilisation risks during residue decomposition, burning generates large amounts of GHGs and adversely affects air quality. Methane emissions have been reported to increase when crop residues are incorporated prior to planting, due to higher amounts of soil microbial activity in temperate and subtropical climates (Dobermann and Fairhurst, 2002; Wang et al., 2015). Wassmann et al. (2000) suggested that residue incorporation during the fallow period (60 days before rice sowing) is beneficial in terms of GHG emission and grain yield as compared to a typical application before transplanting. Removal of rice straw from previous crops can be an effective option in the short term but can reduce soil fertility in the long term.

**Cost considerations:** Low abatement costs (~1-50 USD/t$CO_2$e), as the measure does not demand significant changes in equipment, supplies, or practices, but instead changes in residue collection and distribution timing (Magdoff and Weil, 2004).

**Rice cultivar:** The effect of rice variety on $CH_4$ emissions is related to each cultivar's rice growth performance (i.e., number of plant tillers, above-and below-ground biomass, and root exudates and root aerenchyma) (Mariko et al., 1991; Oo et al., 2016). For most cultivars, the highest rate of $CH_4$ emission occurs in the reproductive phase (flowering phase). This is related to the increase in organic compounds exuded by the roots, serving as a substrate for methanogenic bacteria, and the full development of aerenchymas and other morphological structures that contribute to the diffusion of $CH_4$ into the atmosphere (Ruschel, 1992; Das and Baruah, 2008). Most cultivar evaluations are from Asian studies, while almost no studies have been conducted on varietal differences in $CH_4$ or $N_2O$ emissions in Latin America.

**Applicability**: Measure is applicable in rice cultivation systems.

**Mitigation potential range:** The relative $CH_4$ emission rates for different rice cultivars relative to the standard variety (1 for reference variety, IR64) ranged from 0.64 to 2.51, showing a potential of rice cultivar selection as a mitigation option for $CH_4$ emissions (Yagi et al., 2020). Emission rates depend on water management regimes and climate conditions. Additionally, a meta-analysis reports higher emissions from indica compared to japonica variety cultivars, suggesting a 35 percent reduction in emission per unit of production for japonica varieties (Zheng et al., 2014).

Enabling conditions and barriers: The price of certified seeds for new cultivars may present cost barriers for farmers.

**Trade-offs and synergies:** A significant positive relationship has been found between rice biomass and $CH_4$ fluxes (Sing et al., 1997; Khosa et al., 2010). Studies show that emissions of $CH_4$ and $N_2O$ are lower in the high-yielding improved varieties compared to traditional varieties (Baruah et al., 2010; Gogoi et al., 2008). They also find that $CH_4$ and $N_2O$ show a positive correlation with root dry weight, leaf area, leaf number, and tiller number. Traditional varieties, which are characterised by profuse vegetative growth, recorded higher $CH_4$ and $N_2O$ emissions. These results show that making improved seeds available to farmers can both mitigate GHG emissions and produce higher yields.

**Cost considerations:** Low abatement cost (~1-50 USD/t$CO_2$e) due to a small difference in cultivar seed costs and little need to modify practices (Sapkota et al., 2019).

**Nitrogen fertilisers or organic amendments management:** This measure includes management of N inputs and other amendments such as urea, manure, plant residues, biochar, and ammonium sulphate. Urea is commonly applied to rice and is highly susceptible to losses under irrigation conditions through volatilisation, nitrification, and denitrification. In most cases, the application of urea increases $N_2O$ emissions, compared to alternative N sources such as organic waste and liquid fertiliser with enzyme inhibitor additives (Baruah and Baruah, 2015). Fertiliser application during dry periods can reduce $CH_4$ emissions. Measures that decrease GHG emission include adjustment of fertiliser application rates according to crop needs (Pittelkow et al., 2013), using nitrification inhibitors or slow-release fertilisers (Ghosh et al., 2003; Linquist et al., 2012), adjusting application timing (Ali et al., 2012), and avoiding over applications.

**Applicability**: Measure is applicable in all rice cultivation systems.
**Mitigation potential range:** Mitigation potential is variable, depending on fertiliser type, water management, and strategy. For example, the localised application of urea and dicyandiamide reduces emissions of $N_2O$ by 93 and 73 percent, respectively, compared to a broadcast application of urea. In a field experiment conducted in China, increasing the rates of ammonium sulphate resulted in 44–60 percent reduction in $CH_4$ emissions and increasing urea application rates decreased $CH_4$ emissions by 7–145 percent (Cai et al., 1997). Biochar application to paddy rice can result in 20–40 percent $N_2O$ reductions (Song et al., 2016) as well as 25–50 percent reduction in $CH_4$ emissions (Kammann et al., 2017; He et al., 2017).
**Enabling conditions and barriers:** Availability of material resources limits the adoption of biochar and amendment options. Switching to sulphate-based fertilisers needs to be incentivised.
**Trade-offs and synergies:** There are trade-offs between $N_2O$ and $CH_4$ emissions in rice systems. Application of fertiliser at low rates decreases $N_2O$ emissions but tends to stimulate $CH_4$. On the other hand increased fertiliser application rates can potentially mitigate $CH_4$ emissions but will result in higher $N_2O$ emissions (Li et al., 2010).
**Cost considerations:** Low abatement cost (~1-50 USD/t$CO_2$e) (Ahmed et al., 2020). Improved fertilisation methods can reduce $CH_4$ emissions by about 40 percent without extra costs.

**Seeding methodology:** This measure involves direct seeding of rice. The traditional pre-germinated seed and puddled transplanted rice (Asia) are major sources of $CH_4$ emission. Direct-seeded rice is an alternative that can reduce emissions (Pathak et al., 2012; Liu et al., 2014, Liu et al., 2015). Direct seeding can result in water savings, which helps during drought periods (Ko and Kang, 2000). The reduction of soil disturbance and a shorter flooding period are the major reasons for less $CH_4$ emission in dry direct seeding (DDS) as compared to transplanted rice.

**Applicability**: Measure is applicable in low-land irrigated flooded rice cultivation systems.
**Mitigation potential range:** The average reduction in GHG emissions ($CO_2$, $CH_4$, and $N_2O$) with DDS relative to transplanted rice is 53 percent (Pathak et al., 2012; Corton et al., 2000; Wassmann et al., 2004; Hube et al., 2021). From studies in the USA, DDS reduced $CH_4$ emissions by 60 percent compared with continuous flooding.
**Enabling conditions and barriers:** Direct seeding requires equipment that is typically not available for small farmers. To successfully apply this measure, rain patterns need to align so the soil is dry when seeding is conducted. Late rains in the sowing season can also delay sowing, thereby reducing the growing season and yields.
**Trade-offs and synergies:** DDS may result in a trade-off such that a decrease in $CH_4$ (8–92 percent) (DeAngelo et al., 2006; Kumar and Ladha, 2011; Zhang et al., 2011) may be offset by enhanced $N_2O$ emissions. DDS allows the remaining residue to decompose for about a month under moist non-flooded conditions, resulting in organic matter decomposition releasing $CO_2$ rather than $CH_4$ (Devêvre and Horwath, 2000).
**Cost considerations:** Neutral or cost-beneficial abatement cost (~ < 0 USD/t$CO_2$e) as significant cost savings can be achieved (Ahmed et al., 2020).

**Rotational management:** This measure involves the rotation of irrigated rice with rainfed crops and/or grazing. The use of crop rotations combined with higher-yielding varieties and no-tillage practices can reduce emissions per unit of production.

**Applicability**: Measure is applicable in some irrigated rice cultivation systems depending on soil type.
**Mitigation potential range:** GHG emission reduction potential from this measure is yet to be adequately quantified. The reductions observed for $CH_4$ and $N_2O$ emissions were 1.8–70 percent for a rice-Chinese milk vetch rotation and 1.3–48.5 percent for a rice rotation relative to a rice-wheat rotation. These differences may be due to the higher crop residue under the rice-wheat rotation (Zhang et al., 2019). Tang et al. (2011) reported lower $CH_4$ emissions (27–58 percent) from a double rice system compared with those in four other crop rotation systems (with potato, rapeseed, ryegrass, and Chinese milk vetch).
**Enabling conditions and barriers:** Crop diversification may be limited by the climate in some regions. Rotating irrigated rice with aerobic crops and pastures can be challenging due to the need to manage different soil properties (e.g., compaction, drainage). Also, some types of soil (e.g., high clay) limit the cultivation of other crops but can support grazing.
**Trade-offs and synergies:** Inclusion of aerobic crop rotations (e.g., soybean or wheat) can increase soil $N_2O$ emissions while reducing $CH_4$ emissions from irrigated rice (Nishimura et al., 2011).
**Cost considerations:** Depending on the crop chosen, the rotation could bring more revenue making the measure cost beneficial. If there is a positive abatement cost, it is likely to be low (~1-50 USD/t$CO_2$e) (Rosenberg et al., 2022).

### 3.2.2 Policy instruments

This section describes policy instruments that enable or incentivise the mitigation measures (i.e., technologies and practices) described in the previous section. Information provided here will help users of this guide determine which policy to analyse and how to describe it. Multiple policy instruments can be combined to achieve the desired policy objective; e.g., voluntary agreements achieved through trading programmes; payments and technical support to small-scale farmers to increase livestock productivity. Generic types of policies are described in the following sections.

Refer to this guide's assessment toolkit for additional resources on policy instruments such as the IPCC's Policies, Instruments and Co-operative Arrangements Report. The choice of policy instrument will depend on national circumstances, the characteristics of each emission source and sink, the existing legal system, and financial constraints.

### Regulations and standards

Rules or standards specify abatement technologies (technology standards) or prescribe performance standards (e.g., requirements for erosion rates, tillage setbacks, or nutrient management). They require a legal framework that includes monitoring efforts and legal penalties for noncompliance. Regulations typically offer some certainty regarding emission reductions assuming they are enforced. These instruments are a good choice when price signals are not enough. Regulation and standards need to be clear and unambiguous to be enforceable. Some examples of regulations include:

- Standards on practices addressing livestock health and reproduction
- Standards for implementing silvopastoral systems
- Conservation mandates requiring landowners to place an area equivalent to 10 percent of cultivated lands into conservation reserve
- Standards for nutrient application rates, timing, and type
- Requirements for management plans that meet conservation practice standards

### Taxes and charges

A financial levy on each unit of emissions or unit of activity associated with increased emissions. This policy instrument can be cost-effective but does not guarantee emission reductions. Such policies may be politically untenable and also depend on compliance monitoring and enforcement. Examples include:

- Tax on a agricultural land converted from forest land
- Tax on specific land cultivation practice
- Fee on public services (e.g., license renewal) to finance conservation practices
- Fee on water use for irrigation

### Trading programmes

Programmes that establish a limit on emissions require sources to surrender allowances for each unit of pollution of equal number to their actual emissions and permit these allowances to be traded among regulated sources. Trading programmes require a robust MRV framework in place. Examples include:

- Nutrient trading programmes
- Cap-and-trade programmes

### Voluntary agreements or actions

This policy instrument includes agreements, commitments, or actions undertaken voluntarily by public or private sector actors, either unilaterally or jointly in a negotiated agreement. There is little evidence that such voluntary private-sector efforts lead to significant emission reductions, although they may help accelerate adoption and raise awareness. Examples include:

- Zero net-deforestation commitments
- Conservation agreements with landowners
- National programmes to reduce emissions in a sector (e.g., NAMA)
- Low-carbon development projects

### Subsidies and incentives

Direct payments, tax credits, price supports, or similar actions from a government to an entity for implementing a practice or performing a specified action. These are costly but potentially powerful mechanisms to drive adoption of new technologies and practices. Examples include:

- Tax reductions for setting aside agricultural land
- Tax reduction for specific land cultivation
- Payments for changing agricultural practices
- Payments for ecosystem services such as carbon stored
- Affordable loan scheme to leverage upfront cost and sustain mitigation measure implementation over time

### Research, development, and deployment

Policies aimed at supporting technological advancement through direct government funding or facilitation of investment in technology research, development, demonstration, and deployment. This policy instrument promotes innovation and technology transfer and is more effective when coupled with economic and regulatory policy instruments. Examples include:

- Programmes to train farmers on new technologies or practices through agricultural extension services
- Government funding for livestock breeding programmes
- Auditing and technical assistance to overcome the adoption barriers

### Information

This policy instrument includes labelling programmes, emissions reporting programmes, rating and certification systems, benchmarking, and information or education campaigns aimed at changing behaviour by increasing awareness. Research indicates that these mechanisms have weak and mixed results in achieving emission reductions, but information programmes can improve the impact of other mitigation policies.

- Programmes requiring standardised labelling on environmental attributes of agricultural products
- Emission reporting programmes
- Rating and certification systems
- Benchmarking
- Information or education campaigns aimed at changing behaviour by increasing awareness

### Overview of measures and policy instruments

The user will need to identify the policy instrument(s) corresponding to each selected policy for completing the impact assessment. This information will also be highly useful for national reporting under the Enhanced Transparency Framework. Table 3.3 provides examples of generally applicable policy instruments. Instruments such as information may be broadly applicable to almost any mitigation measure. On the other hand, because trading programmes require robust MRV systems, they are challenging to implement in the Agriculture sector. Section 3.3 provides guidance on how to identify and select a policy for analysis when multiple options are available.

Table 3.3. **Overview of mitigation measures and potential applicable policy instruments**

| | Measure type | Applicable policy instrument examples |
|---|---|---|
| **Livestock – Enteric fermentation** | Feed management | Subsidies and incentives: payments for changing practices<br>Research and development: providing technical support to farmers<br>Information instruments: labelling of organic products |
| | Diet formulation | Regulations and standards: standards for livestock health and reproduction<br>Research and development: providing technical support to farmers<br>Information instruments: labelling of organic products |
| | Rumen manipulation | Voluntary agreements: piloting new technology with early adopters<br>Research and development: providing technical support to farmers |
| | Animal husbandry | Regulations and standards: standards for livestock health and reproduction<br>Subsidies and incentives: discounts for veterinary services<br>Research and development: providing technical support to farmers |
| **Livestock – Manure management** | Manure storage, covers and other handling practices | Subsidies and incentives: payments for equipment installation<br>Research and development: providing technical support to farmers |
| | Application of nitrification or urease inhibitors to stored manure or to urine patches | Subsidies and incentives: payments for changing practices<br>Research and development: providing technical support to farmers |
| | Grazing practices to manage livestock manure deposition | Subsidies and incentives: payments for changing practices<br>Research and development: providing technical support to farmers |
| | Anaerobic digestion | Subsidies and incentives: subsidies to build facilities |
| **Fertiliser management** | Optimising fertiliser application | Standards and regulations: standards for application rates, timing, type<br>Subsidies and incentives: vouchers for purchasing fertiliser<br>Research and development: providing technical support to farmers<br>Information instruments: awareness campaigns |
| | Using slow or controlled-released fertilisers or nitrification inhibitors | Subsidies and incentives: payments for changing practices<br>Research and development: providing technical support to farmers |

Table 3.3. **Overview of mitigation measures and potential applicable policy instruments (Continued)**

| | Measure type | Applicable policy instrument examples |
|---|---|---|
| **Soil carbon** | Residue management and tillage | Subsidies and incentives: payments for changing practices<br>Research and development: providing technical support to farmers<br>Information instruments: awareness campaigns |
| | Restoration of degraded lands/land cover(use) change | Standards and regulations: conservation reserve requirements<br>Subsidies and incentives: tax incentives for setting aside agricultural land<br>Research and development: providing technical support to farmers<br>Information instruments: awareness campaigns |
| | Agronomic improvements | Subsidies and incentives: payments for changing practices<br>Research and development: providing technical support to farmers<br>Information instruments: labelling of organic products |
| | Pasture management | Subsidies and incentives: payments for ecosystem services<br>Research and development: providing technical support to farmers |
| **Rice cultivation** | Management of water | Subsidies and incentives: payments for changing practices<br>Research and development: providing technical support to farmers<br>Information instruments: awareness campaigns |
| | Organic matter management strategies | Subsidies and incentives: payments for changing practices<br>Research and development: providing technical support to farmers |
| | Rice cultivar | Subsidies and incentives: payments for changing practices<br>Research and development: providing technical support to farmers |
| | Fertilisers or amendments | Subsidies and incentives: payments for changing practices<br>Research and development: providing technical support to farmers |
| | Seeding methodology | Subsidies and incentives: vouchers for purchasing seed<br>Research and development: providing technical support to farmers |
| | Rotational management | Subsidies and incentives: payments for changing practices<br>Research and development: providing technical support to farmers |

## 3.3 Policy prioritisation

It is a key recommendation to prioritise a policy for assessment following the steps outlined in this section.

The user should consider to what extent agricultural subsectors contribute to country's emissions to help determine which mitigation measures should be assessed.

Refer to this guide's assessment toolkit for additional resources on evaluating country's emission sources, such as the UNFCCC Greenhouse Gas Data Interface.

The user should identify existing and planned agricultural policies and select 3-5 policies for consideration. Then the assessment team should gather information about each of the policies to understand if they are likely to impact GHG emissions.

Start with basic information on each of the policies under consideration: policy name, date the policy was adopted or date that supporting legislation was adopted (if applicable), date of implementation, status of implementation, and description. The description should contain a brief overview, circumstances that led to the development and need for the policy, and any context to understand the purpose of the policy and its relevance to GHG emission reductions or removal enhancements.

**Table 3.4** outlines considerations and information for evaluating policies and prioritising one for assessment. Users may adjust and add considerations based on their priorities. Information gathered during this step will be used for a more detailed assessment of the selected policy as well as for reporting in NDCs and BTRs.

Table 3.4. **Prioritisation considerations for selecting a policy for assessment**

| |
|---|
| **Policy name:** |
| **Status of implementation:** Can be used for planned, adopted, or implemented policies |
| **Adoption date:** if applicable |
| **Implementation start date:** if applicable |
| **Brief description:** Brief overview, circumstances that led to the development and need for the policy, and a broader context to understand the importance, relevance, and purpose of the policy |
| **Objective:** Describe what the policy is trying to achieve |
| **GHG source categories affected:** Identify emissions sources impacted by the policy and the anticipated level of impact, these may include $CH_4$ from enteric fermentation, $CH_4$ and $N_2O$ from manure management, $CO_2$ from liming, $N_2O$ from soils, or soil carbon stock |
| **Intervention activities:** Identify and describe key mitigation measures included in the policy |
| **Expected level of penetration:** Quantitatively outline what the policy is targeting or expecting to achieve, e.g., 50% of idle land, etc. |
| **Funding allocations:** Describe the designated annual and total budget or funding source that has been committed for the policy to make it feasible for implementation, if any. |
| **Implementation cost:** Provide an estimate of annual and total implementation cost |
| **Sustainable development impacts:** Describe the potential sustainable development impacts of the policy. |
| **Responsible entities and key stakeholders:** Identify who is responsible for the implementation of the policies as well as those who will be affected by the policy |
| **Measurement, Reporting, and Verification of policy implementation:** Describe whether the policy has a defined MRV plan/process outlined. If yes, identify the responsible stakeholders and institutional arrangement to monitor, review and verify the policy implications |
| **Current level of data availability:** Describe data available for estimating GHG emissions from the impacted source categories, state the level of data that is available, and comment on the type of data that is/isn't available to estimate GHG emissions utilising IPCC methodology. Levels of data availability could be characterised as: detailed data available (e.g., country agricultural surveys), general data available (e.g., industry data, public databases), no data available, or unknown. Note if there are plans to collect data, either through policy implementation or establishment of a sectoral MRV system |
| **Risks and barriers:** Identify the potential risks and/or barriers to successfully implementing the policy |
| **Alignment to the country's Agriculture Sector Policy Agenda:** Identify the goals and/or strategic priority areas the policy aims to address |
| **Alignment to country's Low Emissions Development Strategy (LEDS) and Nationally Determined Contribution (NDC) targets:** Identify trade-offs and synergies between the policy and national strategies and targets |
| **Relevance to international climate targets:** state how the implementation and outcomes of the policy impact country's future NDC updates |

Once information about each policy is compiled, the user should apply a qualitative ranking to determine which policy or collection of policies is the best fit for the assessment. The most relevant considerations in the prioritisation ranking will likely focus on the following three considerations: anticipated impact on GHG emissions, data availability, and institutional alignment (i.e., policies that support national development and/or climate action priorities). These will indicate whether an assessment is feasible, the policy has adequate GHG emission impacts, and its implementation is likely to be supported by the government. Other considerations can help further prioritise, for example, whether the policy impacts stakeholders in an equitable manner.

Once a policy is selected for assessment, the user may continue onto Chapter 4 to begin the process of describing the policy and identifying in detail the impact assessment parameters. If the policy is in the planning or design phase, Appendix A provides additional guidance for assessing implementation potential.

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# Chapter 4: Describing the Policy and Impacts

PART II. Select and Describe Policy | Chapter 3 | Chapter 4

4.1 Outline policy activities | 4.2 Identify policy intermediate effects | 4.3 Identify potential GHG impacts | 4.4 Develop a causal chain | 4.5 Select policy assessment boundary and period | 4.6 Consider other policy synergies and interactions

Once the user has familiarised themselves with mitigation measures and policy instruments and selected an agricultural policy for assessment, they can develop a detailed understanding of the policy objective. This chapter will present the process for describing the policy to enable the user to then calculate GHG impacts of the selected policy, demonstrated through examples in later chapters.

## 4.1 Outline policy activities

The previous chapter helped users select a policy to be assessed. This section provides guidance on outlining policy activities.

### Policy description

To effectively conduct an impact assessment, it is necessary to have a detailed understanding and description of the policy being assessed.

The recommended information that should be included in a description to enable an effective assessment includes policy objectives, mitigation measures (i.e., actions taken under the policy), associated mitigation targets, geographic scale, timeline, and budget. The description should also describe the roles of each entity involved in policy implementation and enforcement, data management systems, verification and/or reporting procedures, and administrative needs. The policy description also includes the identification of key stakeholders affected. also saw decreases in emissions. Such regional trends indicate the general direction of agricultural emissions. This guide recommends that the user identifies national emission levels and trends to inform policy analysis.

A template for completing the policy description is available in the Templates section.

Refer to the ICAT *Stakeholder Participation Guide* in this guide's assessment toolkit. This guide's Appendix B contains additional guidance and resources on stakeholder engagement. Users may also identify affected stakeholders from existing stakeholder mapping exercises.

### Policy inputs and activities

Users should identify the policy's inputs and activities. Inputs are resources that go into implementing a policy, such as money allocated for training and education programmes as well as specific administrative capacities needed for implementation. Policy activities are administrative activities needed to implement the policy (undertaken by the responsible authority or entity). Activities may include an agency making payments for tree planting or establishing a tree nursery, hiring staff, or offering grants to conduct trainings on new cultivation methods.

When describing inputs, users should specify the amount of money required to adequately implement the policy, including funding needed for administrative activities. Information about policy inputs and activities should be included in the policy description. This information is used as a basis for understanding intermediate effects that occur as the result of those activities and impacts on GHG emissions.

## 4.2 Identify policy intermediate effects

To estimate the GHG impacts of a policy, it is important to understand how the policy is intended to achieve the desired GHG mitigation outcome. Users should consider how the policy will be implemented, what the potential intermediate effects of the policy will be, and how these effects impact GHGs. This section provides guidance on identifying intermediate effects, identifying potential GHG impacts, and developing a causal chain. This section provides the basis for defining the GHG assessment boundary and period.

Inputs and activities described in the previous section lead to intermediate effects, which are changes in behaviour, technology, processes, or practices that result from the policy. These intermediate effects then lead to the policy's GHG impacts.

Intermediate effects can be characterised by how stakeholders are likely to respond to the inputs or activities. Intermediate effects can also include the measures that are enabled or incentivised by the policy. **Table 4.1** outlines examples of how stakeholders may respond to inputs, activities, or other immediate effects of the policy.

Table 4.1. **Example stakeholder responses to inputs, activities, and intermediate effects for agricultural policies**

| Policy implementation components | Stakeholder response examples |
|---|---|
| Inputs | ▪ Access subsidies or incentives<br>▪ Establishment of demonstration plots or farms |
| Activities | ▪ Enroll in programmes<br>▪ Sign up for training and increase knowledge level regarding technologies or practices<br>▪ Purchase new equipment<br>▪ Submit management data |
| Intermediate effects | ▪ Change livestock feeding strategies<br>▪ Change herd management strategies<br>▪ Change pasture management<br>▪ Change rice water management regime<br>▪ Change soil management practices (e.g., improve degraded grazing lands by implementing rotational grazing, implement no-till practices) |

Agriculture policy intermediate effects can be land-based or activity-based. Land-based effects occur when land use shifts from one land category to another, like when agriculture expands into forest land. Production-based effects occur when the policy changes the production of a commodity causing a change in the supply and market demand equilibrium (i.e., causes shifts in production elsewhere to compensate for the change in supply). For example, when the production of livestock decreases due to decreased stocking rates on grazing lands, livestock production on feedlots elsewhere may increase to compensate for a loss of supply.

When identifying intermediate effects, it may help to consider this general framing question: If effect X happens, what do we expect the reactionary effect to be? For completeness, confirm that all types of mitigation practices, technology, or land use changes enabled or incentivised by the policy are included as activities or intermediate effects. Furthermore, include market-based intermediate effects that have implications for production costs. When characterising effects of the policy, users should consider and identify effects as intended or unintended to differentiate whether effect is based on the original objectives of the policy or not to flag potential issues in policy design.

Users should also identify intermediate effect(s) due to the policy central mitigation measure(s). This helps determine whether activities under the policy lead to adoption of mitigation measures and identify pathways for changes in GHG emissions. Users should describe each intermediate effect according to the following characteristics: affected land category, affected activities, direction and amount of effect, geographic location of effect, and timing of effect. The characteristics are described below in this section. A template is provided in the **Templates** section to help describe intermediate effects and their associated characteristics.

### Affected land category

Intermediate effects can change how land is used or managed. Describe the affected land area by its size. Using IPCC land categories will help with the estimation of GHG emissions in Chapters 5-8. Use the land categories found in the IPCC 2006 GL, Volume 4, Chapter 2 to describe land upon which the intermediate effects occur:

- Forest land
- Cropland
- Grassland
- Wetlands
- Settlements
- Other land

When intermediate effects are a change in how land is used, describe the change in terms of a land category being converted from one type to another, which is in keeping with UNFCCC reporting categories. Typical categorisations of these changes include:

- Land converted to cropland, which could be forest land converted to cropland, or grassland converted to cropland
- Land converted to grassland, which could include forest land converted to grassland or cropland converted to grassland

When intermediate effects are a change in how land is managed, describe the change as a conversion from one type of management to another within a land category (i.e., land category does not change), for example:

- Cropland remaining cropland, for example, annual cropland converted to perennial cropland
- Grassland remaining grassland, for example, improved pasture management or restoration of degraded pasture

### Affected activities

Intermediate effects can also be a change in activity, practice, or technology such as amounts of fertiliser applied to fields or population of animals in each livestock population category. For these effects, they should be described by the activity data categories that are used to prepare national GHG inventories according to the IPCC guidelines. The same activity data categories are used to estimate baseline and policy GHG emissions.

### Direction and magnitude of effect

When characterising inputs, activities, and intermediate effects, identify the direction of the effect (i.e., increase, decrease, no change, or not applicable). For example, indicate "increase" if the policy leads to an increase in an identified effect, such as an increase in the area of pasture or an increase in the numbers of livestock receiving a particular type of diet. If there is no specific direction that can be attributed to the input, activity, or effect, indicate "not applicable". Examples include allocation of funds for the policy or adjustment to milking practices.

Where known, include the intended amount of the effect in the description of the intermediate effect. The intended amount of the effect may have been determined as part of the policy design process. For example, if a policy aims to incentivise conversion of 10,000 hectares (ha) of cropland to pasture, the intermediate effect can be described as: "increase the amount of cropland converted to pasture by 10,000 ha." The direction of the effect is to increase. With this example, note the use of IPCC land categories in the description "cropland converted to grassland."

### Geographic location

Describe the geographic location where the intended intermediate effects are likely to occur. The geographic location of intended effects is likely to be within the jurisdiction of the policy. For example, in a policy that aims to increase agricultural production on degraded lands in one region of the country, the effect can be described as: "increase the amount of cropland converted to pasture in the tropical ecoregion by 10,000 hectares."

Information on geographic location will be relevant for collecting activity data and selecting emission factors when estimating GHG emissions and for monitoring impacts ex-post. It is possible for intermediate effects to occur outside of the intended jurisdiction of the policy. In cases where the policy causes a shift in activity to the outside of the jurisdiction, the effect can be described as out-of-jurisdiction.

### Timing of the effect

Users should describe effects as occurring over the short term or long term. The distinction between short-term and long-term can be defined based on the policy being assessed. Some effects may also be temporary while others are permanent. If known, identify when the effect is likely to occur using specific years or with reference to the start date of a policy. For example, a policy may seek to affect a certain group of stakeholders or actions during the first five years and then a different group during the following five years. This information will be used for estimating GHG emissions and implementation monitoring ex-post.

To continue with the policy example above, if a specific time frame is targeted by the policy, that characteristic can be added to the description as: "an increase in the amount of cropland converted to pasture in the southern tropical region of the jurisdiction by 10,000 hectares by 2030."

## 4.3 Identify potential GHG impacts

Intermediate effects can lead to GHG impacts. For example, improving livestock feed digestibility is an intermediate effect that leads to a decrease in methane emissions from enteric fermentation.

To ensure a complete assessment, users should consider all identified intermediate effects and associate them with specific GHG impacts. A template is provided in the **Templates** section to help document all policy GHG impacts. All potential GHG impacts should be identified at this stage so that they can be used to develop the causal chain of the policy and their significance can be evaluated for inclusion within the assessment boundary.

There is a wide range of tools available to support the quantification of policy impacts, including some that can model entire Agriculture sector emissions, thereby allowing users to assess multiple policies that address more than one emissions source (e.g., FAO EX-Act and NEXT tools, FABLE calculator, Agriculture and Land Use (ALU) inventory software from the Colorado State University, and CCAFS-MOT tool). Sub-sector-specific tools, such as the GLEAM-i model, focus on emissions related to livestock only. Details on these tools are provided in this guide's assessment **toolkit**.

Refer to ICAT *Stakeholder Participation Guide* in this guide's assessment toolkit for information on designing and conducting consultations.

**Consultations with stakeholders** can help to identify intermediate effects and identify and address possible unintended or negative impacts early on.

## 4.4 Develop a causal chain

This section provides guidance for how to develop a causal chain, a conceptual diagram representing the sequence of changes that are expected to occur as a result of the policy. The inputs, activities, and intermediate effects are mapped in a causal chain to illustrate the logical model for how the policy leads to the intended GHG impacts. Users should include market-based effects to note linkages with economic implications and potential KPIs. Furthermore, users should call out which intermediate effects are due to the mitigation measure(s) central to the policy. The causal chain serves as the basis for defining the GHG assessment boundary and assessment period discussed in the following section.

A causal chain approach is used to understand how the policy and its corresponding inputs and activities cause intermediate effects and ultimately result in GHG impacts tracing the process by which the policy leads to GHG impacts through a series of interlinked logical and sequential stages of cause-and-effect relationships. It allows users to visually understand how policies lead to changes in emissions. An example causal chain is provided in **Figure 4.1.** A template for completing a causal chain diagram is also provided in the **Templates** section.

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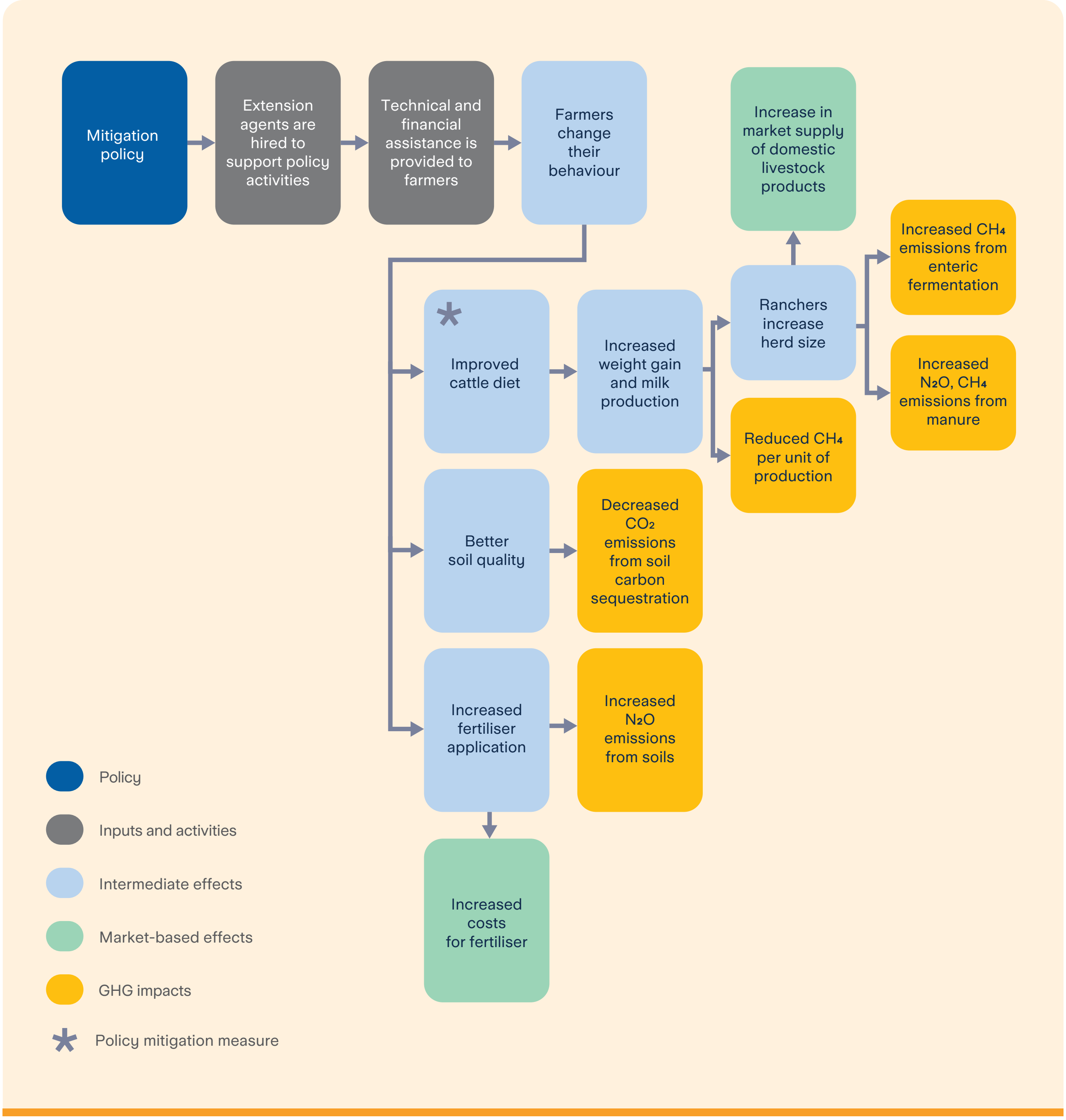
Figure 4.1. **Example of a causal chain for a livestock mitigation policy**



Start by drawing links from the policy to the inputs and activities. Draw links from inputs and activities to stakeholders and intermediate effects. There may be a series of intermediate effects in the causal chain until it leads to a GHG impact. All the detailed information about stakeholders, inputs, activities, and intermediate effects that was described in the previous sections, should be included in the causal chain.

A causal chain represents the sequence of intermediate effects expected to occur as a result of the policy. Implicitly, these changes are relative to a baseline scenario. For example, if an intermediate effect is that new pasture land management will result in an improved diet for 10,000 heads of livestock, this means 10,000 more heads of livestock will have an improved diet than the scenario without the policy intervention (i.e., in the baseline scenario).

**Consultations with stakeholders** can help with the development and/ or validation of the causal chain by integrating stakeholder insights on cause-effect relationships between the policy, behaviour change, and expected impacts.

Together, the causal chain, the policy description, a table of policy impacts, and the provided templates are the tools you need to describe the policy. The tabular format might be most useful in reporting or setting up subsequent assessment steps, while the diagram provides a visual sequential representation of what occurs (or expected to occur) under the policy. The diagram is an effective way to engage stakeholders to enhance understanding of the relevant elements of the policy and their logical flow. The preparation of this diagram offers an interactive exercise, which stimulates a discussion and validates assumptions. The table listing policy impacts and the causal chain are completed iteratively to improve accuracy and completeness.

## 4.5 Select policy assessment boundary and period

### 4.5.1 Policy assessment boundary

The GHG assessment boundary is the range of GHG impacts that are included in the policy assessment. Not all GHG sources or carbon pools associated with GHG impacts in the causal chain will need to be included in the GHG assessment boundary. In this step, users determine which GHG sources and/or carbon pools are significant and should be included in the assessment. The quantification methods for sinks are based on specific carbon pools and the GHG boundary needs to be identified at the level of the carbon pool. Decisions about the assessment boundary are made by evaluating the likelihood and relative magnitudes of each of the GHG impacts identified in the previous section by:

- Assessing the likelihood that each GHG impact will occur
- Assessing the expected magnitude of each GHG impact
- Determining the significance of each GHG impact relative to aggregate GHG impacts

#### Estimate the likelihood that each GHG impact will occur

For each GHG impact identified, estimate the likelihood that it will occur by classifying each impact according to the options in **Table 4.2**. For ex-ante assessments, this involves predicting the likelihood of each impact occurring in the future as a result of the policy. For ex-post assessments, this involves assessing the likelihood that the impact occurred in the past as a result of the policy, since impacts may have occurred during the assessment period for reasons unrelated to the policy being assessed. If a given impact is unlikely to occur, the subsequent impacts that follow from that impact can also be considered unlikely to occur. Where the likelihood is unknown or cannot be estimated, it should be classified as "possible."

Table 4.2. **Estimating likelihood of GHG impacts**

| Likelihood | Description |
|---|---|
| Very likely | Reason to believe the impact will happen (or did happen) as a result of the policy. |
| Likely | Reason to believe the impact will probably happen (or probably happened) as a result of the policy. |
| Possible | Reason to believe the impact may or may not happen (or may or may not have happened) as a result of the policy. About as likely as not. Cases where the likelihood is unknown or cannot be determined should be considered possible. |
| Unlikely | Reason to believe the impact probably will not happen (or probably did not happen) as a result of the policy. |
| Very unlikely | Reason to believe the impact will not happen (or did not happen) as a result of the policy. |

Source: Adapted from Rich (2014)

The likelihood classification should be based on evidence to the extent possible, such as published literature, prior experience, modelling results, risk management methods, **consultation with stakeholders**, or **expert judgement.**

### Estimate the magnitude of each GHG impact

Next, classify the magnitude of each GHG impact as major, moderate, or minor according to **Table 4.3.** This involves approximating the change in GHG emissions and removals resulting from each GHG impact relative to the overall change in GHG emissions from the policy. GHG emissions and removals do not need to be accurately calculated in this step, but the relative magnitude should be categorised.

The relative magnitude of each GHG impact depends on the size of the GHG source or carbon pool affected and the magnitude of the change expected due to policy. The size of the GHG source or carbon pool can be estimated based on GHG inventories or other sources. The magnitude of each GHG impact should be estimated relative to the total GHG emission change expected from the policy and should be based on the absolute value of change in GHG considering both increases and decreases in emissions and removals.

This determination requires some level of **expert judgement** and should be done in **consultation with stakeholders**. If it is not possible to classify the magnitude of an impact as major, moderate, or minor (e.g., due to lack of data or capacity), users can classify a given impact as “uncertain” or “cannot be determined,” as appropriate. When the impact magnitude is unknown, the users should not include this in the assessment boundary. Users can also estimate changes in activity data rather than changes in emissions to assess the magnitude of the GHG impact, where relevant.

Table 4.3. **Estimating relative magnitude of GHG impacts**

| Relative magnitude | Description | Approximate relative magnitude |
|---|---|---|
| Major | The change in the GHG source or carbon pool is (or is expected to be) substantial in size (either positive or negative). The impact significantly influences the effectiveness of the policy. | >10% |
| Moderate | The change in the GHG source or carbon pool is (or is expected to be) moderate in size (either positive or negative). The impact somewhat influences the effectiveness of the policy. | 1-10% |
| Minor | The change in the GHG source or carbon pool is (or is expected to be) insignificant in size (either positive or negative). The impact is inconsequential to the effectiveness of the policy. | <1% |

Source: Adapted from Rich (2014)

Percentages provided in **Table 4.3** provide approximate ranges for determining the relative magnitude of the impact. Users may adjust these ranges to better represent national circumstances.

**Table 4.4** provides additional information when evaluating the magnitude of GHG sources and carbon pools to include in the GHG assessment boundary.

Table 4.4. **Considerations for evaluating magnitude of GHG sources and carbon pools for agricultural policies**

| Source/ carbon pool | Gas | Considerations |
|---|---|---|
| Enteric fermentation | $CH_4$ | This source should be considered significant for all livestock policies with interventions that target enteric fermentation |
| Soil carbon sequestration | $CO_2$ | This source may be significant when policy interventions include improved pasture management and adoption of silvopastoral systems because, in general, adoption of improved pasture management and/or silvopastoral systems will increase plant production and thus inputs to soil carbon pools. The magnitude of the effect varies considerably.<br>This source should be considered significant for all policies with interventions that target soil carbon sequestration. |
| Nutrient management | $N_2O$ | This source is likely to be significant when the policy intervention leads to changes in nitrogen inputs to soils relative to baseline soil management practices. However, the net direction and magnitude of effects can vary greatly.<br>For example, when improved pasture management and silvopastoral systems are part of the policy (a) more fertiliser may be added to promote the growth of high-quality forage species and this will increase $N_2O$ emissions; and (b) livestock productivity may improve such that more can be produced on the same or less area of pasture, reducing the expansion of an overall demand for fertilisers pastures compared to baseline and this will reduce $N_2O$ emissions. |
| Manure management | $N_2O$<br>$CH_4$ | This source may be significant when the policy intervention impacts the amount of time manure is managed or the number of animals stall-fed and managed in housing. The method of manure collection and storage, and separation of solids and liquid animal wastes can have a significant impact on GHG emissions from animal facilities. |
| Manure deposited on pasture, range, and paddock (Agricultural Soils as accounted for under IPCC Guidelines) | $N_2O$<br>$CO_2$ | This source will likely be significant when the livestock policy targets improvements in productivity and efficiency, thereby increasing the number of livestock produced on the area of pasture. Increasing the number of livestock will increase the amount of manure leading to $N_2O$ emissions.<br>This source is not likely to be significant for soil carbon policies. However, increased manure deposition on nutrient-poor soils could have a significant, long-term effect on soil carbon sequestration.<br>Increasing manure deposition on land decreases $CH_4$ emissions associated with manure management, since manure is removed from a management system. |

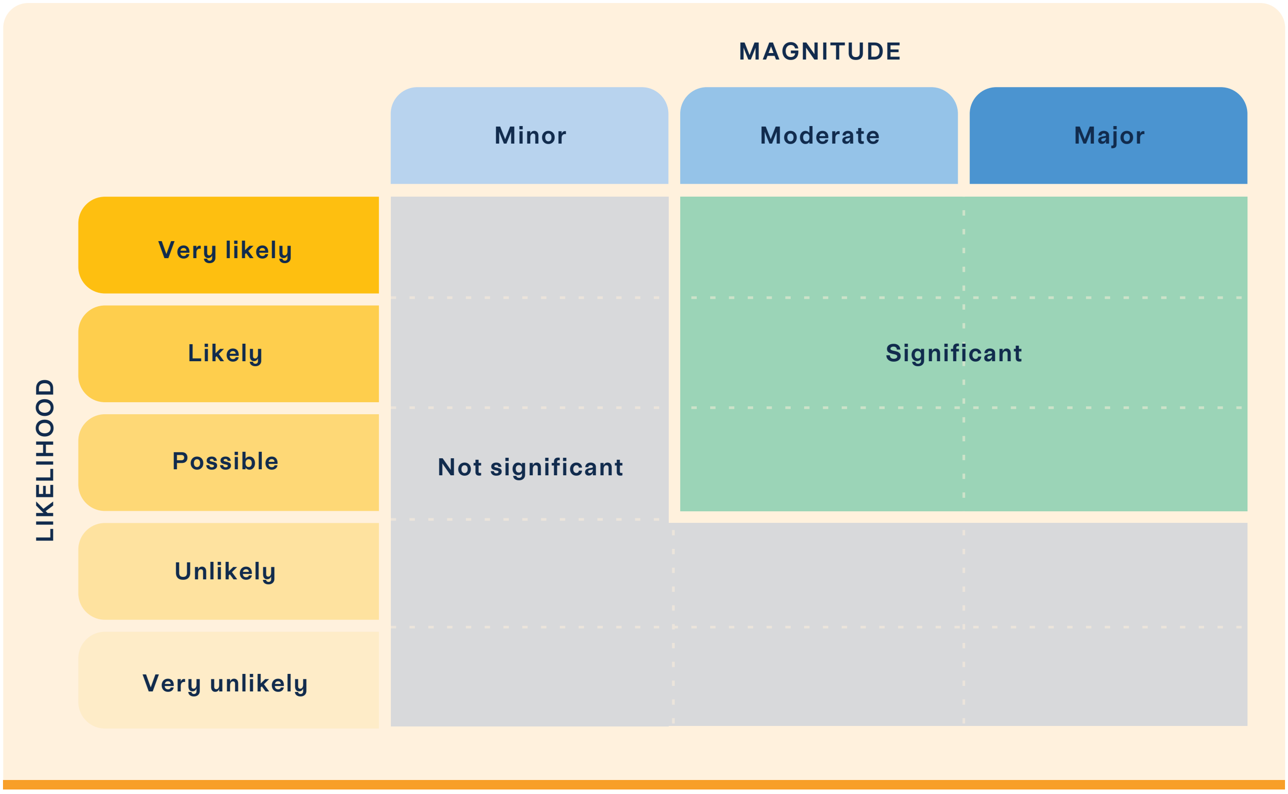
Table 4.4. **Considerations for evaluating magnitude of GHG sources and carbon pools for agricultural policies (Continued)**

| Source/ carbon pool | Gas | Considerations |
|---|---|---|
| Emissions from land-use change | $CO_2$ | Generally, where supply is increased as a result of the policy, negative land-use change effects will likely be insignificant and can be excluded from the GHG assessment boundary. This source may be significant in terms of reducing $CO_2$ emissions from deforestation when the policy intervention leads to increases in productivity on pasture and grazing land. When more can be produced on less area, relative to the baseline, the need to expand pasture and grazing land is reduced. The likelihood and magnitude of the effect are difficult to assess.<br>Where supply is decreased as a result of the policy, then negative land use effects are possible. This may occur when the policy intervention reduces crop outputs or access to land for grazing cattle, compared to baseline.<br>Where the policy reduces supply such that supply is unable to meet demand, users should evaluate the potential significance of the effect (e.g., how much has supply decreased). In this case, users can estimate the volume of goods displaced. Where supply is significantly impacted (e.g., more than 5% of the country's total production), the estimated volume of goods displaced can be used to estimate the hectares of land where activities are shifted to compensate for the decrease in supply. Changes in GHG sources and/or carbon pools on those land areas should be included in the GHG boundary. |
| Rice cultivation | $CH_4$<br>$N_2O$<br>$CO_2$ | Use of water in rice production will affect $CH_4$ and $N_2O$ emissions. Dry seeding allows the remaining residue to decompose under moist but non-flooded conditions, resulting in organic matter decomposition releasing $CO_2$ rather than $CH_4$. Changes in $CH_4$ and $N_2O$ emissions associated with alternate wet and dry systems and dry seeding should be included in the assessment boundary.<br>Rice cultivar affects $CH_4$ and $N_2O$ emissions because improved varieties have shorter cultivation period and decreased biomass production. Furthermore, emission intensity can decrease from high-yielding improved varieties. Emissions associated with rice cultivar changes should be included in the assessment boundary, however, they require country-specific (Tier 2) data and emission factors for estimation.<br>Changes in the application of organic amendments, such as compost, manure, or rice straw will have an effect on $CH_4$ emissions and should be included in the assessment boundary. Furthermore, management of fertilisers and organic amendments in rice cultivation is likely to be significant when the policy leads to changes in nitrogen inputs to soils relative to baseline soil management practices (see "Nutrient Management" above). On the other hand, if urea fertiliser application changes, $CO_2$ emissions have to be accounted for.<br>The adoption of a sustainable crop production with multiple rotations will have an effect on both $CH_4$ and $N_2O$ emissions and should be included in the assessment boundary. Rotation management measures are also expected to increase soil C sequestration and should be accounted for in the assessment boundary. |

### Determine which GHG impacts to include in assessment boundary

Once the likelihood and magnitude of each impact have been determined, users need to also determine which impacts should be considered significant as shown in **Figure 4.2**. Generally, impacts are significant (Rich, 2014) unless they are either minor in size or unlikely or very unlikely to occur. Impacts that are considered significant should be included in the assessment. When the significance of all identified GHG impacts has been evaluated, the user should return to the causal chain diagram and the table where all the policy activities and associated effects are documented and label those that will be included in the assessment.

Figure 4.2. **Recommended approach for determining significance based on likelihood and magnitude**




Source: Adapted from Rich (2014)

### 4.5.2 Define the assessment period

The assessment period is the time over which impacts resulting from the policy are assessed. The starting date and the duration of the assessment period may vary depending on whether or not an ex-ante or ex-post assessment will be conducted. Choosing between ex-ante or ex-post assessment depends on the status of the policy. Where the policy is planned or adopted, but not yet implemented, the assessment will be ex-ante. Alternatively, where the policy has been implemented, the assessment can be ex-ante, ex-post, or a combination of ex-ante and ex-post. The assessment is an ex-post assessment if the objective is to estimate the impacts of the policy to date; an ex-ante assessment if the objective is to estimate the expected impacts in the future; or a combined ex-ante and ex-post assessment to estimate both the future and past impacts, respectively. An ex-ante assessment can include historical data if the policy is already implemented, but it is still an ex-ante assessment (rather than an ex-post) if the objective is to estimate future effects of the policy.

#### Ex-ante assessment

The ex-ante assessment period is usually determined by the longest-term impact included in the GHG assessment boundary. The assessment period can continue until the policy implementation period ends or it can be longer than the policy implementation period, as some significant GHG impacts can occur after the policy implementation period ends. The assessment period should be defined to include all significant GHG impacts included in the GHG assessment boundary, based on when they are expected to occur.
To determine the end of the assessment period, users can choose from the following approaches, among others:

- A timeframe or date that is directly specified in the policy goal or target (e.g., reduce emissions by 50 percent by 2030)
- The length of time for which the policy is funded or expected to be funded
- A period of time that has otherwise been identified as the policy implementation end date
- A period of time aligned to GHG emission and removal dynamics (e.g., 20-year for soil carbon equilibrium period)
- A period of time that corresponds to implementation of another interacting policy

#### Ex-post assessment

For an ex-post assessment, the assessment period can be the period between the date the policy is implemented and the date of the assessment, or it can be a shorter period between those two dates.

Furthermore, if the policy implementation has started, while future impacts have not been assessed, the user can have the assessment period be a combination of ex-ante and ex-post periods. This will evaluate the effect of the policy to date and project its performance into the future.

In addition, users can separately estimate and report impacts over any other time periods that are relevant. For example, if the assessment period is 2020–2040, a user can separately estimate and report impacts over the periods 2020–2030, 2031–2040, and 2020–2040.

#### Emission and removal dynamics in the assessment period

GHG emission and removal dynamics should be considered for GHG impacts that involve carbon sequestration in soils and/or biomass when determining the assessment period. For example, changes in land use or land management can change soil carbon sequestration rates until a new equilibrium is reached. IPCC 2006 GL suggests a default 20-year transition period for soil carbon dynamics to reach a new equilibrium.

Policies that impact carbon sequestration should be evaluated over a sufficiently long assessment period to capture the net impact of gains and losses in carbon pools to the extent possible. Given the IPCC 20-year transition period for soils, it is recommended that users set the assessment period to a minimum of 20 years, even if this extends the assessment period beyond the policy implementation period, if practicable.

Assumptions about baseline and policy scenarios become more uncertain the further forward in time the assumptions are projected. Therefore, it is also recommended that the assessment period is not extended much further than 20 years into the future. Rather, users can define multiple discrete assessment periods that cover the length of the policy implementation period, with each assessment period not to exceed 20 years. For example, where the policy implementation period is 2020-2060, there can be two assessment periods from 2020-2040 and 2041-2060.

Where possible, users should align the assessment period with other assessments being conducted or if interacting policies are being assessed, either as a package or independently. For example, where users are assessing the agriculture policy's sustainable development impacts in addition to assessing GHG impacts, the assessment period should be the same for both the sustainable development and GHG impact assessment. Policy interactions are discussed in the next section.

## 4.6 Consider other policy synergies and interactions

Policies in the agriculture and land-use sector often have linkages to other policies in the same sector, in other sectors, or across sectors. Although the focus of this guide is to provide the user with the tools to assess the impact of a particular agricultural mitigation policy, this guide recommends that users consider what synergies or trade-offs the policy might have and identify interacting policies. Users should consider if it is beneficial to conduct additional assessments for a package of policies based on the feasibility of assessing cross-sector impacts together and the degree of interaction between the policies. The overview of mitigation measures and potential interactions is in Chapter 3.

Policies interact if their total impact, when implemented together, differs from the sum of their individual impacts had they been implemented separately. Policies interact if they affect the same GHG source or carbon pool. For example, national and sub-national policies in the same sector are likely to interact since they likely affect the same GHG sources and carbon pools. Two policies implemented at the same level may also interact. Policies do not interact if they do not affect the same GHG sources and carbon pools, either directly or indirectly.

Users can begin by characterising the type and degree of interaction between the policies under consideration when following the steps in the previous section to describe the policy. Potentially interacting policies can be identified by identifying activities targeted by the policy and then identifying other policies that target the same activities. Once these are identified, users can assess the relationship between the policies and the level of interaction. The assessment of interaction can be based on **expert judgement,** published studies of similar combinations of policies, or consultations with relevant experts or **stakeholders**. The assessment should be limited to a preliminary qualitative assessment at this stage.

Where policy interactions exist, there can be advantages and disadvantages to assessing the interacting policies individually or as a package. Deciding whether to assess policies individually or together depends on the availability of

Refer to the WRI's Policy and Action Standard in this guide's assessment toolkit for additional resources on assessing policy interactions.

resources to conduct accurate and complete analysis and the need for decoupled results in future decision-making and reporting. For example, related policies may have significant interactions (suggesting a package), but it may not be feasible to model the whole package (suggesting an individual assessment). In this case, a user can undertake an assessment of an individual policy, and document identified interactions and note that any subsequent aggregation of the results from individual assessments would need to be adjusted given the interactions between the policies.

Climate change policies have broader sustainable development impacts in addition to their GHG impacts. Sustainable development impacts are changes in environmental, social, or economic conditions that result from a policy, such as changes in air quality, water quality, health, quality of life, employment, or income. Policy descriptions developed as part of GHG impact assessment can also be used as a basis to assess sustainable development impacts or transformational change impacts.

The sustainable development impacts likely affected by agricultural policies may include improving water quality or biodiversity (environmental dimension), addressing food security (social dimension), and ensuring employment for farmers (economic dimension).

Refer to the ICAT *Sustainable Development Methodology* in this guide's assessment toolkit for additional resources on assessing policy sustainable development impact. Refer to Appendix B **Table B.2** for a listing of sustainable development goals relevant to agriculture.

# Part III

## Structure for Assessment Examples

Chapters 5-8 demonstrate the methodologies using hypothetical policy examples, implemented in a hypothetical country, which is described in the Hypothetical Country section of this guide. To demonstrate the assessment methodology, all activity data and financial parameters used in the examples are hypothetical except when specific peer-reviewed studies are referenced to inform mitigation potential. Information reflecting real national circumstances should be used in the assessment.

For the purpose of assessing the hypothetical policies, the examples in Chapters 5-8 assume that no measures affecting associated emission categories have been adopted and implemented prior to adoption of the policies. Therefore, the baseline scenario is termed the scenario without measures (WOM) and the policy scenario is termed the scenario with additional measures (WAM). Furthermore, when default parameters are based on geography, the assessment utilises values for the Indian Subcontinent or South Asia due to the climate characteristics of the hypothetical country.

For additional examples of mitigation policy assessments, refer to the Case Studies included at the end of this guide.

# Chapter 5: Assessing Livestock Policy Impact

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5.1 Livestock policy description and GHG impacts | 5.2 Methodological considerations | 5.3 Estimating GHG emissions | 5.4 Monitoring policy performance

This chapter describes how to conduct a GHG impact assessment for livestock policies. Prior to the assessment, the user has become familiar with key methodological and reporting concepts, identified relevant stakeholders, and considered the objectives of conducting the assessment. The user has also selected a policy for assessment, reviewed the measures likely to be included in the policy, and became familiar with the data types they will need to conduct the assessment.

In Chapter 5, the example policy, the National Dairy Methane Reduction Programme, will be assessed. The policy includes the mitigation measures of feed management and manure storage. The user should assess the GHG impact of a selected policy with the guidance provided in this chapter and follow the steps described in this example.

Refer to Part I and Part II for guidance on planning for the assessment and policy selection and description steps, respectively, if needed.

## 5.1 Livestock policy description and GHG Impacts

### 5.1.1 Policy assessment objectives

Users should identify stakeholders affected by the policy and those to be engaged during the policy assessment's planning phase. The stakeholder groups relevant to the National Dairy Methane Reduction Programme are noted in **Table 5.1**.

Further, users should identify assessment objectives before starting the assessment. For the purpose of the example, policymakers identified assessment objectives and held a series of stakeholder consultations to refine the initial assessment objectives.

The refined policy assessment objectives were:

- Quantify GHG emissions from changes in cattle feed management and changes in how manure is stored
- Build support for additional mitigation measures to be adopted by the decision-makers and farmers
- Track progress toward national goals, e.g., NDCs
- Report domestically and internationally, including under the Paris Agreement's Enhanced Transparency Framework, on the impacts of the policy achieved to date

Refer to the ICAT *Stakeholder Participation Guide* in this guide's assessment toolkit. This guide's Appendix B contains additional guidance and resources on stakeholder engagement.

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### 5.1.2 Policy description

When starting the assessment, the users should describe the policy in detail. In this chapter's example, the country adopted The National Agriculture Policy Act of 2020, which established the National Dairy Methane Reduction Programme and the National Nitrogen Fertiliser Policy (described in Chapter 6). The National Dairy Methane Reduction Programme includes two mitigation measures:

- Reducing enteric fermentation emissions through improved feed management by improving forage quality
- Reducing manure emissions predominantly through storage and covering practices

For manure emissions, the policy incentivises farmers to reduce manure storage time, introduce manure covers, and encourage other improved management practices. The full description of the National Dairy Methane Reduction Programme is in **Table 5.1.**

Refer to Chapter 4 for more information on the process for describing the policy and the Templates section for the policy description template. To effectively carry out an impact assessment, it is necessary to have a detailed understanding and description of the policy being assessed.

Table 5.1. **Description of the National Dairy Methane Reduction Programme**

| Policy description category | Detailed description |
|---|---|
| Name of the policy* | National Dairy Methane Reduction Programme |
| Type of policy instrument* (Note: refer to Section 3.2.2 for policy instrument types and description) | ▪ Subsidies and incentives<br>▪ Research, development, and deployment |
| Description of specific interventions* | The National Dairy Methane Reduction Programme focuses on two mitigation measures, reducing enteric fermentation emissions through improved feed management by improving forage quality, and reducing manure emissions predominantly through storage and covering practices.<br><br>The programme will enable a transition to improved feed and manure management practices for cattle through the following components:<br><br>▪ Establish the Enteric Methane and Manure Assessment (EMMA) survey which will be collected annually by local extension agencies and data will be managed by the National Bureau of Statistics. EMMA survey responses will inform extension offices of local farm management recommendations.<br>▪ Provide technical assistance to farmers in the form of workshops and farm visits to implement best practices on farms<br>▪ Provide financial incentives for participation in the EMMA survey and adopting new practices. Participants will receive a start-up payment scalable to the size of their cattle operation and extent of expected and later demonstrated changes, dispersed annually over five years to cover costs of capital and additional labour needed to implement their recommended farm management plan. This aims to offset the potential risks involved in changing practices. In some cases where farmers are already demonstrating best management practices, they will automatically be eligible for the subsidy.<br><br>Additional supporting activities include extension services establishing flagship/pilot farms (serving for research and education). Flagship farms will explore other measures for reducing manure emissions from dairy production and other housed livestock systems including swine and poultry.<br><br>The main policy instruments for implementation are the provision of financial incentives (subsidies and incentives) and technical assistance (research, development, and deployment), coupled with monitoring and verification of activities and enhanced data collection. Extension agents will monitor the implementation of management plans when conducting farm visits. |
| Status of the policy* | Planned. The funding for the policy was authorised in the National Agriculture Policy Act of 2020 to start in 2025 |

Table 5.1. **Description of the National Dairy Methane Reduction Programme (Continued)**

| Policy description category | Detailed description |
|---|---|
| Date of implementation* | 2025 |
| Date of completion* (if relevant) | 2035 |
| Implementing entity* or entities | Ministry responsible for Agriculture |
| Objectives and intended impacts or benefits of the policy* | The policy objective is to introduce and promote the adoption of sustainable livestock production and manure management methods to improve the environment, economy, and food security of the nation. The policy aims to:<br>▪ Reduce GHG emissions from livestock production<br>▪ Increase economic output for pastoralists by improving livestock productivity and possibly adding revenue sources<br>▪ Improve water quality through better manure management and reduced runoff<br>▪ Accelerate adoption of improved pasture management on a widespread basis (i.e., by non-participating pastoralists) by demonstrating economic benefits of improving pasture management practices<br>▪ Accelerate adoption of best manure management practices through the establishment of flagship farms and increased local farmer knowledge (driven also by profitability of more efficient nutrient use) |
| Level of the policy | National |
| Policy inputs | The following inputs are needed to implement the policy:<br>▪ Funding allocation to support:<br>  ▪ Personnel to establish and manage flagship farms, provide technical assistance, monitoring, and data management and analysis<br>  ▪ Payment for voluntary responses to the EMMA survey (USD 10/per survey)<br>  ▪ Incentives for demonstrated changes in practice, which will cover additional labour required to make changes in feed and manure practices (USD 500/farmer)<br>  Note: incentive levels based on available funding allocations, a typical cost of implementing practices, and expert judgement from survey design professionals<br>▪ Expertise to administer the programme, including:<br>  ▪ Nation policy leadership and expert governance group,<br>  ▪ Statistics personnel who will lead EMMA survey data analysis<br>  ▪ Dedicated extension agents in each region who will perform farm site visits and lead their region's workshops<br>  ▪ Dedicated experts who will manage and coordinate flagship farms' experiments, data collection, and analysis |

Table 5.1. **Description of the National Dairy Methane Reduction Programme (Continued)**

| Policy description category | Detailed description |
|---|---|
| Policy activities | Policy activities include:<br>▪ Establish programme administrative infrastructure to administer payments to farmers registered in the programme<br>▪ Develop and conduct technical assistance workshops<br>▪ Develop survey instrument, collect, and conduct analysis of EMMA survey data<br>▪ Conduct site visits |
| Geographic coverage | All cattle farmers in the country are eligible whether they are considered to be a smallholder or medium-scale farm (≤ 40 cattle) or large-scale farm (>40 cattle) affecting 60,000 farmers and 1.68 million cattle (dairy and other cattle) |
| Subsectors affected* | Livestock, cattle dairy sector |
| Greenhouse gases affected* | $CH_4$, trade-offs for $N_2O$ and other nitrogen-based manure emissions ($NH_3$) will be considered by policymakers and livestock experts in relation to $CH_4$ emission reduction recommendations. |
| Other related policies or actions | Manure management practices that affect use of manure as fertiliser have implications for $N_2O$ emissions from soils and are accounted for when assessing nutrient management policies. |
| Intended level of mitigation to be achieved and/ or target level of other indicators (if relevant)* | The mitigation target of the National Dairy Methane Reduction Programme is to reduce $CH_4$ emissions from enteric fermentation and manure by 35% by the end of the implementation period in year 2035.<br>Additional targets that support activities to achieve GHG reductions are related to data collection, implementation of technical assistance, and uptake of practices by farmers. By the end of the policy implementation period, the policy aims to have:<br>▪ 50% of farmers respond to the EMMA survey<br>▪ 75% of farmers attend workshops and receive technical assistance<br>▪ 50% of farmers will implement changes on farm |
| Key stakeholders | ▪ Farmers and ranchers<br>▪ Two key national Farmers Cooperatives<br>▪ Producer associations<br>▪ Education and research institutions: e.g., National Livestock & Agriculture Research Institute (with flagship farms)<br>▪ Suppliers of equipment and inputs & any other companies<br>▪ National government agencies: e.g., Ministry responsible for Agriculture, Ministry responsible for Water Resources<br>▪ Regional and local government entities<br>▪ Government entities responsible for agriculture and livestock management: e.g., Department of Agriculture Extension and Department of Livestock Services of the Ministry responsible for Agriculture<br>▪ Ministry responsible for the Environment, in charge of coordinating the National Agriculture Inventory<br>▪ National Bureau of Statistics<br>▪ Communities, indigenous peoples, or marginalised groups that are involved in or are affected by agriculture<br>▪ Financial institutions<br>▪ Relevant dairy industry representatives |

Table 5.1. **Description of the National Dairy Methane Reduction Programme (Continued)**

| Policy description category | Detailed description |
|---|---|
| Title of establishing legal framework, or other founding documents | The National Agriculture Policy Act of 2020 |
| Monitoring, reporting, and verification procedures | Annual farm visits conducted by agricultural extension agents to all farms receiving payment from Years 3 – 10. Specialists will verify the implementation of practices according to interviews, site visits, and analysis of EMMA survey responses submitted by participants. |
| Policy Key Performance Indicators (KPIs) | The proposed KPIs for the National Dairy Methane Reduction Programme include:<br>▪ $CH_4$ emissions<br>▪ Emission intensity, $CH_4$ emissions per unit of milk production<br>▪ EMMA survey response rate<br>▪ Technical assistance workshops conducted<br>▪ Technical assistance workshops attendance<br>▪ Proportion of farmers with verified implementation of improved manure storage practices<br>▪ Manure storage time<br>▪ Proportion of solid manure stored with covers<br>▪ EMMA survey incentives<br>▪ Spend rate of Extension services to conduct workshops, farm visits, and manage flagship farms<br>▪ Value of incentive payments disbursed<br>KPIs and associated target levels are discussed in more detail in Section 5.4.1 |
| Compliance and enforcement mechanisms | Participation in the programme is voluntary; however, compliance is contingent on verification and required to receive incentive payments<br>To receive incentive payments, farmers must:<br>▪ Year 1: document feed and manure management practices and systems, including manure storage times and covering practices in the EMMA survey, provided to their local extension office<br>▪ Year 2: respond to the EMMA survey, attend a workshop at established flagship farms and receive recommendations on changes to manure storage and/or covering<br>▪ Year 3 – 10: respond to EMMA survey, annual MRV farm visit to demonstrate changes in feed and/or manure management (e.g., storage, covering) practices |
| Reference to relevant documents | Documents supporting policy implementation will include training materials and practice standards for updated management plans for farmers enrolled in the programme.<br>As an outcome of activities under the policy, the Ministry responsible for Agriculture will publish a report on results of the EMMA survey. |

Table 5.1. **Description of the National Dairy Methane Reduction Programme (Continued)**

| Policy description category | Detailed description |
|---|---|
| The broader context or significance of the policy | Dairy cattle in the country are in fact "dual purpose", and are used for beef production, but for the purpose of this policy are referred to as "dairy cattle". Nationally, ~97% of all cattle are managed on smallholder to medium-sized farms (<200 litres per farm per day or ≤ 40 cattle), and ~3% of all cattle are managed on large-scale farms (200–500 litres per farm per day or > 40 cattle).<br><br>The policy is available for farms of all sizes, however, is designed in a way that will enable and facilitate smallholder to medium-sized farm adoption as they make up most of the national dairy production.<br><br>Most farmers (~80%) store solid manure in uncovered heaps, managed as unconfined piles or stacks ('solid storage') for several months and on open flat areas ('dry lot') for short periods prior to spreading onto fields. Approximately half of stored manure is used as crop fertiliser, and the remaining half is used for fuel. The policy will aim to reduce storage time from several months to < 2 weeks which will in turn reduce $CH_4$, $N_2O$, and $NH_3$ emissions that occur during the storage phase. Where reduced storage time is not possible, the policy will aim to encourage the use of covers on solid storage, which has the co-benefits of reducing $NH_3$ emissions during the storage phase.<br><br>The policy will develop data for more efficient nutrient use and thus the policy is expected to provide farmers with the co-benefit of information to increase other agricultural crop productivity. |
| Outline of sustainable development impacts of the policy | Sanitation and water quality, food security, nutrient efficiency, strengthening rural community. |
| Other relevant information | If this policy is successful, increased knowledge of sustainable feed and manure management practices will support further mitigation measures that reduce emissions and emission intensity per unit of product in the livestock sector. It is also likely to reduce water pollution, optimise nutrient use efficiency, and potentially increase crop yield (which as mentioned is commonly the priority for more months of the year than dairy production is in this country). The policy will improve sanitation conditions and reduce odours which can be offensive to nearby villages and neighbours. |

*Indicates required reporting under the Enhanced Transparency Framework under the Paris Agreement

### 5.1.3 Intermediate effects and GHG impacts

Once the policy is described, the users must document how all the inputs, activities, and intermediate effects lead to changes in behaviour, technology, processes, or practices. Outlining these changes includes understanding which parameters are affected, what is the direction and magnitude of the effect, and where and when this effect is expected to take place. This process helps to determine the policy scenario for the quantification of GHG impacts. Affected parameters may include market-based factors such as increased labour costs, decreased reliance on synthetic fertilisers, fuel savings, and market access. Policy activities may also lead to intermediate effects that lead to trade-offs and some may increase GHG emissions. Consideration of emission trade-offs is particularly important in livestock systems because changes in cattle diets to reduce enteric fermentation emissions will have implications for manure $CH_4$ and $N_2O$ emissions. Estimating emission trade-offs is crucial to prove the success of any policy.

A description of intermediate effects and associated GHG impacts is the next step of the description process and will help identify and consider such trade-offs. For example, in the National Dairy Methane Reduction Programme, the improvement in forage quality and improved digestibility may lead to increased N content of manure and increased $N_2O$ manure emissions. The inputs, activities, and intermediate effects of the National Dairy Methane Reduction Programme are described in **Table 5.2.**

Refer to Chapter 4 for more information on the process for describing the policy intermediate effects and GHG impacts and the Templates section for templates to describe intermediate effects and GHG impacts.

Table 5.2. **Inputs, activities, and intermediate effects (changes in behaviour, technology, processes or practices) of the National Dairy Methane Reduction Programme**

*(I)=input, (A)=activity, (IE)=intermediate effect*

| Inputs, activities, intermediate effects | Detail/ explanation | Affected parameter | Direction | Magnitude | Geographic location | Timing |
|---|---|---|---|---|---|---|
| (I) Allocate funding and hire staff to administer the programme | The incentive payment fund is set up and staff with appropriate expertise is available to administer and implement the programme | Personnel can begin implementation of activities under the policy | NA | USD 14M | National | Year 1 |

Table 5.2. **Inputs, activities, and intermediate effects (changes in behaviour, technology, processes or practices) of the National Dairy Methane Reduction Programme (Continued)**

| Inputs, activities, intermediate effects | Detail/ explanation | Affected parameter | Direction | Magnitude | Geographic location | Timing |
|---|---|---|---|---|---|---|
| (A) Establish programme administrative infrastructure | A system is set up to distribute surveys, promote training workshops, and provide incentive payments | Distribution of incentive payments | NA | NA | National | Year 1 |
| (A) Develop and distribute EMMA survey; conduct data analysis | Surveys to collect manure management information are prepared and distributed | Farmers respond to survey and provide information about manure management | Increase | Distributed to all dairy farmers | National | Years 1 – 10 |
| (IE) Farmers respond to EMMA survey | Farmers fill out survey to improve activity data on management (required to receive incentive payment) | Activity data and management information collected and enhance country's MRV system | Increase | 25% of dairy farmers nationally by 2030, and 50% by 2035 | National | Years 1 – 10 |
| (A) Develop and conduct technical assistance workshops | To increase knowledge level regarding technologies or practices, held on local flagship farm | Farmers adopt new manure management practices | Increase | 3 workshops per year at each of the 6 flagship farms, over 5 years, reaching up to 75% of national farmers by 2035 | National reach with regional management recommendations, at flagship farms | Years 2 – 6 |
| (A) Conduct farm visits | Provide recommendations and assistance to change manure management practices. Verify practices for subsidy payments | Farmers adopt new manure management practices and support enhancement of national MRV system | Increase | Up to 50% of farms that are changing practices by 2035 | National implementation, recommendations are farm-specific | Years 3 – 8 |

Table 5.2. **Inputs, activities, and intermediate effects (changes in behaviour, technology, processes or practices) of the National Dairy Methane Reduction Programme (Continued)**

| Inputs, activities, intermediate effects | Detail/ explanation | Affected parameter | Direction | Magnitude | Geographic location | Timing |
|---|---|---|---|---|---|---|
| (IE) Change livestock feeding strategies and/or pasture management* | To facilitate pasture growth and improvement, implement rotational grazing, new mixed pasture species if relevant, manage feeding times, etc. | Improved forage quality, subsequent improvements in productivity; Note: this affects GHG emissions, see **Table 5.3** for further details | NA | Up to 50% of farmers change practices by 2035 | National, for farmers enrolled in the programme | Years 3 – 10 |
| (IE) Upgrade storage facilities where necessary | May require purchase of minimal resources, will require labour | Increased labour and equipment costs** | NA | Up to 50% of farmers change practices by 2035 | National, for farmers enrolled in the programme | Years 3 – 10 |
| (IE) Adjust livestock milking practices | When forage quality improves, milk production can increase requiring changes to accommodate this | Time spent in milking facilities or milking frequency | NA | Up to 50% of farmers change practices by 2035 | National, for farmers enrolled in the programme | Years 3 – 10 |
| (IE) Change manure management practices: storage duration* | Reduce manure storage time overall | Storage time; Note: this affects GHG emissions, see **Table 5.3** for further details | Decreasing | Reduce storage times from the average of 60 days to < 15 days OR cover where manure must be stored for 15 days or more. | National, for farmers enrolled in the programme | Years 3 – 10 |

Table 5.2. **Inputs, activities, and intermediate effects (changes in behaviour, technology, processes or practices) of the National Dairy Methane Reduction Programme (Continued)**

| Inputs, activities, intermediate effects | Detail/ explanation | Affected parameter | Direction | Magnitude | Geographic location | Timing |
|---|---|---|---|---|---|---|
| (IE) Change manure management practices: cover stored manure* | Cover solid manure heaps with e.g., plastic sheeting where reduction in storage period is not possible | Proportion of manure stored covered; Note: this affects GHG emissions, see **Table 5.3** for further details | Increasing | Amount depends on how many farms reduce storage duration | National, for farmers enrolled in the programme | Years 3 – 10 |
| (IE) Adjust application of manure | To facilitate shorter storage periods, possibly increasing crop yields | Increased labour costs**, change in soil emissions from fertiliser application, reduced use of synthetic fertiliser**; Note: this affects GHG emissions, see **Table 5.3** for further details | Decreasing (time to application), possibly increasing frequency of application (where availability of labour allows) | Related to the reduced storage duration | National, for farmers enrolled in the programme | Years 3 – 10 |

*indicates intermediate effects that are policy mitigation measures
**indicates market-based impacts

Once the policy inputs, activities, and intermediate effects have been documented as shown in **Table 5.2**, the user can further analyse those that lead to changes in GHG emissions and detail the steps that describe how the changes in GHG emissions occur.

It is a key recommendation to work with agriculture experts during this part of the assessment step to analyse intermediate effects and identify potential GHG impacts of the policy.

The user should also consider and identify whether the effects associated with policy activities are intended or unintended (Rich, 2014). Intended effects are based on the original objectives of the policy. However, as mentioned in the previous section, intended effects may have trade-offs in emissions. Unintended effects typically represent effects that fall outside of the policy's control and may amplify or diminish the impact of the policy.

The GHG impacts associated with the National Dairy Methane Reduction Programme are summarised in **Table 5.3.**

Table 5.3. **GHG Impacts of the intermediate effects of the National Dairy Methane Reduction Programme**

| Intermediate effect* | Subsequent intermediate effects | | | Potential GHG impact |
|---|---|---|---|---|
| | Effect 1 | Effect 2 | Effect 3 | |
| Change livestock feeding strategies and/or pasture management | Improved forage quality and quantity | Improved digestibility, Improved livestock health, and livestock growth rate | Production efficiency improves | Decreased $CH_4$ emission intensity due to improved quality forage |
| | | Increased N content in manure | - | Increased $N_2O$ emissions from increased N content of manure |
| | Increased pasture growth | - | - | Increased $CO_2$ removal through soil carbon sequestration |
| Change manure management storage and covering practices | More labour required to manage/apply manure when storage times are reduced | Decrease length of time in storage | - | Decreased manure $CH_4$ emissions when storage duration is reduced |
| | More labour required to manage and maintain manure covers | Manure coverings used on manure heaps | Increased proportion of manure stored covered | Decreased $CH_4$ and $NH_3$ emissions through a reduced gas exchange due to manure coverings |
| | | | Manure stacked anaerobically through compaction | Decreased $N_2O$ and increased $CH_4$ emissions from compaction of manure |

Table 5.3. **GHG Impacts of the intermediate effects of the National Dairy Methane Reduction Programme (Continued)**

| Intermediate effect* | Subsequent intermediate effects | | | Potential GHG impact |
|---|---|---|---|---|
| | Effect 1 | Effect 2 | Effect 3 | |
| Change manure management storage and covering practices | More labour required for adjusted application of manure when duration of storage decreases | Knowledge required to balance with other nutrient inputs (synthetic fertilisers for example) | Increased frequency of manure application to crops | Increased $NH_3$ and $N_2O$ emissions from manure applied to soils |

*indicates intermediate effects that are policy mitigation measure

Similar to the example, users should be able to outline the intermediate effects and GHG impacts of the selected policy.

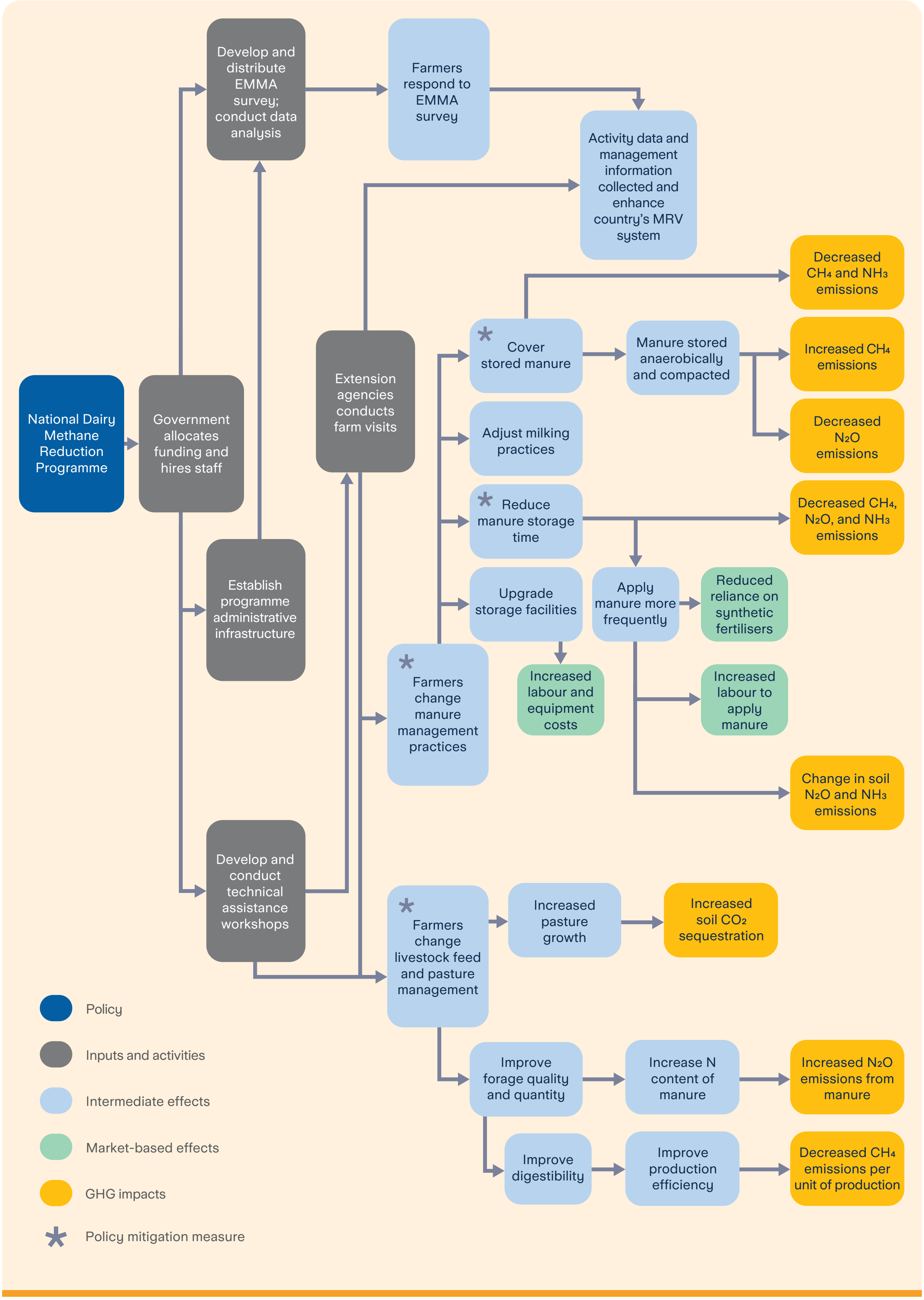
### 5.1.4 Causal chain

A causal chain is a conceptual diagram tracing the process by which the policy leads to GHG impacts through a series of interlinked logical and sequential stages of cause-and-effect relationships. In parallel with the identification of intermediate effects and GHG impacts, the user should prepare a causal chain to better understand, visualise, and communicate how the policy and its corresponding inputs and activities cause intermediate effects and ultimately result in GHG impacts. The causal chain is a visual representation of the information about the policy from **Tables 5.2** and **Table 5.3**. It can also help reveal interdependencies between and the order of implementation of the different activities under the policy that is more challenging to visualise in a table format. The causal chain for the National Dairy Methane Reduction Policy is shown in **Figure 5.1.**

Visualising the policy's causal chain is likely to lead to the refinement of the information listed in **Table 5.2** and **Table 5.3**. The causal chain can be a useful tool for engaging stakeholders in understanding policy design and its effects.

Refer to the Templates section for a template to develop a causal chain following the demonstrated example.

Figure 5.1. **The National Dairy Methane Reduction Programme causal chain**



### 5.1.5 Assessment boundary and period

#### Policy assessment boundary

Once all the potential GHG impacts are identified, the user will determine which ones will be included in the assessment boundary. Determining the policy assessment boundary includes a three-part process of estimating:

- the likelihood of GHG impact
- the expected relative magnitude of GHG impact
- the significance of each GHG impact

The user should then select which impacts will be estimated within the assessment boundary. Typically, the user has a limited number of resources to conduct the assessment. This three-part estimation helps the user to prioritise assessing impacts that are likely and major in size. Impacts considered very likely, likely, or possible in combination with their GHG impact being either moderate or major are significant and should be included in the assessment boundary.

For the National Dairy Methane Reduction Programme, all of the GHG impacts identified in **Table 5.3** are considered. The results of this process are outlined in **Table 5.4**. Changes in $CH_4$ emissions due to decreased storage time and use of covers were determined as significant and included in the assessment boundary.

Refer to Chapter 4 for guidance on determining the significance of GHG impacts and the Templates section for templates to determine assessment boundary.

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Table 5.4. **Likelihood, magnitude, and significance of GHG impacts of the National Dairy Methane Reduction Programme**

| Mitigation measure | GHG impact | Likelihood | Relative magnitude | Significance |
|---|---|---|---|---|
| Change livestock feeding strategies and/or pasture management | Increased $CO_2$ removal through soil carbon sequestration | Likely | Minor | Not significant |
| | Increased $N_2O$ emissions from increased N content of manure | Possible | Minor | Not significant |
| | Decreased $CH_4$ emission intensity due to improved quality forage | Likely | Moderate | Significant |
| Change manure management storage and covering practices | Decreased manure $CH_4$ emissions when storage duration is reduced | Very likely | Major | Significant |
| | Decreased $CH_4$ and $NH_3$ emissions through a reduced gas exchange due to manure coverings (e.g., on manure heaps), only $CH_4$ is quantified in the assessment | Likely | Moderate | Significant |
| | Decreased $N_2O$ emissions from manure storage due to decreased storage time | Likely | Minor | Not significant |
| | Increased $NH_3$ and $N_2O$ emissions from manure applied to soils | Likely | Unknown | Not estimated |
| | Decreased $N_2O$ and increased $CH_4$ emissions from compaction of manure | Possible | Unknown | Not estimated (limited research available) |

Users should evaluate the intermediate effects and GHG impacts of the selected policy and determine the assessment boundary similar to the example.

If land use change occurs as a result of the policy, such as conversion of forest to pasture, users may also refer to the ICAT *Forest Methodology* to estimate associated GHG impacts. Furthermore, assessing unintended effects outside the AFOLU sector (e.g., emissions from fuel consumption) is outside the scope of this guide.

For policies that have unintended effects on other agricultural emission sources, such as from fertilisers or soil carbon sequestration, refer to Chapters 6 and Chapter 7 of this guide, respectively.

**Policy assessment period**

Users should also determine the assessment period that will be used. The National Dairy Methane Reduction Programme example policy was adopted in 2020, with implementation set to begin in 2025. This assessment period is ex-ante and covers the duration of the policy, which is 10 years, 2025 – 2035. There is also a plan to conduct one assessment near the mid-point of the policy to evaluate areas of necessary policy adjustments and improvements and capture GHG impacts from actions taken by early adopters of the policy. For the purpose of the example, assessment is being conducted at time t and the assessment period is t – t+10 (years 2025 – 2035).

### 5.1.6 Other policy synergies and interactions

Users should qualitatively describe potential policy synergies and interactions. Quantitative assessment of interacting policies is beyond the scope of this guide; however, it is important to identify them to inform future policy decisions. Adoption of other agricultural policies and programmes that aim to improve cattle production in the country may have additional synergistic impacts or may result in trade-offs that counter the emission reduction achieved by the National Dairy Methane Reduction Programme.

Livestock policies may have implications for activities and policies related to nutrient management. As mentioned in the description of intermediate effects, changing manure storage practices may reduce reliance on synthetic fertilisers and change agricultural soil $N_2O$ emission levels. Furthermore, improved pasture and manure management may support environmental measures to improve water quality by decreasing excessive loss of nutrients from farmland. Describing the policy and identifying policy interactions lays the groundwork for a more detailed evaluation of policy interactions or non-GHG policy impacts, for example, sustainable development, which the user may conduct in addition to the GHG impact assessment.

Pasture management, in addition to improving feed quality, can be considered as an adaptation strategy if grass species mix is selected to increase biodiversity and ensure tolerance to higher temperatures, flooding or drought conditions, or threats from pests or disease.

After completing the policy description, the user is ready to quantify the GHG emissions impacted by the policy.

Refer to the WRI's Policy and Action Standard in this guide's assessment toolkit for additional resources on assessing policy interactions. Furthermore, refer to the ICAT *Sustainable Development Methodology* for additional resources for assessing sustainable development impacts.

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## 5.2 Methodological considerations

### 5.2.1 Methodology for assessing GHG emissions

Users should determine which methodological tier to apply in their assessment based on data availability. This guide recommends reviewing the country's GHG inventory to identify which methodological tier was utilised, because it may highlight the level of data characterisation potentially applicable for use within the assessment. Initially, data availability is the main factor in selecting the calculation tier. If it is determined that emissions constitute a key source category based on key category analysis as described in the IPCC 2006 GL, the country will need to invest in further data collection to use a higher calculation tier. The emissions associated with cattle production are reported in CRTs 3A and 3B(a), in GHG Inventory categories 3.A.1 and 3.B.1 for enteric fermentation and manure, respectively, under the ETF reporting requirements.

The methodology in this guide is based on the IPCC 2006 GL and 2019 Refinement. The policy assessment example uses methods, equations, default values, and parameters from the 2019 Refinement.

The Tier 1a method allows for differentiation between livestock production systems with different productivity levels, which are defined in the 2019 Refinement Volume 4, Chapter 10, Section 10.2.2. Tier 1a disaggregates default emission factors for low- and high-productivity systems, as defined in 2019 Refinement, Volume 4, Chapter 10, Section 10.2.2. Tier 2 methods use country-specific and/or management-specific emission factors and typically a more detailed characterisation of livestock categories. Utilising Tier 2 or Tier 3 should result in more accurate estimates.

For the purpose of assessing the National Dairy Methane Reduction Programme, detailed livestock characterisation data is not available. Tier 1a is used in estimating the baseline scenario emissions, in the absence of mitigation measures. To capture changes associated with mitigation measures such as feed management, adjustments to emission factors are necessary.

Studies on similar systems were used to adjust default emission factors to reflect changes associated with improved feed and manure storage practices. Therefore, a simplified Tier 2 method is used to estimate policy scenario emissions, when mitigation measures are implemented. In the assessment, default parameters are based on values for the Indian Subcontinent due to similar climate characteristics assigned to the hypothetical country.

When converting $CH_4$ emissions to emission expressed in $CO_2e$, users should, to ensure consistency, utilise the same GWP as the one used in their current national GHG inventory.

Refer to the 2019 Refinement, Volume 4, Chapter 10, Figures 10.2, 10.3, and 10.4 in this guide's assessment toolkit to view the tier decision trees for further guidance on choice of method. Note that Tier 1 and Tier 1a methods capture emission changes associated with livestock population only. Application of a simplified Tier 2 method can be used to adjust default emission factors to estimate GHG emissions associated with management changes.

### 5.2.2 Baseline scenario

The user will need to establish a baseline scenario to estimate GHG emissions without mitigation measures, WOM.

Refer to Section 2.3 for an overview of approaches to constructing a baseline.

Refer to this guide's assessment toolkit for resources on baseline projections and potential data sources such as the World Bank Open Data to inform baseline scenario.

First, the user should establish whether and how the livestock population will change. Where future trend of livestock population data are not available, economic data (e.g., an output or yield) can be used to infer livestock population numbers. When using economic data, trends in demand are used as a proxy for estimating the expected output of milk and/or meat production and inferring livestock population in the baseline scenario. Users should use national demand forecasts. If forecasts are not available, users can extrapolate based on historical data, or consider trends in GDP, population, or other proxy factors to estimate how current demand for milk and/or meat and associated livestock population will change in the future.

Where the above data sources are unavailable, the users can estimate future milk and/or meat demand or production based on **expert judgement**. Users can consult national economic experts for estimating the sector's market growth, to provide the annual growth rate for demand for milk and/or meat production. Using this as an indicator of expected growth, the livestock population to meet projected demand can be estimated based on demand trends. The baseline scenario should also capture the current management practices and the extent to which management might change over the assessment period in the absence of mitigation measures.

For the purpose of assessing the National Dairy Methane Reduction Programme, the baseline scenario is termed the scenario without measures (WOM) and is summarised in **Table 5.5.**

A simple trend baseline is used in the assessment. The country's area of land used for dairy cattle production has remained stable over the previous decades, so it is assumed that total land used for cattle will not expand during the policy period. Rates of dairy cattle population growth are expected to remain the same as in the previous decade (3 percent/yr). The typical manure storage time is two months based on consultation with extension agents. These assumptions are deemed reasonable through further consultations with national livestock experts and extension agents and were validated with specialists and relevant stakeholders in the validation workshop as planned in preparation for the assessment. The baseline scenario assumes there would otherwise be no changes in technology, land use, management practices, or levels of production without the National Dairy Methane Reduction Programme.

### 5.2.3 Policy scenario

The user will need to establish a policy scenario to estimate GHG emissions with mitigation measures.

For the purpose of assessing the National Dairy Methane Reduction Programme, the policy scenario is termed scenario with additional measures (WAM). Two policy scenarios are selected for assessment:

- Optimistic mitigation (WAM-HIGH) with high levels of adoption of recommended changes
- Conservative mitigation (WAM-LOW) with likely levels of adoption of recommended changes in practices

The conservative scenario revises key implementation assumptions to reflect expert estimates. The policy scenarios are summarised in **Table 5.5**.

It is anticipated that there will be significant increases in production efficiency of dairy cattle during the policy implementation period mainly due to the policy fostering improved pasture management practices (key drivers of improved productivity are expected to be rotational grazing and fencing). Based on expert judgement, with mitigation measures, the cattle population growth will be reduced to zero under WAM-HIGH or slow down from 3 percent to 1 percent under WAM-LOW over the course of the policy. Emission intensity, GHG emissions per unit of production, is selected as one of the KPIs (see **Table 5.1** and Section 5.4.1) to track policy implementation. Under the policy, the manure storage time is expected to decrease to 15 days.

Refer to Appendix A for additional guidance on estimating the implementation potential of a policy. Note that users can assess one or more policy scenarios to help refine policy design.

Table 5.5. **Key assumptions for baseline (WOM), optimistic (WAM-HIGH), and conservative (WAM-LOW) mitigation scenarios**

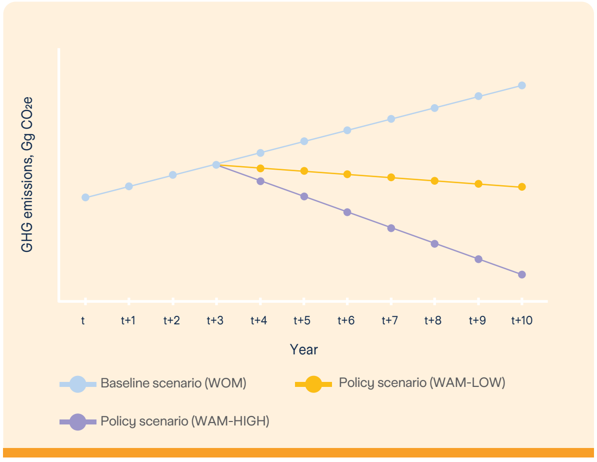
| Scenario description | WOM | WAM-HIGH | WAM-LOW |
|---|---|---|---|
| Workshop and farm site assessment participation as percentage of national farmers, by the end of policy implementation period (year t+10) | - | 75% | 60% |
| Level of uptake of farmers who participate in workshops and farm site assessments by the end of policy implementation period (year t+10) | - | 50% | 20% |
| Dairy cattle population annual growth during policy implementation period | 3% | 0% | 1% |
| Productivity system level during policy implementation period | Low | Low | Low |
| Proportion of manure managed (and stored) as solids | 80% | 80% | 80% |
| Manure storage time when farmers adopt new practices | 60 days | 15 days | 15 days |
| Implementation of changed practices after policy implementation period ends (year t+11 and on) | - | Farmers do not revert to old practices | Farmers do not revert to old practices |
| Enteric fermentation emission reduction from changes in feed and pasture management* | - | -10.6% | -10.6% |
| Manure $CH_4$ emission reduction from changes in storage practices and duration** | - | -50% | -50% |

*Arndt et al., 2022, daily $CH_4$ average reduction for improved forage
**Huque et al., 2017

Assumptions regarding farmer participation in technical assistance workshops and the level of uptake of practices are based on consultation with extension agents. Expected participation and adoption levels are based on the delivery of technical assistance in other programmes. Livestock and manure storage characteristics come from the country's agriculture survey and are validated by national livestock experts.

A farmer survey was conducted to determine the current and optimal manure storage duration to inform policy design. Peer-reviewed studies served as a basis for determining emission reduction rates for mitigation measures under the policy. A conceptual diagram of the policy impact is demonstrated in **Figure 5.2** for the example with two policy scenarios included in the assessment.

Figure 5.2. **Conceptual diagram showing the relationship between baseline and policy scenario emissions**




The example demonstrates how the users should establish baseline and policy scenarios for the policy selected for assessment.

### 5.2.4 Data for assessment

The users must identify activity data and parameters needed to conduct the assessment and specify, to the extent possible, the sources of the data.

The information needed to conduct the GHG impact assessment and associated data sources for the National Dairy Methane Reduction Programme are outlined in **Table 5.6**. Most of the required data are available from the national GHG inventory (e.g., population, climate zones, land uses, and sub-categories for cattle). Activity data used in this example are summarised in the Hypothetical Country section of the guide. Furthermore, by design of the policy, the EMMA survey will collect necessary manure management data, as well as key data on the number of dairy cattle and their physiological characteristics, which will contribute directly to improving the accuracy of enteric fermentation and manure GHG estimates in the future (both for this policy and for the national GHG inventory). The 2019 Refinement outlines default emission factors, GHG estimation methods, and other relevant parameters for this estimation (2019 Refinement, Volume 4, Chapter 10). Activity data and emission factors used in the calculations will be presented in the following sections.

Refer to the Technical Supplement for relevant activity data and emission parameters needed for quantifying GHG emissions associated with livestock mitigation measures for both Tier 1 and Tier 2 methods.

Once the user has determined which methods will be used to calculate emissions and has described baseline and policy scenarios with associated data parameters needed, GHG emissions can be calculated.

Table 5.6. **Sources of data for livestock GHG emission estimation**

| Data type | Data sources |
|---|---|
| Cattle characterisation and annual population | ▪ Population data, livestock classifications (known as livestock characterisation in 2019 Refinement), animal weight, and milk production come from a national agriculture survey and are validated by national livestock experts. Data can also be obtained from FAO's database, FAOSTAT. |
| Productivity system level | ▪ Low- and high-productivity systems are defined in 2019 Refinement, Volume 4, Chapter 10, Section 10.2.2 for use in Tier 1a calculations. |
| Manure management information | ▪ Manure management information on storage practices, including type of storage facility, duration of storage, and form of manure in storage (solid, dry lot, etc.) comes from a national agriculture survey. Information may also be available from DATAMAN, the Database of Greenhouse Gas Emissions from Manure Management.<br>▪ Manure management systems are defined in 2019 Refinement, Volume 4, Chapter 10, Table 10.18. |
| Emission factors and other parameters | Default Tier 1/1a parameters come from the 2019 Refinement, Volume 4, Chapter 10:<br>▪ Live weight, TAM: Table 10A.5<br>▪ Enteric fermentation: cattle emission factors, EF: Table 10.11<br>▪ Manure: average volatile solids excreted, $VS_{rate}$: Table 10.13a, 10A.1<br>▪ $CH_4$ emission factor for volatile solids, EF: Table 10.14<br>For country-specific emission factors, refer to IPCC Emission Factor Database |
| GWP | ▪ 100-year GWP for $CH_4$: IPCC Fifth Assessment Report, or as in national GHG inventory |

## 5.3 Estimating GHG emissions

### 5.3.1 Compile activity data

#### Determine livestock categories and population

Users should characterise livestock species categories (e.g., cattle, sheep, poultry) to be included in the assessment. The policy may be designed specifically to address emissions from a particular livestock category. Otherwise, it may be sufficient to focus on the highest-emitting livestock species (such as dairy and non-dairy cattle). Livestock that do not contribute significantly to overall emissions may be excluded.

> Refer to the 2019 Refinement in this guide's assessment toolkit for more information on average livestock emissions. Dairy cattle tend to have the highest enteric fermentation emissions ranging from 62–138 kg $CH_4$/head/yr. Non-dairy cattle groups, such as beef cattle, have enteric fermentation emissions ranging from 41–64 kg $CH_4$/head/yr. After cattle, the next highest emitters, in rank order, are buffalo, sheep, goats, swine, horses, camels, mules/asses and poultry.

Users should characterise each livestock species. A characterisation is a list of livestock sub-categories. Choose a basic or enhanced livestock characterisation. A basic characterisation uses the livestock subcategories for which there is a default emission factor (e.g., dairy cattle, non-dairy cattle, buffalo, sheep, goats, swine, horses, camels, mules/asses, and poultry). An enhanced livestock characterisation would enable the use of Tier 2 methods resulting in more accurate estimations. For an enhanced livestock characterisation, subdivide the livestock categories further. Livestock subcategories should be defined as relatively homogenous sub-groupings of animals accounting for variations in age structure and animal performance disaggregated to the level of available data on livestock in the country. Users need annual population data for each subcategory of livestock included in the assessment boundary.

> Refer to IPCC 2006 GL and 2019 Refinement, Volume 4, Chapter 10 in this guide's assessment toolkit for guidance on defining country-specific livestock subcategories. Table 10.1 provides representative livestock subcategories.

For the purpose of assessing the National Dairy Methane Reduction Programme which targets cattle as the main source of $CH_4$ emissions, only cattle are included in the assessment. Cattle characterisation of the country's 1.68 million cattle and other characteristics are provided in **Table 5.7.**

### Determine feed characterisation

When using Tier 2 methodology, users should estimate the feed intake for a representative animal in each livestock subcategory. The representative feed intake is used to derive each subcategory's emission factor.

Feed intake is typically measured in terms of gross energy (e.g., MJ per day) or dry matter intake (DMI) (e.g., kg per day). The assumed feed intake should represent animal feeding practices under the baseline scenario. Feed intake is, in many cases, a key parameter that is changed in the policy scenario.

For the purpose of assessing the National Dairy Methane Reduction Programme, activity data on feed characteristics is not available. Under the policy, forage quality is expected to improve as a result of pasture management, therefore, the change is captured by adjusting the emission factors as described in Section 5.3.4.

Refer to IPCC 2006 GL and 2019 Refinement, Volume 4, Chapter 10 in this guide's assessment toolkit for guidance on estimating feed intake.

Table 5.7. **Cattle characterised population data at the start of assessment period, time t**

| Cattle category | Cattle sub-category | Annual population (number of heads) |
|---|---|---|
| Dairy cattle | Dairy: calves < 1-year-old | 369,600 |
| | Dairy: cattle 1-2 years | 436,800 |
| | Dairy: mature cows > 2 years | 621,600 |
| Other cattle | All other cattle | 252,000 |
| **Additional cattle characteristics** | | |
| Average annual milk production | | 1,825 kg/head/yr for small and medium farms |
| Productivity system level | | Low |

### Characterise manure management systems

As a next step, the user will need to categorise the manure management systems (MMS) present within the assessment boundary and identify key MMSs, of which there may be more than one, to estimate $CH_4$ emissions. Definitions of MMSs are provided in 2019 Refinement, Volume 4, Chapter 10, Table 10.18.

The main factors that affect $CH_4$ emissions are:

- Amount of manure produced
- Volatile solids (VS) content of the manure
- Portion of the manure that decomposes anaerobically

The amount of manure produced depends on the amount of feed eaten per animal and the number of animals, while the volatile solids content depends on the digestibility of the feed. The portion of manure that undergoes anaerobic decomposition is a function of how the manure is managed.

When manure is stored or treated as a liquid (e.g., in lagoons, ponds, tanks, or pits) it decomposes anaerobically and can produce a significant quantity of $CH_4$. The temperature and the retention time of the storage unit greatly affect the amount of $CH_4$ produced. When manure is handled as a solid (e.g., in stacks or piles), or when it is deposited on pastures and rangelands, it tends to decompose under more aerobic conditions and less $CH_4$ is produced.

To estimate $N_2O$ emissions, produced directly and indirectly during the storage and treatment of manure, users will need to have information about N excretion, the MMS used, emission factors for $N_2O$, as well as volatilisation and leaching factors.

For the purpose of assessing the National Dairy Methane Reduction Programme, only the $CH_4$ emissions are calculated as determined by the assessment boundary. **Table 5.8** summarises the activity data on MMS for cattle included in the assessment.

Eighty percent of manure is managed and stored as solids. The average length of storage is 60 days. Under the policy, the intended length of storage is 15 days and covering of manure while it is being stored. The change in storage time is captured by adjusting the emission factors as described in Section 5.3.4.

Table 5.8. **Manure management system activity data at the start of assessment period, time t**

| Activity data type | Value |
|---|---|
| Average length of storage | 60 days |
| Fraction of manure in solid storage | 80% |
| Fraction of manure deposited on pasture/range/paddock | 20% |

### 5.3.2 Choose emission factors and parameters

To estimate emissions in the next step of the assessment, the user will need to choose emission factors and parameters for each livestock category and/or manure management system.

It is a key recommendation to select emission factors that best match the characteristics of the livestock category affected by the policy. This might even lead to choosing an emission factor for a region that is different from where the policy is being implemented as long as key parameters match country conditions, e.g., temperature when estimating emissions from manure management.

Users should select emission factors that match their country's animal characteristics (e.g., weight, growth rate, and milk production). For Tier 1 and Tier 1a, IPCC default emissions factors for livestock are grouped by geographic region. For dairy cattle, users should select emission factors based on average annual milk production.

Users may consider conducting the assessment with Tier 2 methods midway through the policy assessment period if more data becomes available.

Refer to this guide's assessment toolkit for resources on compiling activity data to apply Tier 2 methods, the Livestock Activity Data Guidance (L-ADG).

For the purpose of assessing the National Dairy Methane Reduction Programme, the parameters used in the assessment are summarised in **Table 5.9.**

Under the policy implementation scenario (WAM), the emission factors related to feed characterisation are adjusted due to changes in DMI from improved forage quality. The adjustment assumes a 10.6 percent reduction in emission rates (74 kg $CH_4$/head/yr to 62.16 kg $CH_4$/head/yr for dairy cattle, and from 47 kg $CH_4$/head/yr to 39.48 kg $CH_4$/head/yr for other cattle) due to pasture management and improved forage (Arndt et al., 2022).

Under the policy implementation scenario (WAM), the emission factors related to manure $CH_4$ are adjusted due to changes in manure storage time. The emission factor is adjusted down by 50 percent to account for changes in manure management (Huque et al., 2017) from the default value (from 4.4 g $CH_4$ per kg VS to 2.2 g $CH_4$ per kg VS, both dairy and other cattle categories).

Users should compile activity data and identify emission factors to be used in the assessment calculations described in the following sections.

Table 5.9. **Emission parameters used for the National Dairy Methane Reduction Programme emission calculations**

| Emission factors and other parameters | Value | Data source |
|---|---|---|
| Typical animal mass | ▪ Dairy cattle, *TAM*: 265 kg<br>▪ Other cattle (mature male), *TAM*: 309 kg | 2019 Refinement, Volume 4, Chapter 10, Table 10A.5<br>Note: EMMA survey will contribute data to estimate different live weights more accurately for the different cattle sub-categories for future emission estimates |
| Enteric fermentation: cattle emission factors | ▪ Dairy cattle, emission factor, *EF*: 74 kg $CH_4$/head/yr, (based on average milk production of 1,700 kg/head/yr)<br>▪ Other cattle, emission factor, *EF*: 47 kg $CH_4$/head/yr for other cattle | 2019 Refinement, Volume 4, Chapter 10, Table 10.11 |
| Manure: average volatile solids excreted | ▪ Dairy cattle (low productivity system), $VS_{rate}$: 16.1 kg/1000kg animal mass<br>▪ Other cattle (low productivity system), $VS_{rate}$: 12 kg/1000kg animal mass | 2019 Refinement, Volume 4, Chapter 10, Table 10.13a, 10A.1; $CH_4$ emission factor for volatile solids, Table 10.14 |
| Manure $CH_4$ emission factor | ▪ Dairy cattle (low productivity system)/Solid storage, emission factor, *EF*: 4.4 g $CH_4$ per kg volatile solids<br>▪ Other cattle (low productivity system)/Solid storage, emission factor, *EF*: 4.4 g $CH_4$ per kg volatile solids | 2019 Refinement, Volume 4, Chapter 10, Table 10.14<br>Manure management systems are defined in 2019 Refinement, Volume 4, Chapter 10, Table 10.18 |
| GWP | ▪ $CH_4$: 28 | 100-year GWP for $CH_4$: IPCC Fifth Assessment Report, or as in national GHG inventory |

### 5.3.3 Calculate baseline emissions

#### Enteric fermentation

The users should use the data reflecting the baseline scenario to calculate baseline emissions. The equations to calculate emissions from enteric fermentation are **Equation 5.1** and **Equation 5.2**.

Equation 5.1. **Methane emissions from enteric fermentation for a given livestock category (2019 Refinement, Volume 4, Chapter 10, Eq. 10.19)**

$$CH_{4\ Enteric} = EF \times \left(\frac{N}{10^6}\right)$$

Where:

| | |
|---|---|
| $CH_{4\ Enteric}$ | = methane emissions from enteric fermentation (Gg $CH_4$/yr) |
| *N* | = livestock population |
| *EF* | = emission factor (kg $CH_4$/head/yr) |
| $10^6$ | = conversion from kg $CH_4$ to Gg $CH_4$ |

The emission factor (*EF*) is calculated using **Equation 5.2** and is based on changes in DMI according to the energy content of the feed due to policy changes. In the baseline scenario, the default emission factor is applied.

Equation 5.2. **Emission factor for enteric fermentation (2019 Refinement, Volume 4, Chapter 10, Eq. 10.21a)**

$$EF = DMI \times \left(\frac{MY}{1000}\right) \times 365$$

Where:

| | |
|---|---|
| *EF* | = emission factor (kg $CH_4$/head/yr) |
| *DMI* | = kg DMI/day |
| *MY* | = methane yield, kg $CH_4$/kg DMI (Table 10.12 of the 2019 Refinement) |
| 365 | = days per year |
| 1000 | = conversion from g $CH_4$ to kg $CH_4$ |

Because Tier 1a method only has emission factors for dairy cattle and other cattle (regardless of animal maturity), the cattle population is divided into two categories for calculations: dairy (1,428,000 head) and other (252,000 head). The population of each category is multiplied by the appropriate emission factors, 74 and 47 kg $CH_4$/head/yr for dairy and other cattle, respectively. Methane emissions are then converted to $CO_2$ equivalent with the GWP of 28. This is done for each year in the assessment period based, as shown in **Table 5.10.** The emissions are summed across all livestock categories. Full calculations are demonstrated in the Technical Supplement available for download. Note that manual calculations with rounded values as displayed in **Table 5.10** and **Table 5.11** may result in different values than full calculations in the Technical Supplement.

Table 5.10. **Sample $CH_4$ calculations for enteric fermentation for baseline scenario (WOM) at the start of assessment period, time t**

| Parameter (units) | Description | Value or calculated value | |
|---|---|---|---|
| | | Dairy cattle | Other cattle |
| Livestock population, N (# of heads) | Activity data | 1,428,000 | 252,000 |
| EF (kg $CH_4$/head/yr) | Default emission factor | 74 | 47 |
| **Total methane emissions from enteric fermentation** | | | |
| Annual $CH_4$ emissions (Gg) | $CH_4$ emissions, **Eq. 5.1** | EF x N/$10^{-6}$ = 105.67 | EF x N/$10^{-6}$ = 11.84 |
| Annual $CH_4$ emissions (Gg $CO_2$e) | Emissions expressed in $CO_2$e | Annual $CH_4$ emissions (Gg) x 28 = 2,958.8 | Annual $CH_4$ emissions (Gg) x 28 = 331.6 |
| Total $CH_4$ emissions (Gg $CO_2$e) | Sum for all livestock categories | 3,290.45 | |
| **Conversion factors** | | | |
| Unit conversion, kg to Gg | | | $10^{-6}$ |
| $CH_4$ GWP | | | 28 |

### Manure management

The equations to estimate $CH_4$ emissions from managed manure are **Equations 5.3** and **Equation 5.4**. **Equation 5.3** is a necessary precursor to calculate manure $CH_4$ emissions, which converts the IPCC default excretion rate of 1,000 kg animal mass per day, to head of livestock (in this case, dairy cattle) per year. **Equation 5.4** allows users to calculate emissions from manure for a given livestock category and management system.

Equation 5.3. **Annual volatile solid excretion for livestock (2019 Refinement, Volume 4, Chapter 10, Eq. 10.22a)**

$$VS = \left(VS_{rate} \times \frac{TAM}{1000}\right) \times 365$$

Where:

| | |
|---|---|
| *VS* | = annual VS excretion for livestock category (kg VS/ animal/yr) |
| $VS_{rate}$ | = default VS excretion rate, kg VS/1000kg animal mass/day (Table 10.13a) |
| *TAM* | = typical animal mass (for cattle sub-category, default, in kg/animal) |
| 365 | = conversion from days to year |

Equation 5.4. **Manure $CH_4$ emissions (2019 Refinement, Volume 4, Chapter 10, Eq. 10.22)**

$$CH_{4\ Manure} = \frac{N \times VS \times AWMS \times EF}{1000}$$

Where:

*$CH_4$ Manure* = manure $CH_4$ emissions (kg $CH_4$/yr)
*N* = livestock population
*VS* = average volatile solids excreted per head of species (kg VS/head/yr)
*AWMS* = fraction of total annual VS managed in each animal waste management system
*EF* = $CH_4$ emission factor (g $CH_4$/kg VS)
1000 = conversion from g $CH_4$ to kg $CH_4$

This is done for each year for each livestock category (dairy cattle and other cattle) in the assessment period based on assumptions regarding manure management as shown in **Table 5.11.**

Table 5.11. **Sample $CH_4$ calculations for manure for baseline scenario (WOM) at the start of assessment period, time t**

| Parameter (units) | Description | Value or calculated value | |
|---|---|---|---|
| | | Dairy cattle | Other cattle |
| N, livestock population (# of head) | Activity data | 1,428,000 | 252,000 |
| VS (kg VS/ animal/yr) | Default emission parameter | 16.1 | 12 |
| AWMS | Activity data (Fraction) | 80% | 80% |
| EF (g $CH_4$/kg VS) | Default emission factor | 4.4 | 4.4 |
| **Total methane emissions from manure** | | | |
| Annual $CH_4$ emissions (kg) | $CH_4$ emissions, **Eq. 5.4** | *N* x VS x AWMS x *EF*/1000 = 7,827,724 | N x VS x AWMS x *EF*/1000 = 1,200,538 |
| Annual $CH_4$ emissions (Gg) | $CH_4$ emissions | Annual $CH_4$ emissions (kg) x $10^{-6}$ = 7.83 | Annual $CH_4$ emissions (kg) x $10^{-6}$ = 1.20 |
| Annual $CH_4$ emissions (Gg $CO_2e$) | Emissions expressed in $CO_2e$ | Annual $CH_4$ emissions (Gg) x 28 = 219.18 | Annual $CH_4$ emissions (Gg) x 28 = 33.62 |
| Total $CH_4$ emissions (Gg $CO_2e$) | Sum for all livestock categories | 252.79 | |

| Conversion factors | |
|---|---|
| Unit conversion, kg to Gg | $10^{-6}$ |
| $CH_4$ GWP | 28 |

The user can follow the example calculations to estimate $CH_4$ emissions from enteric fermentation and manure for the selected baseline scenario.

The $CH_4$ baseline emissions for the National Dairy Methane Reduction Programme over the assessment period are estimated and shown in **Figure 5.3**. Annual GHG emissions are the sum of enteric fermentation and manure GHG emissions for all cattle categories. Using the values determined in **Table 5.10** and **Table 5.11** for time t, the total emissions equal 3,543.25 Gg $CO_2e$.

Refer to this guide's assessment toolkit for additional tools to conduct emission calculations, such as the IPCC Inventory Software.

Figure 5.3. **Total baseline emissions from enteric fermentation and manure**

### 5.3.4 Calculate policy emissions

The user should utilise the same methods to estimate emissions for both the optimistic and conservative mitigation scenarios with some amendments. The calculations are demonstrated for the National Dairy Methane Reduction Programme below.

#### Enteric fermentation

In this example, **Equation 5.5** is used to determine the adjusted emission factor. DMI is adjusted down by 10.6 percent to account for improved forage quality of a similar percentage (Arndt et al., 2022). Therefore, the $EF_{Mit}$ is adjusted by 10.6 percent from the default value and the adjusted $EF_{Mit}$ is used in the calculations.

Equation 5.5. **Adjusted emission factor for enteric fermentation for policy scenarios (2019 Refinement, Volume 4, Chapter 10, Eq. 10.21a)**

$$EF_{Mit} = DMI_{Adj} \times \left(\frac{MY}{1000}\right) \times 365$$

Where:

| | |
|---|---|
| $EF_{Mit}$ | = reduced emission factor (kg $CH_4$/head/yr) |
| $DMI_{Adj}$ | = dry matter intake, adjusted downwards for higher feed quality (kg DMI/day) |
| $MY$ | = methane yield, kg $CH_4$/kg DMI (Table 10.12 of the 2019 Refinement) |
| 1000 | = conversion from g $CH_4$ to kg $CH_4$ |
| 365 | = days per year |

**Equation 5.6** is then used to calculate enteric fermentation emissions under the policy scenarios.

Equation 5.6. **Methane emissions from enteric fermentation for policy scenarios (2019 Refinement, Volume 4, Chapter 10, Eq. 10.19)**

$$CH_{4 Enteric\ Mit} = EF_{Mit} \times \left(\frac{N}{10^6}\right) \times (Adoption\%)$$

Where:

| | |
|---|---|
| $CH_{4\ Enteric\ Mit}$ | = enteric fermentation $CH_4$ emissions (kg $CH_4$/yr) for mitigation scenarios |
| $EF_{Mit}$ | = reduced $CH_4$ emission factor (kg $CH_4$/head/yr) |
| $EF$ | = $CH_4$ emission factor (kg $CH_4$/head/yr) |
| $N$ | = livestock population |
| $10^6$ | = conversion from kg $CH_4$ to Gg $CH_4$ |
| $Adoption\%$ | = percentage of farms implementing changes |

For each policy scenario, emissions are calculated for each year and each livestock category and summed. Annual emissions are a sum of emissions from livestock population affected by mitigation actions and emissions from livestock managed without mitigation measures.

### Manure management

**Equation 5.7** is used to calculate manure emissions under the policy scenarios. In this example, the emission factor is adjusted down by 50 percent to account for changes in manure management (Huque et al., 2017) from the default value, and the adjusted $EF_{Mit}$ is used in the calculations.

Equation 5.7. **Manure $CH_4$ emissions for policy scenarios (2019 Refinement, Volume 4, Chapter 10, Eq. 10.22)**

$$CH_{4\ Manure\ Mit} = \left(\frac{N \times VS \times AWMS \times EF_{Mit}}{1000}\right) \times (Adoption\%)$$

Where:

| | |
|---|---|
| $CH_{4\ Manure\ Mit}$ | = manure $CH_4$ emissions (kg $CH_4$/yr) for mitigation scenarios |
| *N* | = livestock population |
| *VS* | = average volatile solids excreted per head of species (kg VS/head/yr) (see Eq. 5.3) |
| *AWMS* | = fraction of total annual VS managed in each animal waste management system |
| $EF_{Mit}$ | = reduced $CH_4$ emission factor (g $CH_4$/kg VS) |
| 1000 | = conversion from g $CH_4$ to kg $CH_4$ |
| *Adoption %* | = percentage of farms implementing changes |

For each policy scenario, emissions are calculated for each year and each livestock category and summed. Annual emissions are a sum of emissions from livestock population affected by mitigation actions and emissions from livestock managed without mitigation measures.

Emission reductions observed in the policy scenarios are due to the assumptions described in detail in previous sections (see **Table 5.5**). To summarise, the main parameters that change in the policy scenarios are:

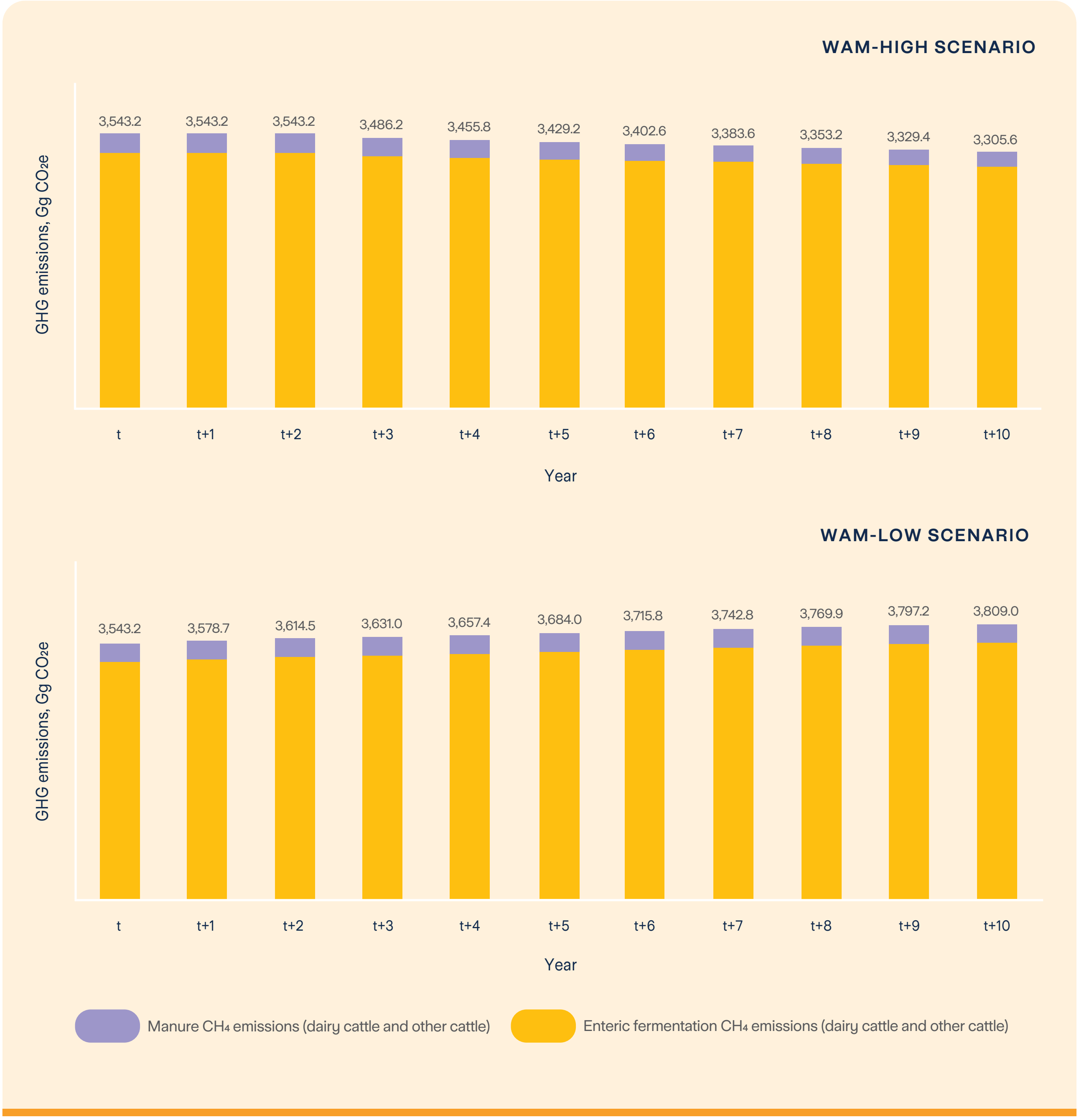
- Adoption rate of mitigation measures by the farmers and associated proportion of solid manure stored covered. In the WAM-HIGH scenario, by the end of the assessment period, 80 percent of all farmers participating in the policy will implement changes on the farms, while in the WAM-LOW scenario, 25 percent of all farmers participating in the policy will implement changes on the farms.

- Dairy cattle population changes as a result of improved production efficiency. In the WAM-HIGH scenario, the dairy cattle population will remain constant. In the WAM-LOW scenario, the dairy cattle population will continue to increase, but at 1 percent instead of the baseline of 3 percent.

- Emission rates reductions are associated with improved forage (10.6 percent) and reduced storage time (50 percent).

Users can also plot the emissions over time to visualise relative magnitudes of each emission source and how it changes over time under the policy scenario. The WAM emission trends for the National Dairy Methane Reduction Programme are shown in **Figure 5.4**. Annual GHG emissions are the sum of enteric fermentation and manure GHG emissions for all cattle categories for each policy scenario.

Figure 5.4. **Total WAM-HIGH and WAM-LOW scenario emissions from enteric fermentation and manure**



### 5.3.5 Calculate GHG emissions impact

After calculating emissions for baseline and policy implementation scenarios, the user can determine the effect of the policy on GHG emissions. The GHG emission change achieved by the policy is determined by subtracting GHG emissions at time t+10 for the policy scenario(s) from the baseline scenario. The percent reduction is determined relative to GHG emissions at the start of the policy, at time t.

As summarised in **Table 5.12**, the National Dairy Methane Reduction Programme is expected to reduce national dairy cattle $CH_4$ emissions by 952.9 – 1,456.2 Gg $CO_2e$ by the end of the policy implementation period relative to WOM scenario. Emissions in WAM-LOW are reduced by 952.9 Gg $CO_{22}e$ compared to the WOM scenario. Emissions in WAM-HIGH are reduced by 1,456.2 Gg $CO_2e$ compared to the WOM scenario.

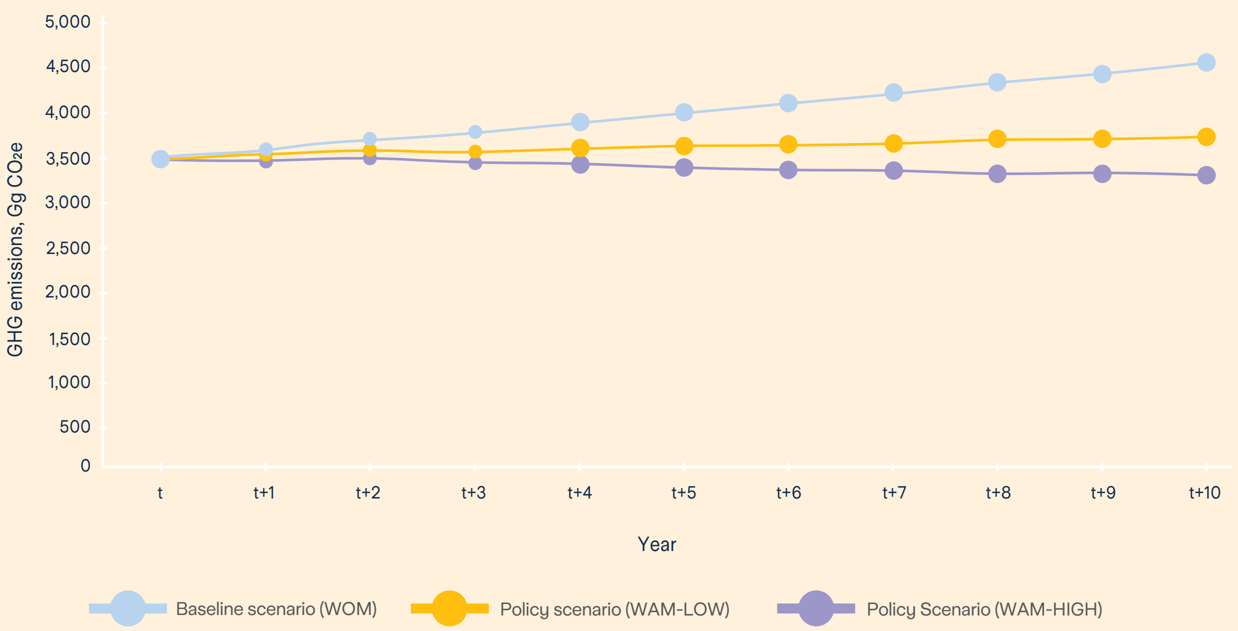
Table 5.12. **$CH_4$ emission reductions from manure and enteric fermentation for policy period for optimistic implementation (WAM-HIGH), and conservative mitigation (WAM-LOW) scenarios**

| Emission source | Policy impact | Reference calculation | WAM-HIGH | WAM-LOW |
|---|---|---|---|---|
| Enteric fermentation | Enteric fermentation $CH_4$ (Gg $CO_2e$) reduction at the end of the assessment period compared to WOM | $WOM_{t+10} - WAM_{t+10}$ | 1,306 | 864.4 |
| | Percent change from enteric fermentation at the end of the assessment period compared to time t | $\frac{WAM_{t+10} - WAM_t}{WAM_t}$ | 5.3% | -8.1% |
| Manure management | Manure $CH_4$ (Gg $CO_2e$) reduction at the end of the assessment period compared to WOM | $WOM_{t+10} - WAM_{t+10}$ | 150.1 | 88.4 |
| | Percent reduction from manure emissions at the end of the assessment period compared to time t | $\frac{WAM_{t+10} - WAM_t}{WAM_t}$ | 25% | 0.6% |
| Enteric fermentation and manure management | Total $CH_4$ emissions (Gg $CO_2e$) reduction at the end of the assessment period compared to WOM | $WOM_{t+10} - WAM_{t+10}$ | 1,456.2 | 952.86 |
| | Percent change in national dairy emissions mitigated at the end of the assessment period compared to time t | $\frac{WAM_{t+10} - WAM_t}{WAM_t}$ | 6.7% | -7.5% |

Changes in pasture management practices such as rotational grazing and fencing, resulting in increased pasture quality and therefore reduced DMI, are expected to result in a 6.7 percent emission reduction by the end of the policy implementation period under the optimistic policy scenario, WAM-HIGH as shown in **Table 5.12**. Under the conservative policy scenario, WAM-LOW, even though the total reductions are reduced by the end of the policy implementation period, there is still a 7.5 percent increase in GHG emissions compared to emissions at the start of the policy implementation period, The time trend of emissions for baseline and policy scenarios is shown in **Figure 5.5.**

The results of the assessment show that a 6.7 percent reduction in emissions can be achieved in the optimistic scenario and a 7.5 percent increase in emissions is projected in the conservative scenario. Following the assessment, monitoring performance over time will allow policymakers to evaluate whether measures are reaching projected reductions. Policy design could be refined by evaluating whether policy instruments employed by the policy are effective to reach intended reduction targets (i.e., technical assistance content, format, frequency, or the incentive payment levels could be adjusted).

Figure 5.5. **Projected emission trends for baseline and policy scenarios over time**




For additional guidance on refining policy design, including financial considerations, refer to Appendix A on implementation potential.

## 5.4 Monitoring policy performance

### 5.4.1 Policy key performance indicators

#### Determine livestock categories and population

Users should identify a set of key performance indicators (KPIs) to evaluate policy performance over time. KPIs should include both GHG impact, as well as non-GHG metrics that allow tracking of inputs, activities, intermediate effects, or market effects reflecting policy implementation steps and outcomes beyond GHG mitigation.

As part of tracking progress in policy implementation, it is helpful to set targets or anticipated levels for policy KPIs, which can inform further assumptions for estimating the policy's mitigation potential and identify corrective actions.

The proposed KPIs for the National Dairy Methane Reduction Programme are classified into three main categories. These are: policy impacts, intermediate effects, and inputs and activities.

Policy impact is evaluated relative to the start of the policy implementation period with the following KPIs as outlined in **Table 5.13**.

Refer to Section 2.5.1 for an overview and example of KPIs. These are documented during the policy description step of the assessment (**Table 5.1**). If a measure is to be included in country's NDC and KPIs will be used for NDC implementation tracking, the users should make sure that KPIs fulfil the minimum requirements as specified in the modalities, procedures, and guidelines (MPGs) (UNFCCC, 2018)

Table 5.13. **Policy impact KPIs for the National Dairy Methane Reduction Programme**

| Key performance indicator | Target | Achievement goal |
|---|---|---|
| $CH_4$ emissions reduction | 35% reduction, relative time t | Year t+10 |
| $CH_4$ emissions intensity per unit of milk production | No target; decrease in $CH_4$ emissions is expected | Years t+1 – t+10 |

Additional KPIs are used to evaluate intermediate effects associated with production and manure management to help evaluate if policy inputs and activities are leading to expected results. These KPIs are outlined in **Table 5.14**.

Furthermore, inputs and activities KPIs are tracked to assess policy costs, incentive levels (e.g., per year, quarter, etc.), and other operational activities of the policy. For instance, extension services will have regular budget expenditures to conduct workshops, farm visits, and manage flagship farms. Frequently tracking these KPIs, including incentives distribution, helps determine where adjustments might be needed. For instance, incentive payment levels might need to be adjusted up to increase practice adoption or down to improve cost-effectiveness. These KPIs are summarised in **Table 5.15**.

Table 5.14. **Policy intermediate effects KPIs for the National Dairy Methane Reduction Programme**

| Key performance indicator | Target | Achievement goal |
|---|---|---|
| Proportion of farmers with verified implementation of new manure management practices | 50% of national dairy farmers | Year t+10 |
| Manure storage time | Implementing farmers average storage time: 15 days<br>National average storage time: 45 days | Year t+10 |
| Proportion of solid manure stored with covers | 20% of all manure stored as solid | Year t+10 |
| EMMA survey response rate | 50% response rate | Year t+10 |
| Technical assistance workshop attendance | 75% of national dairy farmers | Year t+10 |

Table 5.15. **Policy intermediate effects KPIs for the National Dairy Methane Reduction Programme**

| Key performance indicator | Target | Achievement goal |
|---|---|---|
| Spend rate of Extension services operational budget to conduct workshops, farm visits, and manage flagship farms | No fixed target. Target updates at the beginning of each quarter according to budget allocation | Q1-Q4; Years t+1 – t+10 |
| EMMA survey incentives | No fixed target. Target updates at the beginning of each year according to budget allocation | Years t+1 – t+10 |
| Value of incentive payments disbursed | No fixed target. Target updates at the beginning of each year according to budget allocation | Years t+3 – t+10 |
| Technical assistance workshops conducted | 18 workshops per year | Years t+2 – t+6 |

The user can also include additional KPIs to evaluate the impact of the policy on SDGs or other interacting activities or policies identified in Section 5.1.6. Examples for the National Dairy Methane Reduction Programme may include increased sanitation and decreased odour or reductions in water pollution from inefficient manure application.

### 5.4.2 Monitoring plan

The users should develop a monitoring plan for tracking the progress of the policy. For the National Dairy Methane Reduction Programme, the national leadership team developed a monitoring plan and will oversee implementation, documentation, and the process of coordinating with all stakeholders.

To conclude the assessment process, the guidance on summarising the results of the assessment, as well as considering next steps, is in Chapter 9.

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# Chapter 6: Assessing Fertiliser Policy Impact

PART III. Assess Policy | Chapter 5 | Chapter 6 | Chapter 7 | Chapter 8

6.1 Fertiliser policy description and GHG impacts | 6.2 Methodological considerations | 6.3 Estimating GHG emissions | 6.4 Monitoring policy performance

This chapter describes how to conduct a GHG impact assessment for nitrogen fertiliser management policies. Prior to the assessment, the user has become familiar with key methodological and reporting concepts, identified relevant stakeholders, and considered the objectives of conducting the assessment. The user has also selected a policy for assessment, reviewed the measures likely to be included in the policy, and became familiar with the data types they need to conduct the assessment.

Refer to Part I and Part II for guidance on planning for the assessment and policy selection and description steps if needed.

This chapter demonstrates the methodologies using hypothetical policy examples, implemented in a hypothetical country, which is described in the Hypothetical Country section of this guide. The example policy National Urea Fertiliser Policy (contained in the hypothetical National Agriculture Policy Act of 2020) is assessed. The policy includes the mitigation measure of applying urea, a synthetic nitrogen fertiliser, in two split applications. The user should assess the GHG impact of a selected policy with the guidance provided in this chapter and follow the steps described in this simplified yet realistic example.

Changes in agricultural practices can result in both negative and positive environmental impacts. Increased cropping and animal husbandry can lead to soil nutrient deficits. Increasing fertiliser application is a viable mechanism for bolstering soil productivity. Increased fertiliser application and associated production reduce malnutrition, increase farmer income, and contribute to the export of strategic agricultural commodities while increasing GHG emissions and other environmental pollution. Many governments are implementing policies to encourage the application of synthetic fertilisers, such as urea, to address the soil nutrient deficit. To meet the targets of international climate agreements, countries can consider amending existing or adopting new policies that mitigate nitrous oxide ($N_2O$) emissions, the primary GHG associated with fertiliser applications.

## 6.1 Fertiliser policy description and GHG impacts

### 6.1.1 Policy assessment objectives

Users should identify stakeholders affected by the policy and those to be engaged during the policy assessment's planning phase. The stakeholder groups relevant to the National Urea Fertiliser Policy are noted in **Table 6.1.**

Refer to the ICAT *Stakeholder Participation Guide* in this guide's assessment toolkit. This guide's Appendix B contains additional guidance and resources on stakeholder engagement.

Further, users should identify assessment objectives before starting the assessment. For the purpose of assessing the National Urea Fertiliser Policy, policymakers identified assessment objectives and held a series of stakeholder consultations to refine the initial assessment objectives.

The main policy assessment objectives are listed below:

- Quantify GHG emissions from split application of urea fertiliser application on annual crops
- Inform capacity needed for delivery of the technical assistance
- Build support for additional mitigation measures to be adopted by the decision-makers and farmers
- Track progress toward national goals such as NDCs and sustainable development goals
- Report domestically or internationally, including under the Paris Agreement's enhanced transparency framework, on the impacts of policies achieved to date

### 6.1.2 Policy description

When starting the assessment, the users should describe the policy in detail. In this chapter's example, the hypothetical country adopted The National Agriculture Policy Act of 2020, which established the National Livestock Methane Reduction Programme (described in Chapter 5) and the National Urea Fertiliser Policy. The mitigation measure implemented by the National Urea Fertiliser Policy optimises fertiliser application, which reduces fertiliser emissions through split application of urea fertiliser. The description of the National Urea Fertiliser Policy is in **Table 6.1**.

> Refer to Chapter 4 for more information on the process for describing the policy and the Templates section for the template for policy description. To effectively carry out an impact assessment, it is necessary to have a detailed understanding and description of the policy being assessed.

Table 6.1. **Description of the National Urea Fertiliser Policy**

| Policy description category | Detailed description |
|---|---|
| Name of the policy* | National Urea Fertiliser Policy |
| Type of policy instrument* (Note: refer to Section 3.2.2 for policy instrument types and description) | Subsidies and incentives<br>Research, development, and deployment |
| Description of specific interventions* | The National Urea Fertiliser Policy focuses on optimising the application of urea fertiliser and encourages an increase in the proportion of urea fertiliser applied to crops through split application by:<br><br>▪ Conducting research to develop practice standards for the split application of urea on farms and a country fertility map<br>▪ Developing and providing demonstrations and field days in partnership with both the private sector and Non-Government Organisations (NGOs) to visualise the impact of split application fertilisers on flagship farms<br>▪ Conducting farm visits to provide technical assistance to farmers and verify compliance<br>▪ Providing financial incentives to offset operational costs for split application of fertiliser<br><br>The main policy implementation mechanisms are research and technical assistance (research, development, and deployment) and provision of financial incentives (subsidies and incentives), coupled with verification of activities. Extension agents will monitor the implementation of management plans when conducting farm visits. |
| Status of the policy* | Planned. The funding for the policy was authorised in the National Agriculture Policy Act of 2020 to start in 2025 |
| Date of implementation* | 2025 |
| Date of completion* (if relevant) | 2035 |
| Implementing entity* or entities | Ministry responsible for Agriculture |

Table 6.1. **Description of the National Urea Fertiliser Policy (Continued)**

| Policy description category | Detailed description |
|---|---|
| Objectives and intended impacts or benefits of the policy* | Introduce and promote the adoption of sustainable urea fertiliser use to all farmers to improve the environment, economy, and food security of the nation. Specifically:<br>▪ Increase the evidence base of country-specific knowledge of urea fertiliser use<br>▪ Develop country-specific emission factors and best practice standards for split application of urea fertiliser for annual crops<br>▪ Reduce potential $N_2O$ emissions from urea fertiliser use<br>▪ Improve water quality by managing potential N leaching and reducing nitrogen loss through runoff |
| Level of the policy | National |
| Policy inputs | ▪ Funding allocation to support:<br>  ▪ Funding for research activities<br>  ▪ Personnel to provide technical assistance<br>  ▪ Incentives (USD 500/farmer) for demonstrated changes in practice Note: incentive levels based on available funding allocations, a typical cost of implementing practices, and expert judgement from survey design professionals<br>▪ Expertise to administer the programme, including:<br>  ▪ Development of practice standard<br>  ▪ Field days and demonstration events<br>  ▪ Farm site visits and technical assistance |
| Policy activities | ▪ Establish programme administrative infrastructure<br>▪ Develop technical practice standards for split urea application<br>▪ Conduct field days and demonstrations at flagship farms<br>▪ Provide technical assistance to farmers |
| Geographic coverage | Agricultural land with annual crops (excluding rice), approximately 60,000 ha |
| Subsectors affected* | Fertiliser management |
| Greenhouse gases affected* | Direct and indirect $N_2O$; Note: splitting of urea application will not affect $CO_2$ emission from urea application |
| Other related policies or actions | Policies affecting manure management practices should be considered if manure is used as fertiliser. Although this policy changes the use of synthetic fertiliser only, manure $N_2O$ emissions from soils should be accounted for when assessing $N_2O$ emissions from agricultural soils. |

Table 6.1. **Description of the National Urea Fertiliser Policy (Continued)**

| Policy description category | Detailed description |
|---|---|
| Intended level of mitigation to be achieved and/ or target level of other indicators (if relevant)* | The mitigation target of the National Urea Fertiliser Policy is to reduce $N_2O$ emissions from fertiliser application by 20% by the end of the implementation period in year 2035.<br><br>The target level of uptake for the policy is lower in the first 5 years due to the initial period being mainly used for research on best practices of split application of urea application specific to the country. Therefore, the intended targets are:<br>▪ 10% of urea fertiliser amount on annual crops applied in split application by 2030<br>▪ 50% of urea fertiliser amount on annual crops applied in split application by 2035 |
| Key stakeholders | ▪ Farmers<br>▪ Two key national Farmers Cooperatives<br>▪ Producer associations<br>▪ Education and research institutions: e.g., National Livestock & Agriculture Research Institute<br>▪ Suppliers of agricultural inputs and equipment<br>▪ National government agencies: e.g., Ministry responsible for Agriculture, Ministry responsible for Water Resources<br>▪ Regional and local government entities<br>▪ Government entities responsible for agriculture and livestock management: e.g., Department of Agriculture Extension and Department of Livestock Services of the Ministry responsible for Agriculture<br>▪ Ministry responsible for the Environment, in charge of coordinating the National Agriculture Inventory<br>▪ Communities, indigenous peoples, or marginalised groups that are involved in or are affected by agriculture<br>▪ Financial institutions |
| Title of establishing legislation, regulations, or other founding documents | The National Agriculture Policy Act of 2020 |
| Monitoring, reporting and verification procedures | Annual farm visits are conducted by agricultural extension agents to 50% of farms each year on a rotational basis to provide technical assistance to and audit those farms. |

Table 6.1. **Description of the National Urea Fertiliser Policy (Continued)**

| Policy description category | Detailed description |
| --- | --- |
| Policy Key Performance Indicators (KPIs) | The proposed KPIs for the National Urea Fertiliser Policy include:<br>▪ $N_2O$ emissions<br>▪ Practice standard developed<br>▪ Technical assistance field days conducted<br>▪ Technical assistance field day attendance<br>▪ Proportion of urea amount applied using split application<br>▪ Spend rate of Extension services operational budget to conduct demonstrations, field days, and farm visits<br>▪ Spend rate on research activities<br>▪ Value of incentive payments disbursed<br>KPIs and associated target levels are discussed in more detail in Section 6.4.1 |
| Compliance and enforcement mechanisms | Participation in the programme is voluntary. The split application of urea is part of a conservation standard. Farmers that choose to purchase urea fertiliser will be subject to monitoring and will be required to provide an annual report with management information to the government, which will be reviewed and approved by extension agents. Incentives will be provided to farmers upon verification of practice implementation (through auditing of farm plans) and can be back-dated to the previous year. As 50% of farmers will be audited each year, incentives will be paid out biennially for individual farms when practices are verified. |
| Reference to relevant documents | Practice standards for split application will be developed and referenced in the policy procedures. Relevant information materials will be created for distribution to farmers. |
| The broader context or significance of the policy | To maximise agricultural production, it is vital that optimal soil nutrition levels are provided. However, historically soil nutrition has been depleted due to the removal of nutrients through various agricultural practices. Applying urea fertiliser is an effective way to begin addressing the imbalance of soil nutrients. Nitrogen, however, is a source of $N_2O$ and water pollution and therefore the use of N fertiliser use needs to be carried out sustainably. Split application of urea fertiliser, while not mitigating all $N_2O$ emissions, will reduce the potential for water quality degradation and $N_2O$ emissions. The recommendations for how the split application is carried out need to be based on country-specific agricultural/environmental conditions to ensure the greatest benefit. |
| Outline of sustainable development impacts of the policy | Water quality, food security, nutrient efficiency, strengthening rural community. |
| Other relevant information | If this policy is successful, increased knowledge of sustainable nutrient management practices will support further mitigation measures that reduce emissions and improve production. It is also likely to reduce water pollution, optimise nutrient use efficiency, and potentially increase crop yield. |

*Indicates required reporting under the Enhanced Transparency Framework under the Paris Agreement

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### 6.1.3 Intermediate effects and GHG impacts

Once the policy is described, the users must document how all the inputs, activities, and intermediate effects lead to changes in behaviour, technology, processes, or practices. Outlining these changes includes understanding which parameters are affected, what is the direction and magnitude of the effect, and where and when this effect is expected to take place.

This process helps to determine the policy scenario needed for the quantification of GHG impacts. Affected parameters may include market-based parameters such as increased labour costs, decreased reliance on synthetic fertilisers, increased fuel use, and market access. The inputs, activities, and intermediate effects of the National Urea Fertiliser Policy are summarised in **Table 6.2.**

Refer to Chapter 4 for more information on the process for describing the policy intermediate effects and GHG impacts and the Templates section for the table templates for assessing intermediate effects and GHG impacts.

Table 6.2. **Inputs, activities, intermediate effects (changes in behaviour, technology, processes or practices) of the National Urea Fertiliser Policy**

*(I)=input, (A)=activity, (IE)=intermediate effect*

| Inputs, activities, intermediate effects | Detail/ explanation | Affected parameter | Direction | Magnitude | Geographic location | Timing |
|---|---|---|---|---|---|---|
| (I) Funding is allocated | Resources for the policy, funding and staff, are allocated | Policy activities can be implemented | NA | USD 10 M | National | Starts when policy is adopted, renewed after 5 years |
| (A) Admin-istrative system is established | Procedures are established to manage research funding, technical assistance activities, reporting and auditing | Policy operational management system is put in place, knowledge generated for devel-opment of conservation standards and practice guidance | NA | To be determined in year 1 | National and regional | Year 1 |

Table 6.2. **Inputs, activities, intermediate effects (changes in behaviour, technology, processes or practices) of the National Urea Fertiliser Policy. (Continued)**

| Inputs, activities, intermediate effects | Detail/ explanation | Affected parameter | Direction | Magnitude | Geographic location | Timing |
|---|---|---|---|---|---|---|
| (A) Conduct research and data collection, develop best practice guidance | Country-specific research is conducted to establish practice standards for split application of fertilisers | Knowledge is generated to support transition to improved practices | NA | To be determined in year 1 | National, regional focus based on conditions | Year 2 - 3 |
| (A) Extension agents prepare and deliver technical assistance programme for farmers | Technical assistance to include demonstration and field days and site visits to support adoption of the split application practice standard | Farmers are motivated to adopt new fertiliser application practices | Increase | 144 field days, 3 per year at each of 6 flagship farms | National w/ region or crop relevant recommendations | Year 3-10 |
| (IE) Farmers develop individual farm plans based on split application practice standard with support from extension services | Farmers receive recommendations to change fertiliser application practices when extension agents conduct farm visits | Famers develop new management plans that meet new fertiliser standard | Increase | 50% of farmers by 2035 | National | Year 3-10 |

Table 6.2. **Inputs, activities, intermediate effects (changes in behaviour, technology, processes or practices) of the National Urea Fertiliser Policy. (Continued)**

| Inputs, activities, intermediate effects | Detail/ explanation | Affected parameter | Direction | Magnitude | Geographic location | Timing |
|---|---|---|---|---|---|---|
| (IE) Farmers apply fertiliser according to the split application fertiliser standards | Using knowledge gained, application of fertiliser is applied to land following country-specific practice standards; this intermediate effect is a mitigation measure in the policy | Cropland where split application practices are utilised | Increase | 10% of urea applied in split application by 2030<br>50% of urea applied in split application by 2035 | National | Year 3-10 |
| (IE) Extension agents conduct farm visits to verify practices | Extension agents will audit practices for compliance with standards so farmers can receive incentives | Practices are verified | Increase | 50% of farmers by 2035 | National | Year 3-10 |
| (IE) Machinery use increase | Due to increased frequency of application, farmers increase use of machinery | Increased fuel use | Increase | 40-50% increase in machinery use, depending on crop type | National | Year 3-10 |
| (IE) Fuel consumption increase | Due to increased frequency of application, farmers increase use of machinery | Emissions from fuel combustion | Increase | 40-50% increase in fuel consumption | National | Year 3-10 |
| (IE) Production costs increase | Due to increased equipment use and fuel consumption, production expenses increase | Farmer operational costs* | Increase | 20% increase in operational costs | National | Year 3-10 |

*indicates intermediate effects that are policy mitigation measures

**indicates market-based impacts

Once the policy inputs, activities, and intermediate effects are documented, as shown in **Table 6.2,** the user can analyse which of those lead to changes in GHG emissions and further detail the steps that describe how the changes in GHG emissions occur.

The user should also consider and identify whether the effects associated with policy activities are intended or unintended (Rich, 2014). Intended effects are based on the original objectives of the policy. However, as mentioned in the previous section, intended effects may have trade-offs in emissions. Unintended effects typically represent effects that fall outside of the policy's control and may amplify or diminish the impact of the policy. The GHG impacts associated with the National Urea Fertiliser Policy are summarised in **Table 6.3** below.

Following the example, users should be able to outline the intermediate effects and GHG impacts of the selected policy.

It is a key recommendation to work with agriculture experts during this part of the assessment step to analyse intermediate effects and identify potential GHG impacts of the policy.

Table 6.3. **GHG Impacts of the intermediate effects of the National Urea Fertiliser Policy**

| Intermediate effect* | Subsequent intermediate effects | | | Potential GHG impact |
|---|---|---|---|---|
| | Effect 1 | Effect 2 | Effect 3 | |
| Split application of urea fertiliser | Reduction in free N in soil | - | - | Decreased direct $N_2O$ emissions |
| | Reduction in free N in soil | Reduction in N leaching and $NH_3$ volatilisation | - | Decreased indirect $N_2O$ emissions |
| | Increase in labour and equipment use | Increase in fuel consumption from increased equipment use | - | Increased $CO_2$ emissions |

*indicates intermediate effects that are policy mitigation measures

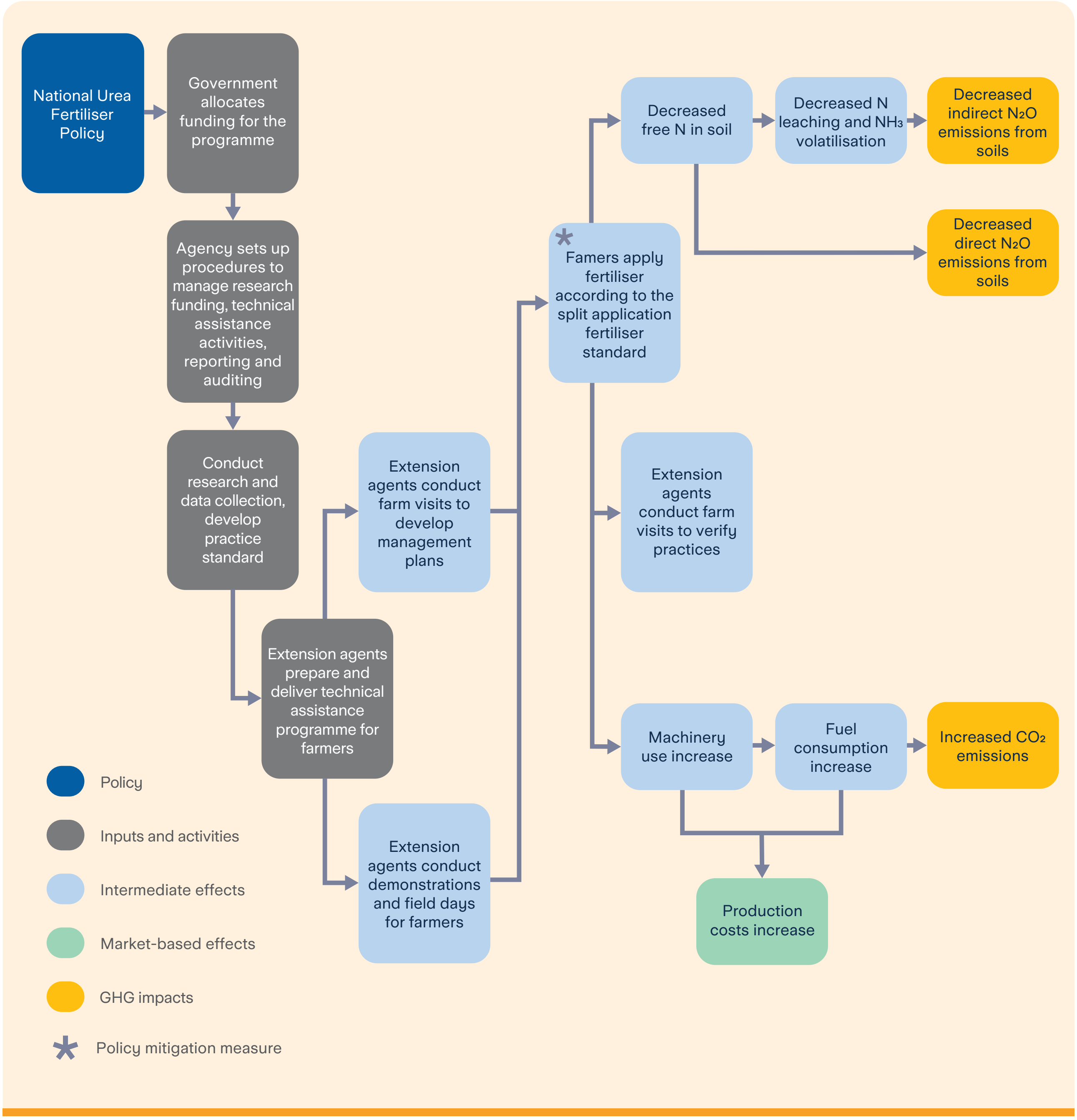
### 6.1.4 Causal chain

A causal chain is a conceptual diagram tracing the process by which the policy leads to GHG impacts through a series of interlinked logical and sequential stages of cause-and-effect relationships. In parallel with the identification of intermediate effects and GHG impacts, the user should prepare a causal chain to better understand, visualise, and communicate how the policy and its corresponding inputs and activities cause intermediate effects and ultimately result in GHG impacts. The causal chain is a visual representation of the information about the policy from **Tables 6.2** and **Table 6.3**. It can also help reveal interdependencies between and the order of implementation of the different activities under the policy which is more challenging to visualise in a table format. The causal chain for the National Urea Fertiliser Policy is shown in **Figure 6.1**.

Visualising the policy causal chain is likely to lead to the refinement of the information listed in **Table 6.2** and **Table 6.3.** The causal chain can be a useful tool for engaging stakeholders in understanding policy design and its effects.

Refer to the Templates section for a template to develop a causal chain following the demonstrated example.

Figure 6.1. **The National Urea Fertiliser Policy causal chain**



### 6.1.5 Assessment boundary and period

#### Policy Assessment Boundary

Once all the potential GHG impacts are identified, the user will determine which ones will then be included in the assessment boundary. Determining the policy assessment boundary includes a three-part process of estimating:

- the likelihood of GHG impact
- the expected relative magnitude of GHG impact
- the significance of each GHG impact

The user should then select which impacts will be estimated within the assessment boundary. Typically, the user has a limited number of resources to conduct the assessment. This three-part estimation helps the user to prioritise assessing impacts that are likely and major in size. Impacts considered very likely, likely, or possible in combination with their GHG impact being either moderate or major are significant and should be included in the assessment boundary.

For the National Urea Fertiliser Policy, all of the GHG impacts identified in **Table 6.3** are considered. The results of this process are outlined in **Table 6.4**. Changes in direct and indirect $N_2O$ emissions from soils from urea split application are determined as significant and included in the assessment boundary.

Even though the magnitude of impact on indirect $N_2O$ emissions due to split application is initially unknown, the steps to calculate indirect emissions are included in subsequent sections to demonstrate the methodology. For the purpose of the example, at the start of the assessment period, the relative magnitude of the change is expected to be moderate. The National Urea Fertiliser Policy is designed so that the research conducted in the first three years of the policy implementation period can inform country-specific emission factors development. These emission factors then can be used in a subsequent assessment in the middle of the policy implementation period, in particular to calculate changes in indirect $N_2O$ emissions. Emissions from increased fuel consumption are expected to be minor in magnitude and would be reported under the Energy sector. Despite increased fuel emissions, overall GHG emission reduction is expected.

Users should evaluate the intermediate effects and GHG impacts of the selected policy and determine the assessment boundary following the example. For policies that have unintended effects on other agricultural emissions sources such as soil carbon sequestration (i.e., increased productivity of pasture when fertiliser is applied to land other than cropland), users may also refer to Chapter 7 for soil carbon impact assessment. If land use change occurs as a result of the policy, such as conversion of forest to cropland, users may also refer to the ICAT *Forest Methodology* to estimate associated GHG impacts. Furthermore, assessing unintended effects that fall outside the AFOLU sector (e.g., emissions from fuel consumption) is outside the scope of this guide.

Refer to Chapter 4 for guidance on determining the significance of GHG impacts and the Templates section for templates to determine assessment boundary.

Table 6.4. **Likelihood, magnitude, and significance of GHG impacts of the National Urea Fertiliser Policy**

| Mitigation measure | GHG impact | Likelihood | Relative magnitude | Significance |
|---|---|---|---|---|
| Split application of urea fertiliser | Decreased direct $N_2O$ emissions | Very likely | Moderate | Significant |
| | Decreased indirect $N_2O$ emissions | Likely | Moderate | Significant |
| | Increased $CO_2$ emissions from increased fuel consumption | Likely | Minor | Not estimated (outside scope) |

### Policy Assessment Period

Users should also determine the assessment period that will be used. The example policy, the National Urea Fertiliser Policy, is adopted in 2020 and its implementation begins in 2025. This assessment period is ex-ante and covers the duration of the policy, which is 10 years, from years 2025 to 2035. An additional assessment is planned for the mid-point of the policy implementation period and evaluates areas where policy adjustments and improvements are necessary. The mid-point ex-post assessment captures GHG impacts from actions taken by early adopters of the policy. For the purpose of the example, assessment is being conducted at time t and the assessment period is t – t+10 (years 2025 – 2035).

## 6.1.6 Other policy synergies and interactions

Users should qualitatively describe potential policy synergies and interactions. Quantitative assessment of interacting policies is beyond the scope of this guide; however, it is important to identify them to better inform future policy decisions and consider evaluating them in more detail in the future. Adoption of other agricultural policies and programmes that aim to optimise fertiliser use in the country may have additional synergistic impacts or may result in trade-offs that counter the emission reduction achieved by the National Urea Fertiliser Policy.

For the National Urea Fertiliser Policy, there are three potential notable policy interactions. The policy may lead to increased fuel consumption due to an increase in application frequency. This may impact any planned policies in the Energy sector, focusing on energy efficiency measures for off-road machinery. Further, the policy may lead to improvements in water quality as the more efficient use of fertiliser through split application may reduce nitrogen pollution and have an impact on associated environmental policies. Finally, fertiliser management and agricultural residue management practices can affect soil GHG emissions. Retaining crop residue can help reduce the need for synthetic fertiliser as it enhances nutrient cycling from the soil. This is especially relevant in areas where organic farming is practiced requiring the use of organic fertilisers such as manure or compost.

The use of synthetic fertiliser is likely to increase in the future to meet the demand in food and feed production and counter threats from floods and droughts, therefore, optimising and managing the use of synthetic fertiliser will be a critical component of climate adaptation strategies.

Describing the policy and identifying policy interactions lays the groundwork for a more detailed evaluation of policy interactions or non-GHG policy impacts, for example, sustainable development, which the user may conduct in addition to the GHG impact assessment.

Refer to the WRI's Policy and Action Standard in this guide's assessment toolkit for additional resources on assessing policy interactions. Furthermore, refer to the ICAT *Sustainable Development Methodology* for additional resources for assessing sustainable development impacts.

After completing the policy description, the user is ready to quantify the GHG emissions impacted by the policy.

## 6.2 Methodological Considerations

### 6.2.1 Methodology for assessing GHG emissions

Users should determine which methodological tier to apply in their assessment based on data availability. This guide recommends reviewing the country's GHG inventory to identify which methodological tier was utilised, because it may highlight the level of data characterisation potentially applicable for use within the assessment. Initially, data availability is the main factor in selecting the calculation tier. If it is determined that emissions constitute a key source category based on key category analysis as described in the IPCC 2006 GL, the country will need to invest in further data collection to use a higher calculation tier. The emissions associated with fertiliser application are reported in CRT 3D, in GHG Inventory categories 3.D.1 and 3.D.2, for direct and indirect $N_2O$ emissions, respectively, under the ETF reporting requirements.

The methodology in this guide is based on the IPCC 2006 GL and 2019 Refinement. The policy assessment example uses methods, equations, default values, and parameters from the 2019 Refinement.

For the purpose of assessing the National Urea Fertiliser Policy, country-specific emission factors are not available, therefore, aggregated default parameters are used. Tier 1 is used to estimate the baseline scenario emissions, in the absence of mitigation measures. To capture changes associated with mitigation measures such as split application, adjustments to emission factors are necessary. Studies on similar systems are used to adjust default emission factors to reflect changes associated with split fertiliser application. Therefore, a simplified Tier 2 method is used to estimate policy scenario emissions when mitigation measures are implemented.

Nitrous oxide emissions can either occur directly (i.e., atmospheric $N_2O$ is produced from the N applied to soils) or indirectly (i.e., nitrogen goes through a chemical or physical transformation such as volatilisation and leaching first, before being converted to atmospheric $N_2O$). Both direct and indirect $N_2O$ emissions are estimated using the same methodological tier.

When converting $N_2O$ emissions to emissions expressed in $CO_2e$, users should, to ensure consistency, utilise the same GWP as the one used in their current national GHG inventory.

Refer to the 2019 Refinement for National GHG Inventories, Volume 4, Chapter 11 Figures 11.2 and 11.3 in this guide's assessment toolkit to view the tier decision trees for further guidance on choice of method. When estimating emissions from synthetic N fertiliser, Tier 1 and Tier 2 methodologies are the same but Tier 2 methodology uses country-specific emissions factors. Utilising Tier 2 or Tier 3 should result in more accurate estimates.

### 6.2.2 Baseline scenario

The user will need to establish a baseline scenario to estimate GHG emissions without mitigation measures.

First, the user should estimate how much urea fertiliser is applied to agricultural soils in the absence of mitigation measures. Urea application can be estimated from the total amount of urea consumed annually. Fertiliser consumption data may be available from the country's national statistics, often recorded as fertiliser sales.

Users can use **expert judgement** from sector experts for estimates of future urea fertiliser use in addition to, or in lieu of, historical data and projections related to demand in crop production and fertiliser consumption.

For the purpose of assessing the National Urea Fertiliser Policy, the baseline scenario is termed the scenario without measures (WOM) and is summarised in **Table 6.5**. Given that the amount of cropland used for annual crops affected by this policy is not expected to change, a constant baseline approach is used. Land under each annual crop is not expected to change during the assessment period. The urea fertiliser application rate at the beginning of the implementation period is 109 kg/ha/yr applied at sowing time and is expected to remain unchanged (African Development Bank, 2019). The baseline scenario assumes there would otherwise be no changes in technology, land use, management practices, and levels of production without the National Urea Fertiliser Policy.

Based on consultations with agricultural experts and extension agents, these assumptions are reasonable. For the calculations in this chapter, aggregated IPCC default emission factors for $N_2O$ emissions are used, therefore there is no requirement to stratify land by soil type or climatic conditions.

Refer to Section 2.3 for an overview of approaches to constructing a baseline.

Refer to this guide's assessment toolkit for resources on baseline projections and potential data sources such as the World Bank Open Data to inform baseline scenario.

### 6.2.3 Policy scenario

The user needs to establish a policy scenario to estimate GHG emissions with mitigation measures.

For the purpose of assessing the National Urea Fertiliser Policy, the policy scenario is termed scenario with additional measures (WAM). Three policy scenarios are selected for assessment to explore potential outcomes and refine the development and delivery of technical assistance:

- High adoption level of recommended practices, WAM-HIGH
- Medium adoption level of recommended practices, WAM-MED
- Low adoption level of recommended practices, WAM-LOW

The policy target is to have 50 percent of urea fertiliser applied via split application by the end of the policy implementation period. WAM-HIGH, WAM-MED, and WAM-LOW scenarios assume 75 percent, 50 percent and 25 percent, respectively, of urea fertiliser is applied with split application to reflect scenarios where adoption rates vary. All policy scenarios assume that urea fertiliser is applied at the rate of 109 kg/ha/yr in two applications (African Development Bank, 2019). The split application parameters are based on crops' needs. **Table 6.5** outlines the key assumptions for each scenario.

Assumptions regarding farmer level of uptake of practices are based on consultation with extension agents. Expected participation and adoption levels are based on the delivery of technical assistance in other programmes. A farmer survey was conducted to determine the current urea application rates. Peer-reviewed studies served as a basis for determining emission reduction rates for mitigation measures under the policy.

Refer to Appendix A for additional guidance on estimating the implementation potential of a policy. Note that users can assess one or more policy scenarios to help refine policy design.

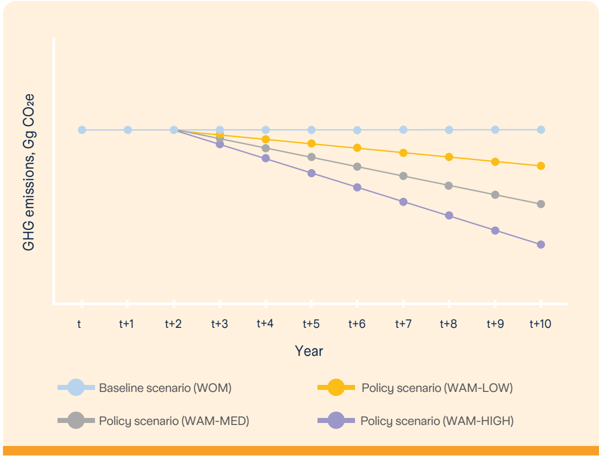
Table 6.5. **Key assumptions for assessment scenarios**

| Assumption | WOM | WAM-LOW | WAM-MED | WAM-HIGH |
|---|---|---|---|---|
| Cropland with annual crops (ha) | 58,246 | 58,246 | 58,246 | 58,246 |
| Urea fertiliser application rate on annual crops per year (kg/ha/yr) | 109 | 109 | 109 | 109 |
| Proportion of urea fertiliser amount applied on annual crops by split application method by 2035 | 0% | 25% | 50% | 75% |
| Application frequency per year | 1 | 2 | 2 | 2 |
| Application timing | Sowing | Sowing/ boosting | Sowing/ boosting | Sowing/ boosting |
| Split application direct $N_2O$ emission factor reduction* | - | -59% | -59% | -59% |

*Schwenke and Haigh, 2019

A conceptual diagram of the policy impact is demonstrated in **Figure 6.2** for the example with three policy scenarios included in the assessment.

Figure 6.2. **Conceptual diagram showing the relationship between baseline and policy scenario emissions**




### 6.2.4 Data for assessment

The users need to identify activity data and parameters needed to conduct the assessment and specify, to the extent possible, the sources of the data. To assess $N_2O$ emissions from agricultural land in the national GHG inventory, emission sources of direct $N_2O$ include synthetic N fertiliser, organic N fertiliser (manure, compost, etc.), urine and dung deposited on pasture by grazing animals, crop residues, N mineralisation when soil organic matter is lost, and drainage of organic soils. For the National Urea Fertiliser Policy, only the use of urea fertiliser is affected. Because urea is a type of synthetic fertiliser, emission estimations are only demonstrated for synthetic N fertiliser inputs. In addition, assessment is limited to the urea applied to annual crops. In the national GHG Inventory, $N_2O$ emissions from all synthetic N fertilisers applied to all agricultural land are calculated. Users will need to identify which sources of $N_2O$ emissions are affected by the policy being assessed and conduct additional calculations to include relevant fertiliser types in their assessment.

The information needed to conduct the GHG impact assessment and associated sources for the National Urea Fertiliser Policy are outlined in **Table 6.6**. Activity data used in this example are summarised in the Hypothetical Country section of the guide.

The area of land in each of the annual crops and their corresponding proportion of total cropland is determined with the country's GHG inventory. The total urea sold in the country is sourced from the national fertiliser industry association. Country-specific emission factors and parameters are to be developed as part of the National Urea Fertiliser Policy research initiative and to be used in an interim assessment of this policy (year t+5) and, subsequently, for the national inventory as reported to the UNFCCC.

Activity data and emission factors used in the calculations are presented in the following sections.

Refer to the Technical Supplement for relevant activity data and emission parameters needed for quantifying GHG emissions associated with fertiliser mitigation measures for both Tier 1 and Tier 2 methods.

Table 6.6. **Sources of data for fertiliser GHG emission estimation**

| Data type | Data sources |
|---|---|
| Area of land under annual crop production and total agricultural area where urea fertiliser is applied | Land use data is available in the Land Use change section of the GHG Inventory, originally sourced from the national agriculture survey and validated by national experts. See Chapter 7 for additional guidance on how to stratify land. If national data is not available, data can also be obtained from FAO's database, FAOSTAT. |
| Application rate and method by climate zone, soil type, and application method | National agriculture survey data and expert judgement can be used to characterise nutrient management practices in the country. Data can also be obtained from the International Fertiliser Association database, IFASTAT, or FAO's database, FAOSTAT. |
| Amount of urea fertiliser applied annually to agricultural land | National sales records for urea fertiliser, validated by expert judgement as the same amount as applied. If policy affects all land where urea fertiliser is applied, the amount of urea fertiliser applied annually can be used without determining areas of agricultural land area and the application rate |
| N content of fertiliser applied | ▪ Fertiliser specifications |
| Amount of N applied | ▪ Information derived from the amount of fertiliser applied and its N content |
| Emission factors and parameters, by climate and fertiliser type where applicable | Default Tier 1 parameters come from 2019 Refinement, Volume 4, Chapter 11:<br>▪ Synthetic fertiliser, $EF_1$: Table 11.1<br>▪ Volatilisation emission factor, $EF_4$: Table 11.3<br>▪ Volatilisation fraction, $Frac_{GASF}$: Table 11.3<br>▪ Leaching emission factor, $EF_5$: Table 11.3<br>▪ Leaching fraction, $Frac_{LEACH}$: Table 11.3<br>For country-specific emission factors, refer to IPCC Emission Factor Database |
| Conversion factor | 2019 Refinement, to convert $N_2O$-N to $N_2O$ emissions, 44/28 |
| GWP | 100-year GWP for $N_2O$: IPCC Fifth Assessment Report, or as in national GHG inventory, as in national GHG inventory |

Once the user determines the methods to be used for emissions calculations and describes baseline and policy scenarios with associated data parameters needed, GHG emissions can be calculated.

After completing the policy description, the user is ready to quantify the GHG emissions impacted by the policy.

## 6.3 Estimating GHG emissions

### 6.3.1 Compile activity data

#### Stratify land

The user needs to stratify land by land use sub-categories and management to determine areas of cropland affected by the policy, using IPCC land-use categorisation and management practices.

Users should identify land categories affected by the policy scenario in addition to noting the total land area where fertiliser is applied. For mitigation measures that impact annual and/or perennial crops, the affected land category would be cropland. For mitigation measures that involve pasture, the affected land category would be grassland. For the National Urea Fertiliser Policy, the land area used for annual crops (except rice) is summarised in **Table 6.7.** Refer to the Hypothetical Country section of the guide for description of land data.

> Refer to Section 4.2, Affected land category for additional guidance on land stratification.

Table 6.7. **Land area used for annual crop production stratified by climate, soil, and cropping system at the start of the assessment period, time t**

| Climate zone | Management category | Crop rotation | Area (ha) |
|---|---|---|---|
| Tropical dry | Annual crops | Corn-soy-alfalfa-alfalfa | 23,738 |
| Tropical dry | | Wheat | 18,183 |
| Tropical dry | | Cassava-beans | 8,586 |
| Tropical dry | | Wheat | 2,309 |
| Tropical dry | | Cassava-beans | 1,195 |
| Tropical dry | | Vegetables | 4,235 |
| Tropical dry | Total annual crops | All crop rotations | 58,246 |

### Characterise inputs

The user needs to categorise the amount and type of N inputs used in production.

Generally, the amount of synthetic fertiliser applied can be based on total fertiliser sales statistics in the country (if policy impacts fertiliser use on all land where fertiliser is applied) or based on application rates for particular land uses or cropping systems for particular fertiliser types. Disaggregating by climate conditions is needed to be able to utilise disaggregated emission factors, which improves the accuracy of the calculations.

For the National Urea Fertiliser Policy, only emissions from urea fertiliser application on annual crops are affected by the policy activities. Climate zone is listed for information even though aggregated emission factors are used in the example calculations. Once country-specific emissions factors are developed, they may be applied to calculate $N_2O$ emissions from land in different climatic zones. The annual application rate for urea in the hypothetical country is 109 kg/ha/yr (African Development Bank, 2019). Using this information and the land area estimated above, the amount of urea applied and the associated amount of N applied to soil is determined and summarised in **Table 6.8**.

When assessing a policy, users should estimate the amount of N applied to soils for all types of N inputs used in the system to make sure all potential sources of emissions are included in the assessment.

Refer to the 2019 Refinement in this guide's assessment toolkit for more information on $N_2O$ emissions from agricultural soils. The $N_2O$ agricultural emissions result from soil N inputs, organic soil management, and dung and urine from grazing animals. Nitrogen inputs can be due to the application of synthetic fertiliser, organic amendments (manure, compost, etc.), crop residue, and/or mineralisation associated with soil disturbance. All should be accounted for if they occur within the policy assessment boundary.

Table 6.8. **Fertiliser N characteristics at the start of assessment period, time t**

| Parameter | Units | Value |
|---|---|---|
| Synthetic fertiliser | | Urea (N) |
| Application rate | kg/ha/yr | 109 |
| N content | % | 46%* |
| Annual N application rate | kg N/ha/yr | 50.1 |
| Area | ha | 58,246 |
| Annual amount of synthetic fertiliser N applied to soils | kg N/yr | 2,920,454.4 |

*based on molecular weight of N in urea

### 6.3.2 Choose emission factors and parameters

To estimate emissions, the user will need to choose emission factors and parameters for direct and indirect emissions for each climate type or fertiliser type used.

To assess the National Urea Fertiliser Policy, aggregated Tier 1 default emissions factors are used in the baseline scenario to calculate direct and indirect $N_2O$ emissions. This is due to limitations in the availability of data to adjust emission factors in the policy scenario. The emission factors to estimate direct $N_2O$ emissions from split fertiliser application, estimated from literature and **expert judgement**, do not differentiate between climate conditions. Therefore, aggregated emission factors were used for all direct and indirect $N_2O$ emission calculations to maintain consistency.

Users may consider conducting the assessment with disaggregated Tier 1 emission factors or Tier 2 emission factors as data becomes available.

For the purpose of assessing the National Urea Fertiliser Policy, until country-specific emission factors and parameters are developed through the research under the policy, default values are used, with the exception of the emission factor to estimate direct $N_2O$ emissions under the mitigation scenarios. Under the policy scenario, the emission factors related to direct $N_2O$ emissions are adjusted by 59 percent based on literature (Schwenke and Haigh, 2019). The parameters used in the assessment are summarised in **Table 6.9**. Since information regarding adjusted emission factor for direct $N_2O$ emissions is not available for different climate conditions, all other default emissions used are aggregated.

Users should compile activity data and identify emission factors to be used in the assessment calculations described in the following sections.

Table 6.9. **Emission parameters used for the National Urea Fertiliser Policy emission calculations**

| Emission factors and other parameters | Value | Data source |
|---|---|---|
| Direct $N_2O$ emission factor | $EF_1$: 0.01 kg $N_2O$–N/kg N (aggregated) | 2019 Refinement, Volume 4, Chapter 11, Table 11.1 |
| Indirect $N_2O$ emission factor, volatilisation | $EF_4$: 0.01 kg $N_2O$–N /kg $NH_3$–N + $NO_x$–N volatilised (aggregated) | 2019 Refinement, Volume 4, Chapter 11, Table 11.3 |
| Indirect $N_2O$ emission factor, leaching | $EF_5$: 0.011 kg $N_2O$–N/kg N leaching/runoff | |
| Fraction of synthetic N that volatilises | $Frac_{GASF}$: 0.15 kg $NH_3$–N + NOx–N)/kg N applied (disaggregated based on fertiliser type - urea) | |
| Fraction of all N that leaches | $Frac_{LEACH}$: 0.24 kg N/kg N additions or deposition by grazing animals | |
| Conversion factor | To convert $N_2O$-N to $N_2O$ emissions, 44/28 | 2019 Refinement, Volume 4, Chapter 11 |
| GWP | $N_2O$: 265 | 100-year GWP for $N_2O$: IPCC Fifth Assessment Report, or as in national GHG inventory |

### 6.3.3 Calculate baseline emissions

Users should use the data reflecting the baseline scenario to calculate baseline emissions. The full equation for direct $N_2O$ emissions in the 2019 Refinement is presented in Equation 6.1.

Depending on the types of soils and N inputs that are affected by the policy being assessed, the user might need to calculate all or some of the terms in this equation. To assess the National Urea Fertiliser Policy, only the terms relevant to synthetic N fertiliser use, FSN, are applied.

Equation 6.1. **Direct $N_2O$ emissions from managed soils (2019 Refinement, Volume 4, Chapter 11, Eq. 11.1)**

$$N_2O_{Direct} - N = N_2O - N_{N\,inputs} + N_2O - N_{OS} + N_2O - N_{PRP}$$

Where:

$$N_2O - N_{N\,inputs} = (F_{SN} + F_{ON} + F_{CR} + F_{SOM}) \times EF_1 + (F_{SN} + F_{ON} + F_{CR} + F_{SOM})_{FR} \times EF_{1FR}$$

$$N_2O - N_{OS} = \left[\left(F_{OS,CG,Temp} \times EF_{2CG,Temp}\right) + \left(F_{OS,CG,Trop} \times EF_{2CG,Trop}\right) + \left(F_{OS,F,Temp,NR} \times EF_{2F,Temp,NR}\right) + \left(F_{OS,F,Temp,NP} \times EF_{2F,Temp,NP}\right) + \left(F_{OS,F,Trop} \times EF_{2F,Trop}\right)\right]$$

$$N_2O - N_{PRP} = \left(F_{PRP,CPP} \times EF_{3PRP,CPP}\right) + \left(F_{PRP,SO} \times EF_{3PRP,SO}\right)$$

Where:

$N_2O_{Direct}–N$ = annual direct $N_2O$–N emissions produced from managed soils, kg $N_2O$–N/yr

$N_2O–N_{N\,inputs}$ = annual direct $N_2O$–N emissions from N inputs to managed soils, kg $N_2O$–N/yr

$N_2O–N_{OS}$ = annual direct $N_2O$–N emissions from managed organic soils, kg $N_2O$–N/yr

$N_2O–N_{PRP}$ = annual direct $N_2O$–N emissions from urine and dung inputs to grazed soils, kg $N_2O$–N/yr

$F_{SN}$ = annual amount of synthetic fertiliser N applied to soils, kg N/yr

$F_{ON}$ = annual amount of animal manure, compost, sewage sludge and other organic N additions applied to soils, kg N/yr

$F_{CR}$ = annual amount of N in crop residues (above-ground and below-ground), including N-fixing crops, and from forage/pasture renewal, returned to soils, kg N/yr

$F_{SOM}$ = annual amount of N in mineral soils that is mineralised, in association with loss of soil C from soil organic matter as a result of changes to land use or management, kg N/yr

$F_{OS}$ = annual area of managed/drained organic soils, ha (Note: the subscripts $_{CG, F, Temp, Trop, NR}$ and $_{NP}$ refer to Cropland and Grassland, Forest Land, Temperate, Tropical, Nutrient Rich, and Nutrient Poor, respectively)

$F_{PRP}$ = annual amount of urine and dung N deposited by grazing animals on pasture, range and paddock, kg N/yr (Note: the subscripts $_{CPP}$ and $_{SO}$ refer to Cattle, Poultry and Pigs, and Sheep and Other animals, respectively)

$EF_1$ = emission factor for $N_2O$ emissions from N inputs, kg $N_2O$–N/kg N input

$EF_{1FR}$ = is the emission factor for $N_2O$ emissions from N inputs to flooded rice, kg *$N_2O$–N/kg N input*

$EF_2$ = emission factor for $N_2O$ emissions from drained/managed organic soils, kg $N_2O$–N/(ha*yr). (Note: the subscripts $_{CG, F, Temp, Trop, NR}$ and $_{NP}$ refer to Cropland and Grassland, Forest Land, Temperate, Tropical, Nutrient Rich, and Nutrient Poor, respectively) *See guidance in 2013 Supplement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories: Wetlands, Chapter 2, Table 2.5 where further disaggregation by climate and land use is available.*

$EF_{3PRP}$ = emission factor for $N_2O$ emissions from urine and dung N deposited on pasture, range and paddock by grazing animals, kg $N_2O$–N/kg N input (Note: the subscripts $_{CPP}$ and $_{SO}$ refer to Cattle, Poultry and Pigs, and Sheep and Other animals, respectively)

Based on the full equation for direct $N_2O$ emissions, in Equation 6.1, the equation to calculate direct $N_2O$ emissions for the National Urea Fertiliser Policy is simplified to the applicable parameters in **Equation 6.2**.

Equation 6.2. **Direct $N_2O$ emissions from synthetic fertiliser (2019 Refinement, Volume 4, Chapter 11, Eq. 11.1 adapted to include only the synthetic fertiliser term)**

$$N_2O_{Direct} - N = F_{SN} \times EF_1$$

Where:

| | |
|---|---|
| $N_2O_{Direct} - N$ | = annual direct $N_2O$-N emissions produced from synthetic fertiliser, kg $N_2O$–N/yr |
| $F_{SN}$ | = annual amount of synthetic fertiliser N applied to soils, kg N/yr |
| $EF_1$ | = emission factor for $N_2O$ emissions from synthetic N fertiliser, kg $N_2O$–N/kg N input |

Indirect $N_2O$ emissions are calculated using **Equation 6.3** and **Equation 6.4**. **Equation 6.3** determines indirect emissions due to N volatilisation from the soil. **Equation 6.4** determines indirect emissions from leaching/runoff.

Equation 6.3. **Indirect $N_2O$ emissions from synthetic fertiliser volatilisation (2019 Refinement, Volume 4, Chapter 11, Eq. 11.9)**

$$N_2O_{ATD} - N = \left[(F_{SN} \times Frac_{GASF}) + \left((F_{ON} + F_{PRP}) \times Frac_{GASM}\right)\right] \times EF_4$$

Where:

| | |
|---|---|
| $N_2O_{ATD}$ | = annual amount of $N_2O$–N produced from atmospheric deposition of N volatilised from managed soils, kg $N_2O$–N/yr |
| $F_{SN}$ | = annual amount of synthetic fertiliser N applied to soils, kg N/yr |
| $Frac_{GASF}$ | = fraction of synthetic fertiliser N that volatilises as $NH_3$ and NOx, kg N volatilised/kg of N applied |
| $F_{ON}$ | = annual amount of managed animal manure, compost, sewage sludge and other organic N additions applied to soils, kg N/yr |
| $F_{PRP}$ | = annual amount of urine and dung N deposited by grazing animals on pasture, range and paddock, kg N/yr |
| $Frac_{GASM}$ | = fraction of applied organic N fertiliser materials ($F_{ON}$) and of urine and dung N deposited by grazing animals ($F_{PRP}$) that volatilises as $NH_3$ and NOx, kg N volatilised/kg of N applied or deposited |
| $EF_4$ | = emission factor for $N_2O$ emissions from atmospheric deposition of N on soils and water surfaces, kg N– $N_2O$/(kg $NH_3$–N + NOx–N volatilised) |

Equation 6.4. **Indirect $N_2O$ emissions from synthetic fertiliser leaching (2019 Refinement, Volume 4, Chapter 11, Eq. 11.10)**

$$N_2O_{LEACH} - N = (F_{SN} + F_{ON} + F_{PRP} + F_{CR} + F_{SOM}) \times Frac_{LEACH} \times EF_5$$

Where:

| | |
|---|---|
| $N_2O_{LEACH-N}$ | = annual amount of $N_2O$–N produced from atmospheric deposition of N volatilised from managed soils, kg $N_2O$–N/yr |
| $F_{SN}$ | = annual amount of synthetic fertiliser N applied to soils kg N/yr |
| $F_{ON}$ | = annual amount of managed animal manure, compost, sewage sludge and other organic N additions applied to soils in regions where leaching/runoff occurs, kg N/yr |
| $F_{PRP}$ | = annual amount of urine and dung N deposited by grazing animals in regions where leaching/runoff occurs, kg N/yr |
| $F_{CR}$ | = amount of N in crop residues (above- and below-ground), including N–fixing crops, and from forage/pasture renewal, returned to soils annually in regions where leaching/runoff occurs, kg N/yr |
| $F_{SOM}$ | = annual amount of N mineralised in mineral soils associated with loss of soil C from soil organic matter as a result of changes to land use or management in regions where leaching/runoff occurs, kg N/yr |
| $Frac_{LEACH}$ | = fraction of synthetic fertiliser N added to managed soils in regions where leaching/runoff occurs that is lost through leaching and runoff, kg N/kg of N applied |
| $EF_5$ | = emission factor for $N_2O$ emissions from N leaching and runoff, kg $N_2O$–N /kg N leached and run-off |

Only $F_{SN}$ terms in **Equation 6.3** and **Equation 6.4** are evaluated because the National Urea Fertiliser policy affects only the amount of N from synthetic fertiliser applied to soils. Urea's direct and indirect $N_2O$ emissions are calculated for each year in the assessment period following the example in **Table 6.10**. The $N_2O$–N is converted to $N_2O$ and then to $CO_2e$. Full calculations are demonstrated in the Technical Supplement available for download. Note that manual calculations with rounded values as displayed in **Table 6.10** may result in different values than full calculations in the Technical Supplement.

Table 6.10. **Sample $N_2O$ calculations for urea for baseline scenario (WOM) at the start of assessment period, time t**

| Parameter (units) | Description | Value or calculated value |
|---|---|---|
| *Direct $N_2O$ emissions* | | |
| *$EF_1$* (kg $N_2O$–N/kg N) | Default emission factor | 0.01 |
| *$F_{SN}$* (kg N/yr) | Derived from activity data (**Table 6.8**) | 2,920,454 |
| *$N_2O_{Direct}$–N* (kg $N_2O$-N/yr) | $N_2O$-N emissions, **Eq. 6.2** | *$F_{SN}$* x *$EF_1$* = 29,205 |
| *Total direct $N_2O$ emissions* (kg) | $N_2O$ emissions (kg) | *$N_2O_{Direct}$–N* x 44/28 = 45,893 |
| *Total direct $N_2O$ emissions* (Gg $CO_2e$) | Emissions expressed in $CO_2e$ (Gg) | *Direct $N_2O$ emissions x 265 = 12.16* |
| *Indirect $N_2O$ emissions - volatilisation* | | |
| *$EF_4$* (kg $N_2O$–N/kg $NH_3$–N + NOx–N volatilised) | Default emission factor | 0.01 |
| *$Frac_{GASF}$* (kg $NH_3$–N + NOx–N/kg N applied) | Default emission factor | 0.15 |
| *$N_2O_{ATD}$–N* (kg $N_2O$–N/yr) | $N_2O$-N emissions, **Eq. 6.3** | *$FS_N$ x $Frac_{GASF}$ x $EF_4$* = 4,381 |
| *Total indirect $N_2O$ emissions* (kg) | $N_2O$ emissions (kg) | *$N_2O_{ATD}$–N x 44/28* = 6,884 |
| *Total indirect $N_2O$ emissions* (Gg $CO_2e$) | Emissions expressed in $CO_2e$ (Gg) | *Indirect $N_2O$ emissions x 265= 1.82* |
| *Indirect $N_2O$ emissions – leaching/runoff* | | |
| *$EF_5$* (kg $N_2O$–N/kg $NH_3$–N + NOx–N volatilised) | Default emission factor | 0.011 |
| *$Frac_{LEACH}$* (kg $NH_3$–N + NOx–N/kg N applied) | Default emission factor | 0.24 |
| *$N_2O_{LEACH}$*–N (kg $N_2O$–N/yr) | $N_2O$-N emissions, **Eq. 6.4** | *$F_{SN}$ x $Frac_{LEACH}$ x $EF_4$* = 7,710 |
| *Total indirect $N_2O$ emissions* (kg) | $N_2O$ emissions (kg) | *$N_2O_{ATD}$–N* x 44/28 = 12,116 |
| *Total indirect $N_2O$ emissions* (Gg $CO_2e$) | Emissions expressed in $CO_2e$ (Gg) | *Indirect $N_2O$ emissions x 265 = 3.21* |
| *Total annual $N_2O$ emissions from urea application* | | |
| Total annual $N_2O$ emissions (Gg $CO_2e$) | Emissions expressed in $CO_2e$ | Total annual $N_2O$ emissions (Gg) *= 12.16 + 1.82 + 3.21 = 17.2* |

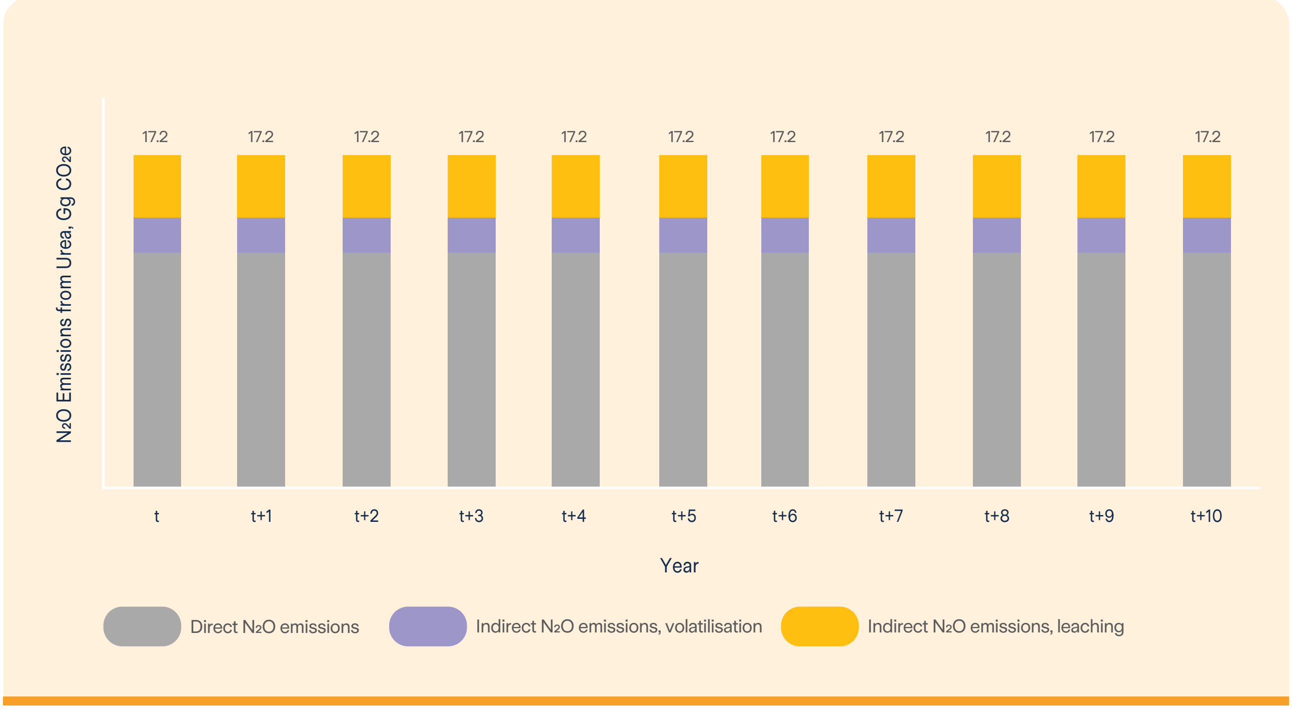
| **Conversion factors** | |
|---|---|
| Molecular weight ratio, $N_2O$–N to $N_2O$ | 44/28 |
| Unit conversion, kg to Gg | $10^{-6}$ |
| $N_2O$ GWP | 265 |

Because the baseline scenario assumes that no changes are made to the area of cropland under annual crop production during the assessment period, the estimated amount of $N_2O$ is projected to remain constant over the assessment period. Users can plot the emissions over time to visualise relative magnitudes of each emission type and how it changes over time. The baseline emission trend for the National Urea Fertiliser Policy is shown in **Figure 6.3**. Annual GHG emissions from urea application are a sum of direct and indirect $N_2O$ emissions from soil. Using the values determined in **Table 6.10** for time t, the total emissions equal 17.2 Gg $CO_2e$.

The user can follow the example calculations to estimate direct and indirect $N_2O$ emissions from urea for the selected baseline scenario.

Refer to this guide's assessment toolkit for additional tools to conduct emission calculations, such as the IPCC Inventory Software.

Figure 6.3. **Total direct and indirect $N_2O$ baseline emissions**



### 6.3.4 Calculate policy emissions

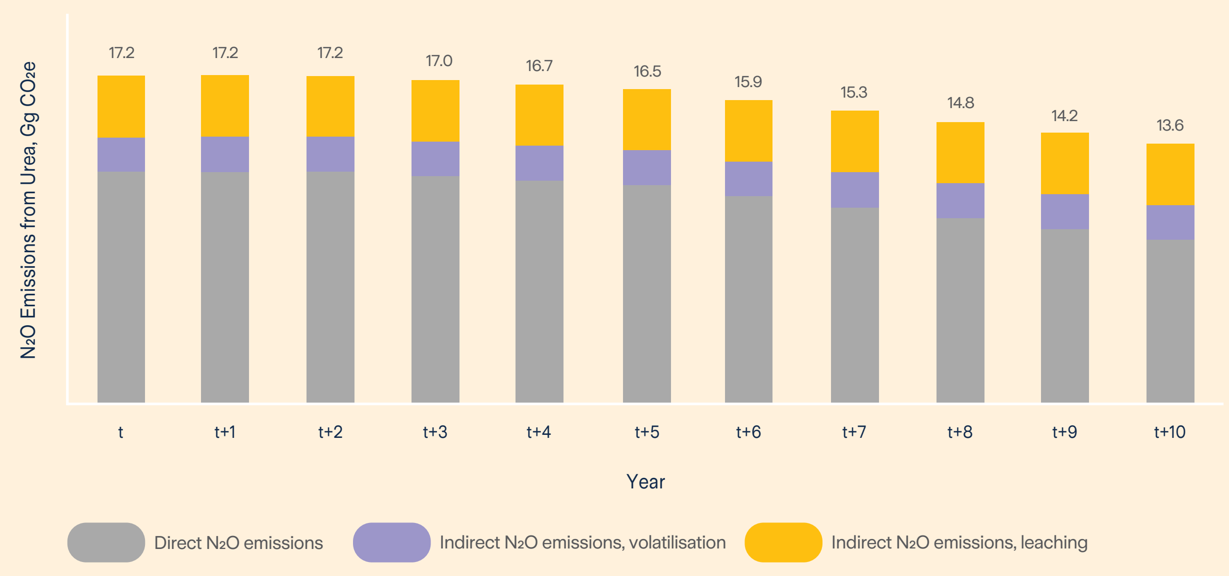
The same methods and equations used for estimating emissions for the baseline are used for the policy scenarios. However, the emission factor for direct $N_2O$ emissions, EF1, is adjusted down by 59 percent from the default value to reflect the split application fertiliser practice (Schwenke and Haigh, 2019). When calculating emissions under the policy scenario, emissions for the proportion of fertiliser that is applied with split application are calculated using the adjusted emission factor, while emissions from the fertiliser applied using the same single application are calculated using the same emission factors as in the baseline calculation. They are summed to determine total annual emissions.

Emission reductions observed in the policy scenarios are due to the assumptions described in detail in previous sections (see **Table 6.6**). To summarise, the main parameter that changes in the policy scenarios is the adoption rate of mitigation measures by the farmers.

- In the WAM-HIGH scenario, 15 percent of urea to be applied by split application by t+5, while by the end of the assessment period (t+10), 75 percent of urea to be applied by split application.
- The WAM-MED scenario represents the intended level of mitigation to be achieved, which is 10 percent by time t+5 and 50 percent by time t+10.
- In the WAM-LOW scenario, only 5 percent of farmers will implement changes by time t+5 and 25 percent of all farmers will implement changes on farms by time t+10.

Users can also plot the emissions over time to visualise the relative magnitudes of each emission source and how it changes over time under the policy scenario. The WAM-MED emission trends for the National Urea Fertiliser Policy are shown in **Figure 6.4.** Annual GHG emissions are the sum of direct and indirect $N_2O$ emissions with indirect including both from volatilisation and leaching.

Figure 6.4. **Total policy emissions over time for the WAM-MED scenario**



### 6.3.5 Calculate GHG emission impact

After calculating emissions for baseline and policy scenarios, the user can determine the effect of the policy on GHG emissions. The GHG emission change achieved by the policy is determined by subtracting GHG emissions at time t+10 for the policy scenario(s) from the baseline scenario. The percent reduction is determined relative GHG emissions at the start of the policy, at time t.

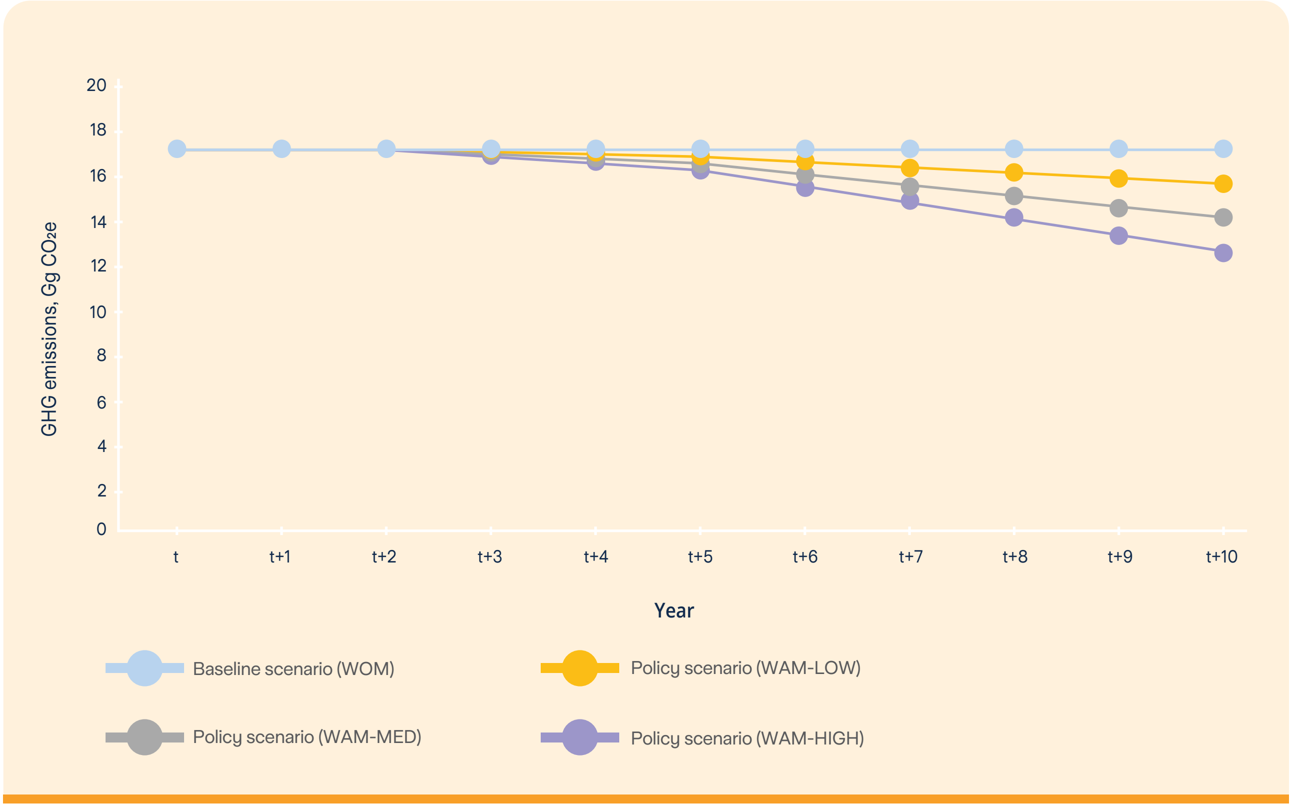
As summarised in **Table 6.11**, the National Urea Fertiliser Policy is expected to reduce national urea $N_2O$ emissions by 1.79 – 5.38 Gg $CO_2e$ over the duration of the policy period depending on the mitigation scenario, corresponding to a 10.4-31.3 percent reduction. The total GHG emissions reduction is calculated by subtracting WAM total GHG emissions at time t+10 from WOM total GHG emissions. The percent reduction is calculated relative to the start of the policy implementation period.

The time trend of emissions for baseline and policy scenarios is shown in **Figure 6.5.**

Table 6.11. **$N_2O$ emission reductions from urea application for the policy period for policy mitigation (WAM) scenarios**

| Policy impact | Reference calculation | WAM-LOW | WAM-MED | WAM-HIGH |
|---|---|---|---|---|
| Total GHG reduction at the end of the assessment period (Gg $CO_2e$) compared to WOM | $WOM_{t+10} - WAM_{t+10}$ | 1.79 | 3.59 | 5.38 |
| Percent GHG reduction at the end of the assessment period compared to time t | $\frac{WAM_{t+10} - WAM_t}{WAM_t}$ | 10.4% | 20.9% | 31.3% |

Figure 6.5. **Projected emission trends for baseline and policy scenarios over time**



Following the assessment, monitoring performance over time allows policymakers to evaluate whether measures are reaching projected reductions. If they are not, the policy could be refined by evaluating whether policy instruments employed by the policy are effective (i.e., technical assistance content, format, frequency, or the incentive payment levels could be adjusted).

Research conducted during the first two years of the policy implementation can provide data to derive country-specific parameters to more accurately evaluate GHG impact, in particular for indirect $N_2O$ emissions from soils, where data is currently lacking.

The user can utilise the same methods to estimate emissions for mitigation scenarios for the selected policy.

For additional guidance on refining policy design, including financial considerations, refer to Appendix A on implementation potential.

## 6.4 Monitoring policy performance

### 6.4.1 Policy key performance indicators

Users should identify a set of key performance indicators (KPIs) to evaluate policy performance over time. KPIs should include both GHG impact as well as non-GHG metrics that allow tracking of inputs, activities, intermediate effects, or market effects reflecting policy implementation steps and outcomes beyond GHG mitigation.

As part of tracking progress in policy implementation, it is helpful to set targets or anticipated levels for policy KPIs, which can inform further assumptions for estimating the policy's mitigation potential and identify corrective actions. The proposed KPIs for the National Urea Fertilisation Policy have been classified into three main categories. These are: policy impacts, intermediate effects, and inputs and activities. The policy impact KPIs are summarised in **Table 6.12.**

Refer to Section 2.5.1 for an overview and example of KPIs. These are documented during the policy description step of the assessment (**Table 6.1**). If a measure is to be included in the country's NDC and KPIs will be used for NDC implementation tracking, the users should make sure that KPIs fulfil the minimum requirements as specified in the modalities, procedures, and guidelines (MPGs) (UNFCCC, 2018).

Table 6.12. **Policy impact KPIs for the National Urea Fertiliser Policy**

| Key performance indicator | Target | Achievement goal |
|---|---|---|
| $N_2O$ emissions | 20% reduction, relative time t | Year 10 |

Additional KPIs are used to evaluate intermediate effects associated with production and manure management to help evaluate if policy inputs and activities are leading to expected results. These KPIs are outlined in **Table 6.13.**

Furthermore, budgetary KPIs will also be tracked to assess policy costs and incentive levels (e.g., per year, quarter, etc.). For instance, extension services will have regular budget expenditures to conduct workshops, or trials. Frequently tracking budgetary KPIs will help determine where adjustments might be needed. These KPIs are summarised in **Table 6.14**.

**Table 6.13. Policy intermediate effects KPIs for the National Dairy Urea Fertiliser Policy**

| Key performance indicator | Target | Achievement goal |
|---|---|---|
| Proportion of urea amount applied using split application | 10%<br>50% | Year 5<br>Year 10 |
| Technical assistance field day attendance | 50% of farmers | Years 3-10 |

**Table 6.14. Policy inputs and activities KPIs for the National Urea Fertiliser policy**

| Key performance indicator | Target | Achievement goal |
|---|---|---|
| Spend rate of t Extension services operational budget to conduct demonstrations, field days, and farm visits | No fixed target. Target updates at the beginning of each quarter according to budget allocation | Q1-Q4; Years 1-10 |
| Spend rate on research activities | No fixed target. Target updates at the beginning of each year according to budget allocation | Years 1-2 |
| Value of incentive payments disbursed | No fixed target. Target updates at the beginning of each year according to budget allocation | Years 3-10 |
| Practice standard developed | Complete with country-specific parameters for GHG estimation | Year 2 |
| Technical assistance field days conducted | 144 field days | Years 3-10 |

The user can also include additional KPIs to evaluate the impact of the policy on SDGs or other interacting activities or policies identified in Section 6.1.6. Examples for the National Urea Fertiliser Policy may include reductions in water pollution from reducing leaching of urea fertiliser.

### 6.4.2 Monitoring plan

The users should develop a monitoring plan for tracking the progress of the policy. For the National Urea Fertiliser Policy, the national leadership team will develop and implement a monitoring plan and oversee documentation and the process of coordinating with all stakeholders.

To conclude the assessment process, the guidance on summarising the results of the assessment, as well as considering next steps, is in Chapter 9.

# Chapter 7: Assessing Soil Carbon Policy Impact



This chapter describes how to assess the GHG impact of policies that influence soil carbon stocks and may result in $CO_2$ removal from the atmosphere. Prior to conducting the assessment, the user has become familiar with key methodological and reporting concepts, identified relevant stakeholders, and considered the objectives of conducting the assessment. The user has also planned for the assessment by selecting a policy to assess, reviewed the measures included in the policy, and has become familiar with the data they will need to conduct the assessment.

Refer to Part I and Part II for guidance on planning for the assessment and policy selection and description steps if needed.

In this chapter, the example policy, the National Conservation Agriculture Policy, is used to demonstrate the assessment process. The policy includes a mitigation measure to reduce soil disturbance through improved tillage practices on annual crops, excluding rice (note, a rice cultivation policy is covered in Chapter 8). The user should assess the GHG impact of a selected policy with the guidance provided in this chapter and follow the steps described in this example.

## 7.1 Soil carbon policy description and GHG impacts

### 7.1.1 Policy assessment objectives

Users should identify stakeholders that should be engaged as a matter of conducting the assessment as well as those affected by the policy. The stakeholder groups relevant to the National Conservation Agriculture Policy are noted in **Table 7.1**.

Users should identify assessment objectives before starting the assessment. For the purpose of the National Conservation Agriculture Policy example, policymakers identified assessment objectives and held a series of stakeholder consultations to refine the initial assessment objectives.

The refined policy assessment objectives were:

- Quantify GHG removals and emissions from improving tillage practices on croplands planted with annual crops
- Evaluate policy effectiveness
- Build support for additional mitigation measures amongst decision-makers and farmers
- Track progress towards achieving national goals, e.g., NDCs
- Report the policy's GHG impact achieved to date domestically and internationally, including under the Paris Agreement's Enhanced Transparency Framework

Refer to the ICAT *Stakeholder Participation Guide* in this guide's assessment toolkit. This guide's Appendix B contains additional guidance and resources on stakeholder engagement.

### 7.1.2 Policy description

As described in Part II, users should have a detailed description of the policy. The full description of the National Conservation Agriculture Policy is shown in **Table 7.1**. In reading this description, users should note that the National Conservation Agriculture Policy was adopted in 2000 and includes a mitigation measure to enhance soil carbon storage by meeting a conservation tillage standard for improved tillage practices and reduced soil disturbance during the cultivation of annual crops. The policy, when initially adopted, focused on enhancing soil carbon through the adoption of reduced-till and no-till methods in accordance with the recently developed conservation standard. At the start of the policy implementation period, all cropland has been managed under full tillage for more than 20 years. As a result, soil carbon stock was in equilibrium and the land was severely degraded.

After meeting the intended adoption targets in 2020, the policy was amended to include additional soil sampling activities to enhance the accuracy of emission estimates and derive country-specific emission factors. These additional research activities do not directly impact GHG emission levels. The policy employs a regulatory mechanism to drive adoption where farmers meeting the tillage conservation standard become eligible for enhanced crop insurance benefits. Compliance targets are increased over the course of the policy implementation period to transition all cropland with annual crops to either reduced-till or no-till management.

Refer to Chapter 4 for more information on the process for describing the policy and the Templates section for the policy description template. To effectively carry out an impact assessment, it is necessary to have a detailed understanding and description of the policy being assessed.

Table 7.1. **Description of the National Conservation Agriculture Policy**

| Policy description category | Detailed description |
|---|---|
| Name of the policy* | National Conservation Agriculture Policy |
| Type of policy* | ▪ Regulation and Standards (adoption of a conservation standard to reduce soil disturbance)<br>▪ Information Instruments (awareness campaign)<br>▪ Research, development, and deployment (soil testing to refine estimates, implementation of practices) |
| Description of specific interventions* | Farmers utilise conservation agriculture on cropland by improving tillage on annual crops. Activities under the policy include:<br>▪ An awareness campaign at the beginning of the implementation period with ongoing communication to farmers regarding policy as long as the policy is in effect<br>▪ Provision of technical assistance to farmers in the form of one-on-one consultations<br>▪ Implementation of reduced-till and/or no-till practices on cropland with annual crops (excluding rice) in accordance with conservation standard<br>▪ Submission of annual reports documenting management activities implemented<br>▪ Farm visits to verify compliance with the rules and conduct soil testing<br>▪ Eligibility for enhanced crop insurance benefits when compliance is achieved |
| Status of the policy* | The funding for the policy was authorised in the National Agriculture Policy Act of 2000, implementation began in 2000 and is ongoing |
| Date of implementation* | 2000, amended in 2020 to include soil testing activities |
| Date of completion* (if relevant) | Ongoing |
| Implementing entity* or entities | Ministry responsible for Agriculture |
| Objectives and intended impacts or benefits of the policy* | Introduce and promote the adoption of conservation agriculture to:<br>▪ Raise awareness about soil health and increase farmers' knowledge regarding improving soil health<br>▪ Improve soil fertility<br>▪ Reduce soil erosion<br>▪ Improve water quality |
| Level of the policy | National |

Table 7.1. **Description of the National Conservation Agriculture Policy (Continued)**

| Policy description category | Detailed description |
|---|---|
| Policy inputs | Funding:<br>▪ Awareness campaign<br>▪ Extension agents' labour costs<br>▪ Soil testing laboratory analysis<br><br>Expertise:<br>▪ Conservation tillage practice standard<br>▪ Dedicated extension agents in each region will provide technical support, conduct farm visits, and collect and analyse soil data<br>▪ Dedicated staff to implement a national awareness campaign |
| Policy activities | ▪ Ministry responsible for Agriculture: plan and implement a national awareness campaign to launch and support policy implementation; ensure extension agencies have sufficient staff and expertise to carry out their activities.<br>▪ Extension agencies: provide technical assistance to farmers to support adoption of reduced-till or no-till practices; review and approve annual management reports from farmers; conduct site visits to verify management practices (as technology develops, verification can be conducted through remote sensing and monitoring); and design and implement soil testing |
| Geographic coverage | All cropland in the country with annual crops (approximately 60,000 ha), excluding rice |
| Sectors affected* | LULUCF, Cropland remaining cropland |
| Greenhouse gases affected* | Increase $CO_2$ removal through soil carbon sequestration |
| Other related policies or actions | Compliance with tillage restrictions makes farmers eligible for enhanced crop insurance benefits, therefore crop insurance programme risk profiles and budgets are likely to be affected |
| Intended level of mitigation to be achieved and/ or target level of other indicators (if relevant)* | Adoption of reduced-till and no-till practices is phased in over time, and farmers who begin adopting practices are expected to continue to do so, to maintain erosion and soil carbon benefits:<br>▪ By 2020, 25% land is managed with reduced-till and 25% land is managed with no-till<br>▪ By 2040, 25% land is managed with reduced-till and 50% land is managed with no-till<br>▪ Remaining 25% land is transitioned to reduced-till or no-till after 2040. Prior to transition, land is managed under full tillage. |

Table 7.1. **Description of the National Conservation Agriculture Policy (Continued)**

| Policy description category | Detailed description |
|---|---|
| Key stakeholders | ▪ Farmers growing annual crops<br>▪ National government agencies: e.g., Ministry responsible for Agriculture, Ministry responsible for Water Resources<br>▪ Regional and local government entities<br>▪ Government entities responsible for agriculture: e.g., Department of Agriculture Extension<br>▪ Ministry responsible for the Environment<br>▪ NGOs or civil society organisations<br>▪ Communities, indigenous peoples, or marginalised groups that are involved in or are affected by agriculture |
| Title of establishing legal framework, or other founding documents | The National Agriculture Policy Act of 2000 |
| Monitoring, reporting and verification procedures | Annual farm visits conducted by agricultural extension agents to all participating farms. Agents to verify the implementation of practices according to policy rules which set a minimum threshold % residue to be retained depending on the crop/soil/climate conditions. See "enforcement mechanisms" for more information on reporting |
| Policy Key Performance Indicators (KPIs) | The proposed KPIs for National Conservation Agriculture Policy include:<br>▪ Change in soil organic carbon<br>▪ Proportion of land utilising reduced-till<br>▪ Proportion of land utilising no-till<br>▪ Proportion of land sampled following adoption of new practices<br>▪ Spend rate of Extension services operational budget to conduct technical assistance and farm visits<br>▪ Spend rate on soil testing activities<br>▪ Information campaign reach<br>KPIs and associated target levels are discussed in more detail in Section 7.4.1 |
| Compliance and enforcement mechanisms | Adoption of no-till is a part of a conservation standard developed prior to adoption of the policy, which all farmers are required to meet as the policy is phased in. Farmers provide an annual report with management information to the government, which is reviewed and approved by extension agents. Extension agents conduct farm visits to verify practice implementation. Remote sensing will be adopted for verification when technology becomes available.<br><br>Compliance helps farmers receive enhanced benefits from a crop insurance programme |
| Reference to relevant documents | Reduced-till and no-till practice conservation standards will be used to ensure farmers adhere to and implement practices according to policy rules |

Table 7.1. **Description of the National Conservation Agriculture Policy (Continued)**

| Policy description category | Detailed description |
|---|---|
| The broader context or significance of the policy | Increasing the soil organic matter of soils through conservation tillage improves soil fertility, reduces erosion, increases moisture retention and can lead to increased yields. Furthermore, increased levels of soil organic matter can help make agricultural soils resilient to the stresses from climate change and support adaptation efforts. In particular, the moisture retention properties of soils with higher carbon content can help agricultural lands remain productive as climates become drier. Conservation tillage, while not going to be sufficient to mitigate the bulk of agricultural GHG emissions, is a good agricultural practice anyway that most farmers will benefit from and is a cost-neutral or cost-beneficial measure with no major technology barriers. Limited data prevents more advanced methods of estimation to be used.<br><br>Collecting management information from farmers and conducting soil testing will lead to refined GHG impact estimation, enhanced policy design, an enhanced country's MRV system and understanding of mitigation potential from the Agriculture sector in the country. |
| Outline of sustainable development impacts of the policy | Improved water quality with reduced erosion; energy conservation; more resilient and profitable farming operations due to improved soil fertility and lower fuel and labour costs |
| Other relevant information | Trade-off: slight decrease in yield might occur due to a decrease in planting depth and incorporation, leading to increased use of fertiliser and nitrogen emissions |

*indicates required reporting under the Enhanced Transparency Framework under the Paris Agreement

### 7.1.3 Intermediate effects and GHG impacts

As described in Part II, users will need to document how the inputs, activities, and intermediate effects lead to the changes in behaviour, technology, processes, or practices that may occur as a result of the policy. Describing these changes includes documenting which parameters are affected, the direction and magnitude of the effect, and where and when this effect is expected to occur. This process helps to determine and communicate the policy scenario that leads to the GHG impact.

Affected parameters may include market-based factors such as decreased labour costs and fuel savings. Users should also recognise that some policy activities may result in trade-offs or may increase GHG emissions. For example, in the National Conservation Agriculture Policy, the retained crop residue increases soil carbon sequestration while also increasing the amount of nitrogen applied to soil, resulting in an increase in $N_2O$ soil emissions. Further changes in $N_2O$ emissions may also result from adjustments in fertiliser application on crops. Fertiliser application may decrease if crop residues provide additional nutrients and soil fertility improves due to reduced tillage. On the other hand, if crop productivity decreases due to different tillage management, increased fertiliser use may occur depending on crop needs.

The inputs, activities, and intermediate effects of the National Conservation Agriculture Policy are summarised in **Table 7.2.**

Refer to Chapter 4 for more information on the process for describing the policy intermediate effects and GHG impacts and the Templates section for templates to describe intermediate effects and GHG impacts.

Table 7.2. **Inputs, activities, and intermediate effects (changes in behaviour, technology, processes, or practices) that result from the National Conservation Agriculture Policy**

*(I)=input, (A)=activity, (IE)=intermediate effect*

| Inputs, activities, intermediate effects | Detail/ explanation | Affected parameter | Direction | Magnitude | Geographic location | Timing |
|---|---|---|---|---|---|---|
| (I) Funding is allocated | Resources for the policy are allocated that allow its implementation | Awareness campaign; extension agents labour; soil testing capability | NA | Budget allocated to the policy is to be determined | National, regional allocations for extensions | Starts when policy is adopted, renewed every 10 years |

Table 7.2. **Inputs, activities, and intermediate effects (changes in behaviour, technology, processes, or practices) that result from the National Conservation Agriculture Policy. (Continued)**

| Inputs, activities, intermediate effects | Detail/ explanation | Affected parameter | Direction | Magnitude | Geographic location | Timing |
|---|---|---|---|---|---|---|
| (A) Conduct information campaign | To increase awareness about soil health and policy requirements | Farmers understand the policy and are motivated to implement conservation practices | NA | To be determined during strategy planning in Year 1 | National, refined based on priorities and annual cropland location | Strategy and kick-off in Year 1, and ongoing communication in subsequent years depending on need |
| (A) Extension agents prepare and execute a technical assistance programme | To facilitate the adoption of no-till, usually done through individual consultations and assistance with management planning | Farmers' adoption of practices is enabled and supported | NA | 2 extension agents per region, 20-30% of their time is spent on providing technical support | National, regional focus based on conditions | Year 1 and on |
| (IE) Farmers seek out and receive technical assistance to adopt no-till practices | To inform management decisions and facilitate the adoption of no-till practices | Farmers' adoption of practices is enabled and supported | Increase | 25% of farmers in Years 1-20; 50% of farmers in Years 21-40; 25% of farmers past year 40 | Regional, National | Year 1 and on |
| (IE) Farmers adopt conservation tillage practices* | Conservation tillage is a key component of conservation agriculture that helps reduce erosion and increase soil organic matter levels | Multiple parameters are affected: soil carbon stock, fuel/ labour costs, fertiliser use, eligibility to other programmes | Dependent on parameter (see below) | Dependent on parameter (see below) | National | Year 1 and on |

Table 7.2. **Inputs, activities, and intermediate effects (changes in behaviour, technology, processes, or practices) that result from the National Conservation Agriculture Policy. (Continued)**

| Inputs, activities, intermediate effects | Detail/ explanation | Affected parameter | Direction | Magnitude | Geographic location | Timing |
|---|---|---|---|---|---|---|
| (IE) Fuel savings from reduced equipment use | equipment use, less fuel is required during production | Emissions from fuel combustion | Decrease | 15-20% reduction in fuel consumption, depending on crop type | National | Year 1 and on |
| (IE) Reduced soil disturbance | Reduced soil disturbance leads to soil carbon sequestration | Soil carbon stock | Increase | Soil tillage intensity rating decreases by 90% | National, annually cropped land | Year 1 and on |
| (IE) Crop residues retained | Due to decreased tillage, crop residues remain on land and serve as a source of organic carbon to increase soil carbon sequestration | Soil carbon stock | Increase | 60% or more of crop residues remain on the field | National, annually cropped land | Year 1 and on |
| (IE) Adjusted use of fertiliser | As tillage is reduced, yields might be affected resulting in adjusted levels of fertiliser applied | Nitrogen applied to soils | Increase or decrease, depending on crop needs | Unknown | National, annually cropped land | Year 1 and on |
| (IE) Labour cost | Due to reduced equipment use, less labour is required during production | Farmer operational costs** | Decrease | 20% reduction in operational costs | National | Year 1 and on |

Table 7.2. **Inputs, activities, and intermediate effects (changes in behaviour, technology, processes, or practices) that result from the National Conservation Agriculture Policy. (Continued)**

| Inputs, activities, intermediate effects | Detail/ explanation | Affected parameter | Direction | Magnitude | Geographic location | Timing |
|---|---|---|---|---|---|---|
| (IE) Farmers qualify for enhanced benefits under the crop insurance programmes | As a result of compliance with no-till regulations, farmers qualify for enhanced benefits such as lower premiums or increased coverage through the crop insurance programme | Practices adoption rates | Increase | All participating farmers | National | Year 21 and on (the crop insurance benefit provision was included when last reauthorised) |
| (IE) Extension agencies conduct soil testing | Measurements of soil organic carbon are conducted as part of the programme to track programme performance and develop country-specific emission parameters and reference values | Data collection | Increase | Statistically-significant sample is collected to capture reference levels of soil carbon and changes on land under different management | Regional, national | Years 11-13 to establish soil organic carbon reference levels, and every 4 years as policy continues |
| (IE) Farmers submit annual reports | To ensure compliance and track management changes on cropland | Practice adoption rates, data collection | Increase | All farmers that transition to reduced-till or no-till | National | Year 1 and on |

Table 7.2. **Inputs, activities, and intermediate effects (changes in behaviour, technology, processes, or practices) that result from the National Conservation Agriculture Policy. (Continued)**

| Inputs, activities, intermediate effects | Detail/ explanation | Affected parameter | Direction | Magnitude | Geographic location | Timing |
|---|---|---|---|---|---|---|
| (IE) Extension agencies verify practices and review/ approve submitted annual reports | To ensure compliance and track management changes on cropland | Practice adoption rates, data collection | Increase | Ongoing and increasing as farmers adopt practices, switching to automated verification in the future | Regional, National | Year 1 and on |

*indicates intermediate effects that are policy mitigation measures
**indicates market-based impacts

Once the policy inputs, activities, and intermediate effects have been documented as shown in **Table 7.2,** the user can further analyse those that lead to changes in GHG emissions and detail the steps that describe how the changes in GHG emissions occur.

The user should also consider and identify whether the effects associated with policy activities are intended or unintended (Rich, 2014). Intended effects are based on the original objectives of the policy. However, as mentioned in the previous section, intended effects may have trade-offs in emissions. Unintended effects typically represent effects that fall outside of the policy's control and may amplify or diminish the impact of the policy.

The GHG impacts associated with the National Conservation Agriculture Policy are summarised in **Table 7.3**.

It is a key recommendation to work with agriculture experts during this part of the assessment step to analyse intermediate effects and identify potential GHG impacts of the policy.

Table 7.3. **GHG impacts of the intermediate effects of the Conservation Agriculture Policy**

| Intermediate effect* | Subsequent intermediate effects | | | Potential GHG impact |
|---|---|---|---|---|
| | Effect 1 | Effect 2 | Effect 3 | |
| Farmers adopt reduced-till or no-till practices | Fuel savings from reduced equipment use | - | - | Decreased $CO_2$ emissions |
| Farmers adopt reduced-till or no-till practices | Reduced soil disturbance | - | - | Decreased $CO_2$ emissions |
| Farmers adopt reduced-till or no-till practices | Crop residues retained | - | - | Decreased $CO_2$ emissions |
| Farmers adopt reduced-till or no-till practices | Crop residues retained | Additional N content from residue is incorporated into soil | - | Increased $N_2O$ emissions |
| Farmers adopt reduced-till or no-till practices | Crop residues retained | Adjusted use of fertiliser depending on crop needs | - | Change in $N_2O$ emissions |

*indicates intermediate effects that are policy mitigation measure

Similar to the example, users should be able to outline the intermediate effects and GHG impacts of the selected policy.

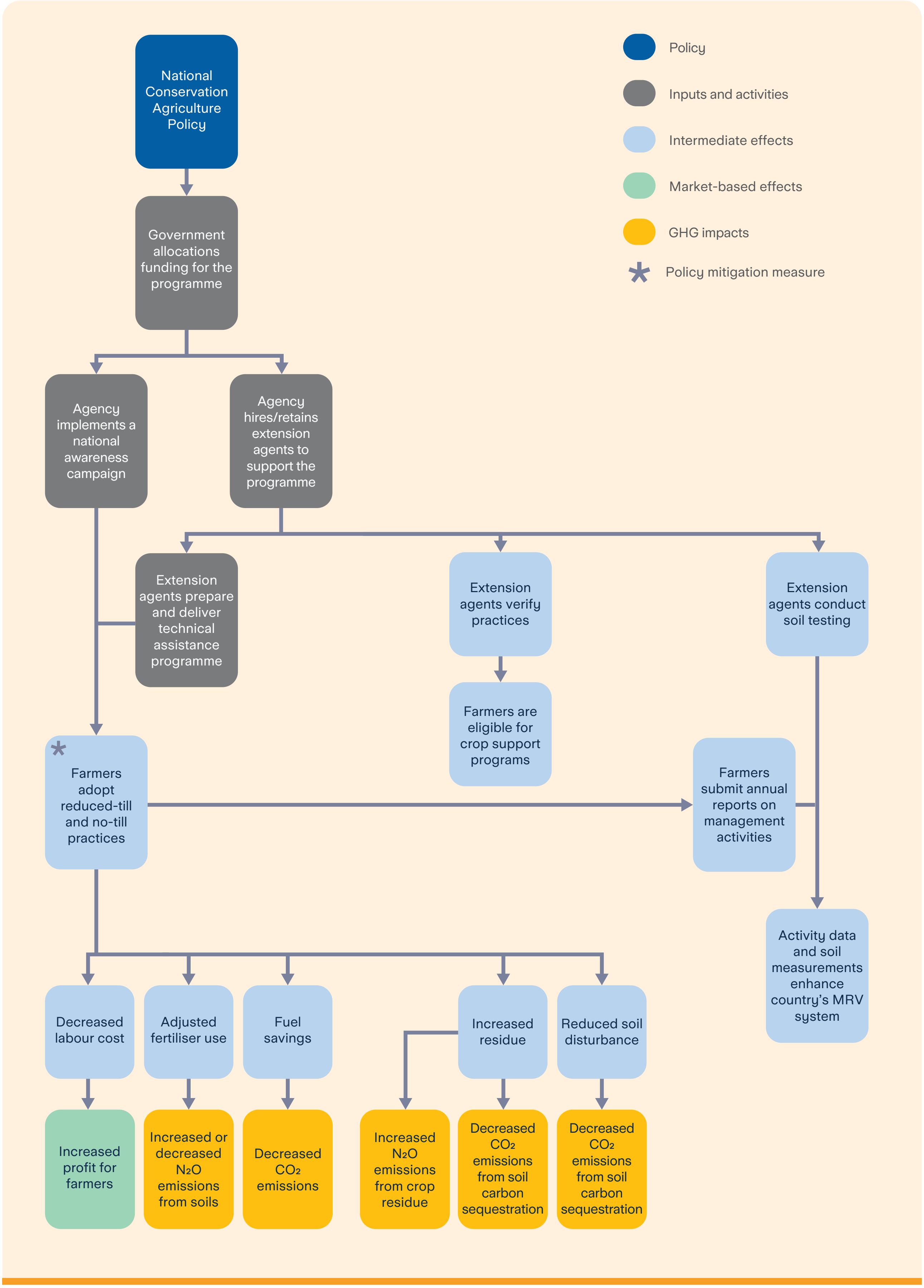
### 7.1.4 Causal chain

A causal chain is a conceptual diagram tracing the process by which the policy leads to GHG impacts through a series of interlinked logical and sequential stages of cause-and-effect relationships. In parallel with the identification of intermediate effects and GHG impacts, the user should prepare a causal chain to better understand, visualise, and communicate how the policy and its corresponding inputs and activities cause intermediate effects and ultimately result in GHG impacts. The causal chain is a visual representation of the information about the policy from **Tables 7.2** and **Table 7.3.** It can also help reveal the order of activities and the interdependencies between them. This is especially useful for policies that are more challenging to visualise in a table format. The causal chain for the National Conservation Agriculture Policy is shown in **Figure 7.1.**

Visualising the policy's causal chain is likely to lead to the refinement of the information listed in **Table 7.2** and **Table 7.3**. The causal chain can be a useful tool for engaging stakeholders in understanding policy design and its effects.

Refer to the Templates section for a template to develop a causal chain following the demonstrated example.

Figure 7.1. **The National Conservation Agriculture Policy causal chain**



### 7.1.5 Assessment boundary and period

#### Policy Assessment Boundary

Once all the potential GHG impacts are identified, the user will determine which ones will be included in the assessment boundary. Determining the policy assessment boundary includes a three-part process of estimating:

- the likelihood of GHG impact
- the expected relative magnitude of GHG impact
- the significance of each GHG impact

The user should then select which impacts will be estimated within the assessment boundary. Typically, the user has a limited number of resources to conduct the assessment. This three-part estimation helps the user to prioritise assessing impacts that are likely and major in size. Impacts considered very likely, likely, or possible in combination with their GHG impact being either moderate or major are significant and should be included in the assessment boundary.

For the National Conservation Agriculture Policy, all of the GHG impacts identified in **Table 7.3** are considered. The results of this process are outlined in **Table 7.4**. Changes in $CO_2$ removal due to reduced soil disturbance from different tillage practices are determined as significant and included in the assessment boundary.

Refer to Chapter 4 for guidance on determining the significance of GHG impacts and the Templates section for templates to determine assessment boundary.

Table 7.4. **Likelihood, magnitude, and significance of GHG impacts of the National Conservation Agriculture Policy**

| Mitigation measure | GHG impact | Likelihood | Relative magnitude | Significance |
|---|---|---|---|---|
| Adoption of reduced- and no-till practices | Decreased $CO_2$ emissions/ increased soil carbon sequestration associated with reduced soil disturbance | Very likely | Major | Significant |
| | Decreased $CO_2$ emissions/ increased soil carbon sequestration associated with retained crop residues | Very likely | Moderate | Significant |
| | Increased $N_2O$ emissions from crop residue | Possible | Minor | Not significant |
| | Increased $N_2O$ emissions from adjustments to fertiliser use | Possible | Unknown | Not estimated (crop dependent) |
| | Reduced $CO_2$ emissions from decreased equipment use and fuel consumption | Likely | Minor | Not estimated (outside scope) |

It is possible that changes occur in the application of fertiliser as a result of tillage and residue management changes, however, the effect on $N_2O$ emissions is unknown (fertiliser use may increase or decrease depending on climate, crop needs, and soil conditions). If the user, in the policy they are assessing, is expecting significant changes in fertiliser application to occur, the methodology to quantify those is demonstrated in Chapter 6. Emissions from decreased fuel consumption are expected to be minor in magnitude and would be reported under the Energy sector.

If land use change occurs as a result of the policy, such as conversion of forest land to cropland, users may also refer to the ICAT *Forest Methodology* to estimate associated GHG impacts. Furthermore, assessing unintended effects outside the AFOLU sector (e.g., emissions from fuel consumption) is outside the scope of this guide and falls under the Energy sector.

Similar to the policy example above, users should document the GHG impacts resulting from the mitigation measure and determine the impacts to include and exclude from the assessment boundary.

### Policy Assessment Period

Users should also determine the assessment period that will be used. It is important to select a policy period that aligns with the time period for which the GHG impact will occur. In the case of policies that aim to influence soil carbon stocks, a minimum of a 20-year assessment period is recommended. For the National Conservation Agriculture Policy, the assessment is composed of both an ex-post and ex-ante assessment period. This is because the policy was already underway in 2020, the point in time when the ex-post assessment is conducted. For the purpose of the example, assessment is being conducted at time t. The following assessment periods are used:

- For ex-post analysis, the assessment period is t-20 – t (years 2000 – 2020)
- For ex-ante analysis, the assessment period is t+1 – t+20 (years 2021 – 2040)

An ex-post assessment is conducted to evaluate the performance of the policy while the ex-ante assessment is done to project future performance of the policy. The user can conduct either ex-post or ex-ante assessment if they selected a policy for which implementation period started. Furthermore, ex-post assessment could be done at the conclusion of the implementation period or any time in the future to compare projected results to the achieved results of the policy.

### 7.1.6 Other policy synergies and interactions

Users should qualitatively describe potential policy synergies and interactions. Quantitative assessment of interacting policies is beyond the scope of this guide; however, it is important to identify them to inform future policy decisions. Adoption of other agricultural policies and programmes that result in soil carbon stock changes may have additional synergistic impacts or may result in trade-offs that counter the emission reduction achieved by the National Conservation Agriculture Policy.

For the National Conservation Agriculture Policy described in this chapter, potential policy interactions may be related to fuel savings that are expected to occur under the policy. This may support an existing or a planned policy in the Energy sector, focusing on energy efficiency measures for non-road machinery. Furthermore, fertiliser use and associated $N_2O$ emissions may increase or decrease depending on the cropping system and associated crop yield when no-till is adopted. There may be separate agricultural policies in place that deal with fertiliser application standards or practices on crops, which may restrict additional application of fertiliser. The National Conservation Agriculture Policy can also lead to improvements in water quality due to reduced soil erosion. Increased organic matter that results from implementing reduced-till and no-till practices is also a promising adaptation option as it can stabilise the soil structure and make soil more resilient to both flooding and drought conditions that are likely to occur as a result of climate change.

Refer to the WRI's Policy and Action Standard in this guide's assessment toolkit for additional resources on assessing policy interactions. Furthermore, refer to the ICAT *Sustainable Development Methodology* for additional resources for assessing sustainable development impacts.

After documenting other policy synergies and interactions, the user is ready to quantify the GHG emissions impacted by the policy.

## 7.2 Methodological considerations

### 7.2.1 Methodology for assessing GHG emissions

Users should determine which methodological tier to apply in their assessment based on data availability. This guide recommends reviewing the country's GHG inventory to identify which methodological tier was utilised, because it may highlight the level of data characterisation potentially applicable for use within the assessment. Initially, data availability is the main factor in selecting the calculation tier. If it is determined that emissions constitute a key source category based on key category analysis as described in the IPCC 2006 GL, the country will need to invest in further data collection to use a higher calculation tier. The emissions or removals associated with soil carbon stock changes are reported in CRT 4B, in GHG Inventory category 4.B.1, Cropland remaining cropland, under the ETF reporting requirements.

The methodology in this guide is based on the IPCC 2006 GL and 2019 Refinement. The policy assessment example uses methods, equations, default values, and parameters from the 2019 Refinement.

When converting $N_2O$ emissions to emissions expressed in $CO_2e$, users should, to ensure consistency, utilise the same GWP as the one used in their current national GHG inventory.

Land use and management lead to a shift in carbon stock from one equilibrium state to another. A Tier 1 method assumes this shift occurs linearly over a 20-year default time period. For the purpose of assessing the National Conservation Agriculture Policy, parcel-specific land management change data and country-specific emission factors are not available, therefore, Tier 1 methods are applied.

Refer to the 2019 Refinement, Volume 4, Chapter 2, Figures 2.4 in this guide's assessment toolkit to view the tier decision trees for further guidance on choice of method to estimate changes in carbon stocks in mineral soils. Tier 2 methods use country-specific and/or management-specific emission factors and typically require more detailed data characterisation of land use categories and management systems. Utilising Tier 2 or Tier 3 should result in more accurate estimates. Only Tier 1 methodology for soil carbon is covered in this guide.

### 7.2.2 Baseline scenario

The user will need to establish a baseline scenario to estimate GHG emissions without mitigation measures.

For the ex-post assessment, the user should establish how land use and management would have changed in the absence of the mitigation measure. Historical data on land use and management, as well as **expert judgement**, can be used.

For ex-ante assessment, the user should establish if and how the land use and land management will change in the absence of mitigating measures. Where land data are not available, economic data (e.g., an output or yield) can be used to infer land use trends. When using economic data, trends in demand are used as a proxy for estimating the expected output in crop production in the baseline scenario. Users should use national demand forecasts for annual crops. If forecasts are not available, users can extrapolate based on historical data, or consider trends in GDP, population, or other proxy factors to estimate how current demand for annual crops will change in the future.

In addition to, or in lieu of, historical data and projections, users can base estimates of future land use or change in management using expert judgement. Experts may be sector-specific experts or national economic experts. For example, in estimating market growth, an economic expert may be able to provide the annual demand rate for annual crops, which can be used as an indicator of expected growth. The baseline scenario should also capture the current management practices and the extent to which management might change over the assessment period in the absence of mitigation measures.

For the purpose of assessing the National Conservation Agriculture Policy, the baseline scenario is termed the scenario without measures (WOM) and is summarised in **Table 7.5.**

The country's area of land used for annual crops has remained stable over the ex-post assessment period, and it is assumed that area of cropland remains at the current level during the ex-ante assessment period. Before the policy went into effect in 2000, all annual crops were managed with full tillage. Experts relied on data from Derpsch, R. (2010) to estimate the rate of adoption occurring without measure to inform the following baseline assumptions. During the ex-post assessment period, 5 percent of the land would have transitioned to reduced-till management and 5 percent would have transitioned to no-till management without the policy. It is assumed that the transition occurs linearly with 0.25 percent of cropland changing management each year. These assumptions were deemed reasonable through further consultations with national agriculture experts and extension agents and were validated with relevant stakeholders in the validation workshop as planned in preparation for the assessment. Low level of adoption of reduced-till and no-till practices would have occurred even without the policy due to growing awareness of the benefits of reducing soil disturbance on fertility.

For the ex-ante assessment period, the baseline assumes that reduced-till and no-till practices continue to be adopted at the same rate (0.25 percent/yr) resulting in 10 percent of land converted to reduced-till and 10 percent converted to no-till management by year t+20. Furthermore, once land transitions to a different tillage regime, it remains under the same regime during the assessment period. Assuming a linear change in land management practices, a simple trend baseline approach is used.

For both ex-post and ex-ante assessment periods, when land is managed under reduced-till or no-till, the residue level increases, going from a low-input system to a high-input system (without manure). Based on consultations with national agriculture experts, these assumptions are considered reasonable. For both assessment periods, the baseline scenario assumes there would be no other changes in land use or management practices.

Refer to Section 2.3 for an overview of approaches to constructing a baseline.

Refer to this guide's assessment toolkit for resources on baseline projections and potential data sources such as the World Bank Open Data to inform baseline scenario.

### 7.2.3 Policy scenario

The user needs to establish a policy scenario to estimate GHG emissions with mitigation measures.

For the purpose of assessing the National Conservation Agriculture Policy, the policy scenario is termed the scenario with additional measures (WAM). The policy establishes a mandatory conservation standard and provides technical assistance to farmers raising annual crops to comply with the standard's rules. An additional incentive to transition to reduced- or no-till management is eligibility for enhanced crop insurance benefits. The policy scenario is summarised in **Table 7.5**.

Under the policy scenario, there is a higher rate of adoption of reduced-till and no-till practices while the cropland area used for annual crop production remains constant under both ex-post and ex-ante periods. Similar to the baseline scenario, the residue input levels are expected to change to high (without manure) once the land is managed with reduced-till or no-till.

For the ex-post assessment, the WAM scenario is based on monitored data. Based on the cropland management survey, during the ex-post assessment period, the policy resulted in 31 percent of land transitioning to reduced-till and 27 percent of land transitioning to no-till. This exceeded the target goal set by the policy. However, lands with different crops experienced different rates of adoption.

For the ex-ante period, the WAM scenario reflects the policy goals. That is to have 25 percent of land under reduced-till management and 50 percent of land under no-till management, reducing the proportion of total land that's being intensively tilled to 25 percent overall by the end of the ex-ante assessment period. Since the ex-post level of adoption for reduced-till is already at 31 percent, the ex-ante WAM scenario assumes that some land will transition from reduced-till to no-till, leading to a slight decrease in the proportion of land under reduced-till management.

The transition is assumed to occur incrementally over a 20-year period, but because land under different crops adopted reduced-till and no-till at different rates during the ex-post period, the transition rates used in projecting changes in soil carbon stocks ex-ante will vary depending on the crop. As summarised in **Table 7.5**, the policy scenario assumes there would otherwise be no changes in technology or land use.

Refer to Appendix B for additional guidance on estimating the implementation potential of a policy. Note that users can assess one or more policy scenarios to help refine policy design.

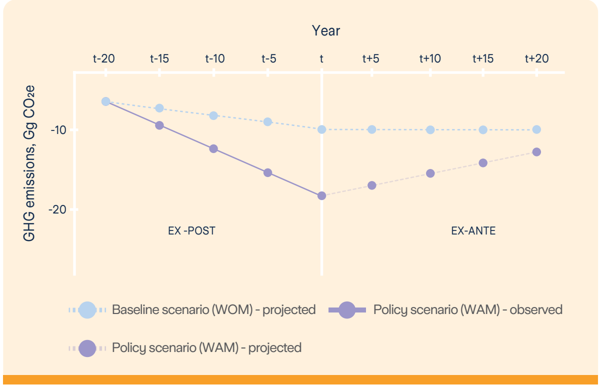
Table 7.5. **Key assumptions for baseline (WOM) and mitigation (WAM) scenarios.**

<table>
<tr><th>Assumption</th><th>WOM EX-POST</th><th colspan="2">WAM EX-POST</th><th>WOM EX-ANTE</th><th colspan="2">WAM EX-ANTE</th></tr>
<tr><td>Proportion of cropland used for annual crops under full till at the end of the period</td><td>90%</td><td colspan="2">42%</td><td>80%</td><td colspan="2">25%</td></tr>
<tr><td>Proportion of land under reduced-till at the end of the period</td><td>5%</td><td colspan="2">31%</td><td>10%</td><td colspan="2">25%</td></tr>
<tr><td>Proportion of land under no-till at the end of the period</td><td>5%</td><td colspan="2">27%</td><td>10%</td><td colspan="2">50%</td></tr>
<tr><td>Total cropland area with annual crops</td><td colspan="6">Constant</td></tr>
<tr><td>Organic amendments/input level</td><td colspan="6">Full till: Low-input system</td></tr>
<tr><td rowspan="6">Annual rate of transition to reduced-till (depends on crop/management/climate stratification)</td><td rowspan="6">0.25%</td><td>corn-soy-alfalfa-alfalfa</td><td>1.25%</td><td rowspan="6">0.25%</td><td>corn-soy-alfalfa-alfalfa</td><td>0%</td></tr>
<tr><td>wheat</td><td>3%</td><td>wheat</td><td>-1.75%</td></tr>
<tr><td>cassava-beans</td><td>0%</td><td>cassava-beans</td><td>1.25%</td></tr>
<tr><td>vegeta-bles</td><td>0%</td><td>vegeta-bles</td><td>1.25%</td></tr>
<tr><td>cassava-beans</td><td>0%</td><td>cassava-beans</td><td>1.25</td></tr>
<tr><td>wheat</td><td>2%</td><td>wheat</td><td>-0.75%</td></tr>
<tr><td rowspan="6">Annual rate of transition to no-till (depends on crop/management/ climate stratification)</td><td rowspan="6">0.25%</td><td>corn-soy-alfalfa-alfalfa</td><td>2.5%</td><td rowspan="6">0.25%</td><td>corn-soy-alfalfa-alfalfa</td><td>0%</td></tr>
<tr><td>wheat</td><td>1%</td><td>wheat</td><td>1.5%</td></tr>
<tr><td>cassava-beans</td><td>0%</td><td>cassava-beans</td><td>2.5%</td></tr>
<tr><td>vegeta-bles</td><td>0%</td><td>vegeta-bles</td><td>2.5%</td></tr>
<tr><td>cassava-beans</td><td>0%</td><td>cassava-beans</td><td>2.5%</td></tr>
<tr><td>wheat</td><td>0.5%</td><td>wheat</td><td>2%</td></tr>
</table>

Note: Target proportions are based on the overall cropland area. Tillage proportions vary depending on crop type as outlined in the Land Stratification section. These scenarios will be applied to each stratum.

**Figure 7.2** depicts a conceptual diagram of the emissions for baseline and policy implementation scenarios. Changing crop management results in emission changes associated with fluxes in mineral soil organic carbon (SOC). Reducing tillage is expected to result in negative emissions (i.e., increases carbon storage and removal of $CO_2$ from the atmosphere) in both the baseline and policy scenarios; however, at different rates due to different rates of practice adoption.

Figure 7.2. **Conceptual diagram showing emissions due to change in SOC for baseline and policy scenarios across both assessment periods (solid line represents observed changes, dashed lines represent projected changes)**




### 7.2.4 Data for assessment

The users must identify activity data and parameters needed to conduct the assessment and specify, to the extent possible, the sources of the data.

The information needed to conduct the GHG impact assessment and associated data sources for the National Conservation Agriculture Policy are outlined in **Table 7.6.** Some of the required data is available from the national GHG inventory (climate zones, land uses). Other information is obtained from national agriculture surveys (management practices) and publicly available databases (area of land under different vegetation/crops).

Refer to the Technical Supplement for relevant activity data and emission parameters needed for quantifying GHG emissions associated with carbon stock mitigation measures for Tier 1 methods.

Table 7.6. **Sources of data for soil carbon GHG emission estimation**

| Data type | Data sources |
|---|---|
| Land categorisation | Land category affected under this policy is cropland, refer to 2019 Refinement, Volume 4, Chapter 3, Box 3.1A for land categories; Information from a national land inventory. If national data are not available, data can also be obtained from FAO's database, FAOSTAT. |
| Land stratification by climate zone (c), soil type (s), and management category (i) (unitless) | Land stratifications based on climate zones, soil types, and management category (e.g., annual crops, perennial crops, etc.). Refer to 2019 Refinement, Volume 4, Chapter 3, Table 3.1 for stratification categories; information on cropping systems comes from a national agriculture survey and is validated by national experts. Information on soil types can be obtained from the Harmonized World Soil Database |
| Area of land in each stratum (ha) | Area of land in each stratum comes from a national agriculture survey for years during the assessment period. Data can also be obtained from FAO's database, FAOSTAT. |
| Management practices information | This includes land management such as crop rotation, tillage practices, residue management, and fertiliser use for each land stratum from the national agriculture survey; used to determine the value of emission parameters to use in calculations<br><br>Management data categories and area for each is needed for the years during the assessment period |
| Emission factors and other parameters, by climate, soil, and management type | Default Tier 1 parameters come from 2019 Refinement, Volume 4<br>▪ Soil organic carbon reference values for each land stratum, $SOC_{ref}$ : Chapter 2, Table 2.3<br>▪ Relative stock change factors for land use, $F_{LU}$, management practices, $F_{MG}$, and inputs, $F_I$: Chapter 5, Table 5.5<br>For country-specific emission factors, refer to IPCC Emission Factor Database |
| Conversion factor | 2019 Refinement, to convert carbon stocks to $CO_2$ emissions, 44/12 |

Furthermore, by design of the policy, annual reports from farmers and soil testing conducted under the policy will contribute directly to improving the accuracy of soil carbon stock estimates in the future (both for this programme and for the national inventory as reported to the UNFCCC).

Once the user has determined which methods will be used to calculate emissions and has described baseline and policy scenarios with associated data parameters needed, GHG emissions can be calculated.

After completing the policy description, the user is ready to quantify the GHG emissions impacted by the policy.

## 7.3 Estimating GHG emissions

### 7.3.1 Compile activity data

Once the data and their sources have been identified, the next step is to compile the needed activity data.

#### Stratify land

The user needs to identify: the climate regions, soil types and management categories that occur on land affected by the policy (2019 Refinement, Volume 4, Chapter 3, Table 3.1). The definitions of the categories are provided in 2019 Refinement, Volume 4, Chapter 3, Annex 3A.5. Additional, more detailed, management categories for cropland and grassland are provided in 2019 Refinement, Volume 4, Chapter 5, Tables 5.5 and 2019 Refinement, Volume 4, Chapter 6, Table 6.2, respectively.

Following guidance in Section 4.2 users should have identified the affected land categories where soil carbon management impacts are expected to occur under the policy scenario. For mitigation measures that involve agronomic improvements or tillage/residue management, the affected land category would be cropland. For mitigation measures that involve pasture management, the affected land category would be grassland. Restoration of degraded cropland or grassland to native vegetation, changes in production efficiency or increasing demand for crop production may lead to land conversion and therefore, land use change. Estimating emissions associated with land use changes and carbon stock changes in biomass is outside the scope of this guide. The land can be further stratified based on crop rotations and degraded/non-degraded cropland or pasture to capture differences in management for different tracts of land in the country.

Stratification according to IPCC categories enables the user to utilise default emission factors and parameters needed to calculate emissions using Tier 1 approach.

For the National Conservation Agriculture Policy, the affected land category is cropland remaining cropland. The land is stratified according to climate zones, soil types, and management categories as shown in **Table 7.7** reflecting land strata at the time of the assessment, i.e., between ex-post and ex-ante assessment periods. At the time of the assessment, there is 58,246 ha of land used for annual crop production. Refer to the Hypothetical Country section of the guide for land stratification data.

> Refer to 2019 Refinement, Volume 4, Chapter 3 in this guide's assessment toolkit for guidance on how to stratify land following the land stratification. Utilise Approach 1, which documents land-use area totals within a defined spatial unit, typically defined by political boundaries, such as a country, province, or municipality and only the net changes in land-use area can be tracked through time. More advanced approaches to stratify land require additional information about land conversions and spatial referencing and are beyond the scope of this guide.

Table 7.7. **Land stratification for hypothetical example country at time t**

*High activity Clay mineral (HAC), Volcanic mineral (VOL), Low-activity Clay mineral (LAC)*

| Land use category | Province | Climate | Soil type | Management | Area (ha) |
|---|---|---|---|---|---|
| Cropland remaining cropland | East | TRD | HAC | Annual crops* | 50,507 |
| | East | TRD | HAC | Perennial crops | 19,974 |
| | East | TRD | HAC | Set aside | 24,980 |
| | East | TRD | VOL | Annual crops* | 5,430 |
| | East | TRD | VOL | Perennial crops | 34,210 |
| | East | TRD | LAC | Annual crops* | 2,309 |
| | East | TRD | LAC | Set aside | 7,895 |
| | West | TM | LAC | Wetland rice | 23,493 |
| | West | TM | LAC | Sugarcane | 2,005 |
| | West | TM | VOL | Perennial crops | 9,011 |

*Land with annual crops affected by policy

### Land Management

At the time of the assessment, the cropping systems and management conditions are summarised in **Table 7.8.**

Table 7.8. **Land strata and management for land affected by the policy at time t**

| Stratum | Soils | Crop rotation | Area (ha) | Full till area % | Reduced-till area % | No-till area % | Input system type |
|---|---|---|---|---|---|---|---|
| 1 | HAC | corn-soy-alfalfa-alfalfa | 23,738 | 25% | 25% | 50% | Full till: Low-input system<br>Reduced-till: high-input system<br>No-till: high-input system |
| 2 | HAC | wheat | 18,183 | 20% | 60% | 20% | |
| 3 | HAC | cassava-beans | 8,586 | 100% | 0% | 0% | |
| 4 | VOL | vegetables | 4,235 | 100% | 0% | 0% | |
| 5 | VOL | cassava-beans | 1,195 | 100% | 0% | 0% | |
| 6 | LAC | wheat | 2,309 | 50% | 40% | 10% | |
| | | Total | 58,246 | 42%* | 31%* | 27%* | |

*Percentage of total area under each tillage type for cropland affected by policy

### 7.3.2 Choose emission factors and parameters

- To estimate emissions in the next step of the assessment, the user will need to choose emission factors and parameters for each land stratum. IPCC default parameters are used in the calculations. To estimate changes in soil carbon stocks, the user needs to determine two sets of parameters, namely the soil organic carbon reference value for each soil type ($SOC_{ref}$) and the soil carbon stock change factors (F) associated with each land management regime. The stock change factors scale the reference value of soil carbon stock up or down based on soil management practices. There are three types of stock change factors:
- stock change factor for land-use systems or sub-systems ($F_{LU}$)
- stock change factor for management regime ($F_{MG}$)
- stock change factor for inputs of organic matter ($F_I$)

Where there is no suitable IPCC default factor for the conditions in the country, users can apply a factor of “1”.

For the land in the National Conservation Agriculture Policy, SOCref values and stock change factors are summarised in **Table 7.9.**

Table 7.9. **Emission parameters used for the National Conservation Agriculture Policy emission calculations**

| Emission factors and other parameters | Value | Data source |
|---|---|---|
| Reference soil organic carbon | ▪ Stratum 1 (HAC), $SOC_{ref}$: 21 t C/ha<br>▪ Stratum 2 (HAC), $SOC_{ref}$: 21 t C/ha<br>▪ Stratum 3 (HAC), $SOC_{ref}$: 21 t C/ha<br>▪ Stratum 4 (VOL), $SOC_{ref}$: 50 t C/ha<br>▪ Stratum 5 (VOL), $SOC_{ref}$: 50 t C/ha<br>▪ Stratum 6 (LAC), $SOC_{ref}$: 19 t C/ha | 2019 Refinement, Volume 4, Chapter 2, Table 2.3 |
| Stock change factors | ▪ $F_{LU}$: annual crops: 0.92<br>▪ $F_{MG}$: full tillage systems: 1.00<br>▪ $F_{MG}$: reduced-till systems: 0.99<br>▪ $F_{MG}$: no-till systems: 1.04<br>▪ $F_I$: low-input systems: 0.95<br>▪ $F_I$: high-input systems, without manure: 1.04 | 2019 Refinement, Volume 4, Chapter 5, Table 5.5 |
| Conversion factor | To convert carbon stocks to $CO_2$ emissions, 44/12 | 2019 Refinement, Volume 4, Chapter 2 |

### 7.3.3 Calculate baseline soil carbon stocks and emissions

The users should calculate the change in soil organic carbon stock for the baseline scenario using **Equation 7.1**.

Equation 7.1. **Change in carbon soil stocks for a given land stratum (2019 Refinement, Volume 4, Chapter 2, Eq. 2.25)**

$$\Delta C_{Mineral} = \frac{\left(SOC_0 - SOC_{(0-T)}\right)}{D}$$

$$SOC_{Mineral} = \sum_{c,s,i} SOC_{REF_{c,s,i}} \times F_{LU_{c,s,i}} \times F_{MG_{c,s,i}} \times F_{I_{c,s,i}} \times A_{c,s,i}$$

Where:

| | |
|---|---|
| $\Delta C_{Mineral}$ | = annual change in organic C stocks in mineral soils, tonnes C/yr |
| $SOC_0$ | = mineral soil organic C stock ($SOC_{Mineral}$) in the last year of an assessment period, tonnes C |
| $SOC_{(0-T)}$ | = mineral soil organic C stock ($SOC_{Mineral}$) at the beginning of the assessment period, tonnes C |
| $T$ | = number of years over an assessment period, yr (i.e., policy implementation period or period over which the change in management occurred) |
| $D$ | = time dependence of mineral soil organic C stock change factors which is the default time period for transition between equilibrium *SOC* values, yr, commonly 20 years. If T exceeds D, use the value for T to obtain an annual rate of change over the inventory time period (0-T years) |
| $c$ | = represents the climate zones included in the inventory |
| $s$ | = represents the soil types included in the inventory |
| $i$ | = represents the set of management systems included in the inventory. |

| | |
|---|---|
| $SOC_{Mineral}$ | = total mineral soil organic C stock at a defined time, tonnes C |
| $SOC_{REF\ c,s,i}$ | = the soil organic C stock for mineral soils in the reference condition, tonnes C/ha |
| $F_{LU\ c,s,i}$ | = stock change factor for mineral soil organic C land-use systems or sub-systems for a particular land-use, dimensionless |
| $F_{GM\ c,s,i}$ | = stock change factor for mineral soil organic C for management regime, dimensionless |
| $F_{I\ c,s,i}$ | = stock change factor for mineral soil organic C for the input of organic amendments, dimensionless |
| $A_{c,s,i}$ | = land area of the stratum being estimated, ha |

The steps for calculating the stock change and the emissions for the baseline are provided below. Example calculations are shown for Stratum 1 in **Table 7.10**. Full calculations are demonstrated in the Technical Supplement available for download. Note that manual calculations with rounded values as displayed in **Table 7.10** may result in different values than full calculations in the Technical Supplement.

- Step 1: Determine the land area under each management system for each stratum using baseline scenario assumptions
- Step 2: Determine the final SOC value for each stratum and sum these to give the total final SOC value ($SOC_0$) for the year **(Equation 7.1)**
- Step 3: Determine the initial SOC value for each stratum and sum these to give the total initial SOC value ($SOC_{0-T}$) for the year (**Equation 7.1**) *Note: the initial SOC value is the value that was determined 20 years ago (if the IPCC default 20-year transition period is being used)*
- Step 4: Calculate the annual SOC change by subtracting the overall initial SOC value for the year from the final SOC value for the year and dividing by the default transition period of 20 years (**Equation 7.1**)
- Step 5: Convert the carbon to $CO_2$ by multiplying by 44/12 (molecular weight ratio of C to $CO_2$) and then by -1. *Note: The change of sign (-) is due to the convention that a positive (+) stock changes, represent a removal (or 'negative' emission) from the atmosphere, while a negative (-) stock changes, represent an emission to the atmosphere. When emissions are negative it indicates a removal of $CO_2$ from the atmosphere (carbon sequestration)*
- Step 6: Complete this step to determine the relative change in soil carbon stock as a result of the policy. Calculate the total SOC for each year by adding the SOC change to the initial SOC, i.e., the initial year SOC is the initial SOC, the first year of implementation SOC is the initial SOC plus the annual SOC change. Subsequent years will be the previous year's SOC plus the annual SOC change.

### Ex-post baseline calculations

The ex-post baselines scenario has the assumptions that (a) all land is initially under full tillage, (b) and that 0.25 percent of land in each stratum would have converted to reduced-till each year and 0.25 percent of land would also have converted to no-till each year. Refer to Section 7.2.2. for an explanation of the baseline scenario.

The ex-post assessment period is t-20 to t. As mentioned above, the soil carbon changes occur slowly over a 20-year period. The initial soil carbon ($SOC_{0-T}$) is therefore the time t-20. In this example, it is also assumed that the croplands were the same and had the same management (full till) 20 years prior to policy implementation. The initial soil carbon ($SOC_{0-T}$) is the same for the whole ex-post assessment period (i.e., is equal to the SOC value for time t-20).

### Ex-ante baseline calculations

For the ex-ante assessment period, the same assumptions as the ex-post baseline with regards to the initial full tillage and the rate of change for tillage practices are made, except this is projected to occur in time t+1 to t+20. The same calculations are done for each year in the assessment period to determine the initial ($SOC_{0-T}$) and final ($SOC_0$) soil carbon stock and the associated change in C stocks.

Since the ex-ante period (t+1 – t+20) begins 20 years after the policy implementation start year, the land has undergone some management changes in the previous 20 years (t-20 – t). This means that in the ex-ante assessment period, the initial SOC ($SOC_{0-T}$) for time t+1 is now the final SOC for time t-19, and the initial SOC for time t+2 is the final SOC for time t-18, and so on.

Table 7.10. **Example $CO_2$e emission calculations for Stratum 1 for the baseline scenario**

| Parameter (units) | Description | Value or calculated value | Value or calculated value | Value or calculated value |
|---|---|---|---|---|
| | | | t-19 | t+1 |
| Soil carbon factors | | | | |
| $SOC_{Ref}$ (t C/ha) | Default emission parameter | 21 | 21 | 21 |
| $F_{LU}$ - annual crops | Default emission parameter | 0.92 | 0.92 | 0.92 |
| $F_{MG\text{-}FT}$ - full till | Default emission parameter | 1 | 1 | 1 |
| $F_{MG\text{-}RT}$ - reduced-till | Default emission parameter | - | 0.99 | 0.99 |
| $F_{MG\text{-}NT}$ - no-till | Default emission parameter | - | 1.04 | 1.04 |
| $F_{I\text{-}L}$ - low input | Default emission parameter | 0.95 | 0.95 | 0.95 |
| $F_{I\text{-}H}$ - high input | Default emission parameter | - | 1.04 | 1.04 |
| **Step 1: Determine area under each management** | | | | |
| Area (ha) | Activity data | $A_{Full\text{-}till}$: 23,738<br>$A_{Reduced\text{-}till}$: 0<br>$A_{No\text{-}till}$: 0 | $A_{Full\text{-}till}$: (99.5/100) x 23,738 = 23,619.3<br>$A_{Reduced\text{-}till}$: (0.25/100) x 23,738 = 59.3<br>$A_{No\text{-}till}$: (0.25/100) x 23,738 = 59.3 | $A_{Full\text{-}till}$: (89.5/100) x 23,738 = 21,245.5<br>$A_{Reduced\text{-}till}$: (5.25/100) x 23,738 = 1,246.2<br>$A_{No\text{-}till}$: (5.25/100) x 23,738 = 1,246.2 |
| **Step 2: Calculate final SOC for each stratum: $SOC_0 = SOC_{Ref} \times F_{LU} \times F_{MG} \times F_I \times A$** | | | | |
| $SOC_0$ (t C) | Calculated, **Eq. 7.1** | $SOC_{0\ Full\text{-}till}$ = 21 x 0.92 x 1 x 0.95 x 23,738 = 435,687.3<br>$SOC_{0\ Reduced\text{-}till}$ = 0<br>$SOC_{0\ No\text{-}till}$ = 0 | $SOC_{0\ Full\text{-}till}$ = 21 x 0.92 x 1 x 0.95 x 23,619.3 = 433,508.6<br>$SOC_{0\ Reduced\text{-}till}$ = 21 x 0.92 x 0.99 x 1.04 x 59.3 = 1,179.6<br>$SOC_{0\ No\text{-}till}$ = 21 x 0.92 x 1.04 x 1.04 x 59.3 = 1,239.2 | $SOC_{0\ Full\text{-}till}$ = 21 x 0.92 x 1 x 0.95 x 21,245.5 = 389,939.9<br>$SOC_{0\ Reduced\text{-}till}$ = 21 x 0.92 x 0.99 x 1.04 x 1,246.2 = 24,789.3<br>$SOC_{0\ No\text{-}till}$ = 21 x 0.92 x 1.04 x 1.04 x 1,246.2 = 26,041.2 |

Table 7.10. **Example $CO_2$e emission calculations for Stratum 1 for the baseline scenario (Continued)**

| Parameter (units) | Description | Value or calculated value | Value or calculated value | Value or calculated value |
|---|---|---|---|---|
| Total $SOC_0$ (t C) for stratum 1 | | 435,687.3 | 433,508.6 + 1,179.6 + 1,239.2 = 435,927.4 | 389,939.9 + 24,789.3 + 26,041.2 = 440,770.4 |
| **Step 3: Calculate initial SOC for each stratum:** $SOC_{0\text{-}T} = SOC_{Ref} \times F_{LU} \times F_{MG} \times F_I \times A$ | | | | |
| $SOC_{0\text{-}T}$ (t C) | Calculated, **Eq. 7.1** | Equal to $SOC_0$ for year t-20 | Same as for year t-20 | Equal to the $SOC_0$ for year t-19 |
| Total $SOC_{0\text{-}T}$ (t C) | | 435,687.3 | 435,687.3 | 435,927.4 |
| **Step 4: Calculate annual SOC change** *Note that the annual change in SOC should be calculated using the sum of all strata. In other words, the sum of initial SOC for each stratum and the sum of final SOC for each stratum should be calculated and then incorporated into this step. In this example it is only demonstrated for stratum 1.* | | | | |
| $\Delta SOC$ (t C/yr) | Calculated, **Eq. 7.1** | $\Delta SOC$ = (435,687.3 – 435,687.3)/20 = 0 | $\Delta SOC$ = (435,927.4 – 435,687.3)/20 = 12.1 | $\Delta SOC$ = (440,770.4 – 435,927.4)/20 = 242.2 |
| **Step 5: Convert carbon to $CO_2$:** $(\Delta SOC \times -(44/12))/1000$ | | | | |
| $\Delta SOC$ $CO_2$ (Gg $CO_2$) | Calculated | $\Delta SOC$ $CO_2$ = (0 x –(44/12))/1000 = 0 | $\Delta SOC$ $CO_2$ = (12.1 x –(44/12))/1000 = -0.04 | $\Delta SOC$ $CO_2$ = (242.2 x – (44/12))/1000 = -0.89 |
| **Step 6: Calculate total SOC:** *Previous year SOC plus annual SOC change* | | | | |
| Total *SOC* (t C) | Calculated | Total *SOC* = 435,687.3 | Total *SOC* = 435,687.3 + 12.1 = 435,699.4 | Total *SOC*ǂ = 438,235.2 + 242.2 = 438,477.4 |

ǂCalculations for total SOC for t not displayed in this table

| Conversion factors | |
|---|---|
| Unit conversion, t to Gg | $10^{-3}$ |
| Molecular weight ratio, C to $CO_2$ | 44/12 |

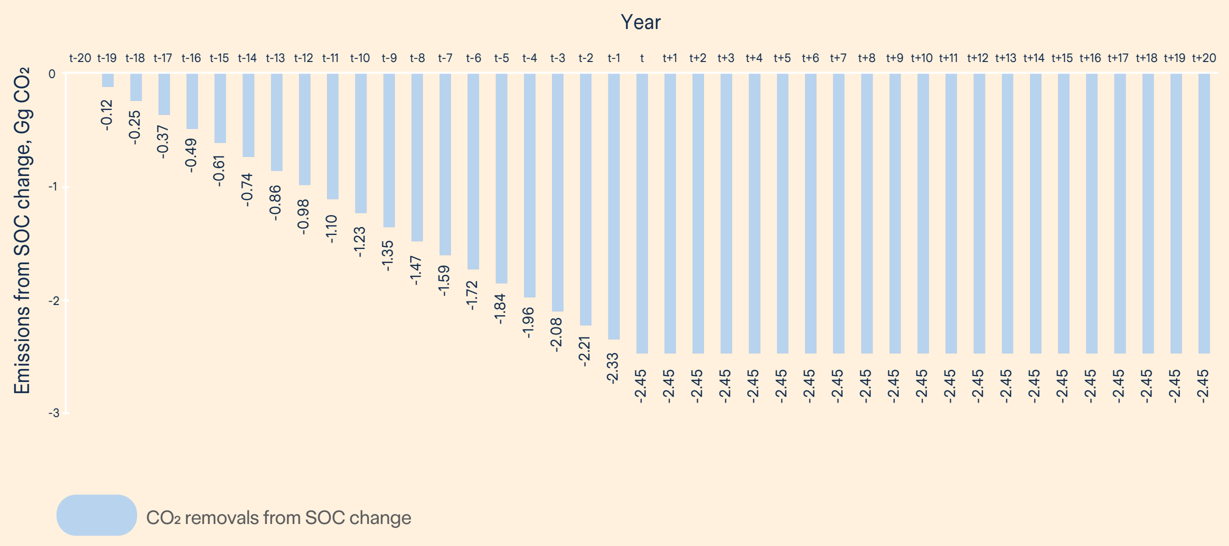
*Convention that increases in C stocks, i.e., positive stock changes, represent a removal, while decreases in C stocks, i.e., negative stock changes, represent a positive emission to the atmosphere.

The user can follow the example calculations to estimate $CO_2$ removals through soil carbon sequestration for the selected baseline scenario.

**Figure 7.3** shows the resulting baseline emission due to change in SOC for the example when all strata have been included.

Refer to this guide's assessment toolkit for additional tools to conduct emission calculations, such as the IPCC Inventory Software.

Figure 7.3. **Emissions from change in SOC for baseline scenario, t is assessment year**




### 7.3.4 Calculate policy soil carbon stocks and emissions

The user should utilise the same process to calculate the policy emissions, however now the policy assumptions (ex-ante) or actual data (ex-post) are applied. The ex-post assessment uses monitored data, while the ex-ante assessment is based on projections. Refer to **Table 7.5** for policy scenario assumptions. The amount of land utilised for annual crop production remains constant at 58,246 ha, as at the start of the implementation period, time t-20.

#### Ex-post policy calculations

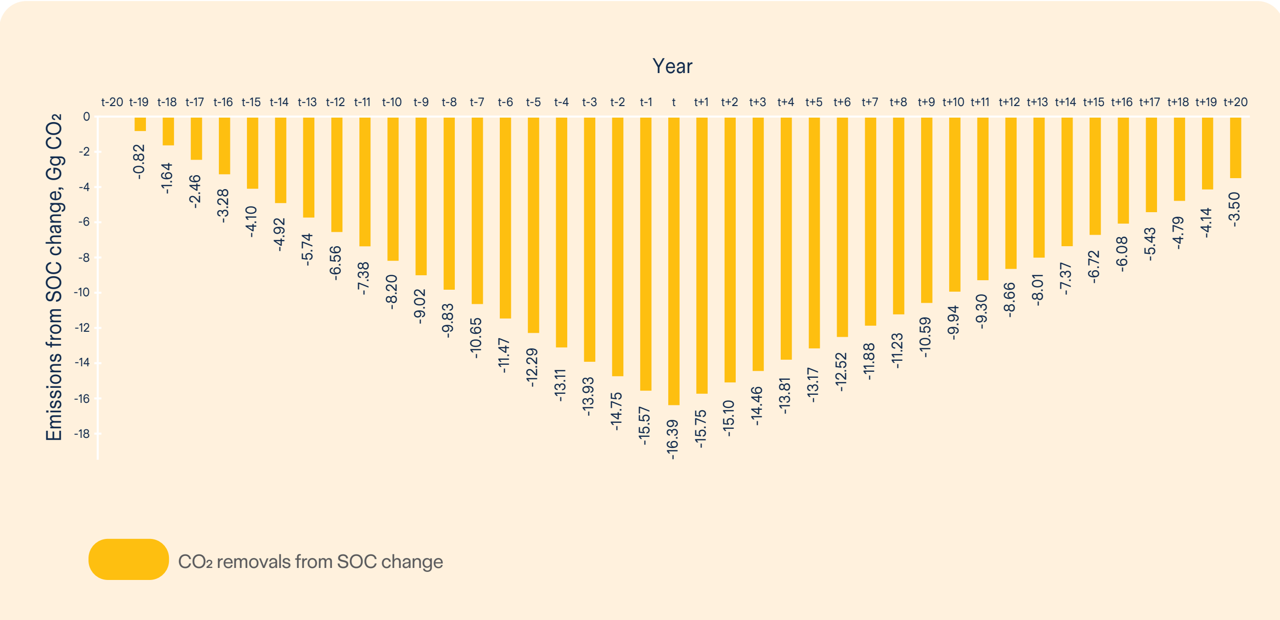
For the ex-post assessment period, the initial value of SOC is based on the condition at the start of the implementation period, i.e., that all land remains under full tillage. The final values of SOC are based on monitored data. At the end of the ex-post assessment period, time t, 31 percent of land was under reduced-till, and 27 percent was under no-till management. A linear trend is assumed for the change in the area that undergoes a transition to different tillage practices. The transition rate varies depending on the crop as shown in **Table 7.8.**

## Ex-ante policy calculations

For the ex-ante assessment period, the policy scenario projects that by t+20, only 25 percent will remain under full till. The remaining 25 percent and 50 percent will be managed with reduced-till or no-till, respectively. Therefore, the linear trend for area changing management will depend on current adoption level. Note that for stratum 1 (corn-soy-alfalfa-alfalfa rotation), the land already meets that target, therefore, no additional change will be expected there. In addition, for stratum 2 (wheat rotation) 60 percent is under reduced-till and 20 percent under no-till so it is assumed that some reduced till areas will be converted to no-till between t+1 and t+20 to reach the policy targets.

With Tier 1, the overall area under full till, reduced-till and no-till is considered in the equations each year. If Tier 2 is used for the calculations, more advanced spatially explicit methods can be used to track parcels of land and associated management on those parcels It can then be seen if the land changes from full till to no-till directly or if some converts to reduced-till first and then no-till. This way Tier 2 can provide more accuracy as the specific conversion stock change factors can be used for each conversion stage. **Figure 7.4** shows the resulting policy change in emissions for the example when all strata have been included. The removals due to change in SOC increase each year during the ex-post assessment period as more land is managed under reduced-till or no-till. During the ex-ante assessment period, the removals due to change in SOC still occur, but slow down as less new land is converted to reduced-till and no-till. In addition, the lands that started conversion more than 20 years ago, reach a new equilibrium and there is no more change in SOC between years, therefore removals are reduced.

Figure 7.4. **Emissions from change in SOC from policy-driven adoption rate of mitigation measure for ex-post and ex-ante assessment periods, t is assessment year**



### 7.3.5 Calculate GHG emissions impact

After calculating the emissions for baseline and policy scenarios, the user can determine the effect of the policy on GHG emissions. The reduction in emissions is the difference between the baseline (WOM) and policy scenario (WAM) as summarised in **Table 7.11.** The National Conservation Agriculture Policy is expected to remove a cumulative total of 289.8 Gg $CO_2$ by time t+20.

The GHG emission change achieved by the policy in the ex-post assessment period is determined by subtracting the cumulative emissions change (i.e., cumulative total of Step 5 in **Table 7.10** between time t-20 and t) in the baseline scenario from the cumulative emissions from the policy. The GHG emission change during the ex-ante assessment period can be determined similarly based on cumulative emission changes between time t+1 and t+20.

The relative impact of the policy (percent change from the start of implementation) can only be determined from the carbon stock values (refer to Step 6 in **Table 7.10**). For the ex-post assessment period, the percent change is the difference between the total SOC (in t C) at time t and time t-20 relative to the initial SOC level at the start of the policy (i.e., SOC at time t-20). For the ex-ante assessment period, percent change is the difference between the total SOC (in t C) at time t+20 and time t-20 relative to the initial SOC level at the start of the policy (i.e., at time t-20).

As summarised in **Table 7.11,** activities under the National Conservation Agriculture Policy led to a removal of 146.4 Gg $CO_2$ during the ex-post assessment period and is expected to remove 143.4 Gg $CO_2$ during the ex-ante period, with a total of 289.8 Gg $CO_2$ removed by t+20, the end of the ex-ante assessment period resulting in an overall 8.3 percent change in total SOC from the start of policy implementation period.

Following the assessment, monitoring performance over time will allow policymakers to evaluate whether measures are reaching projected reductions. If not, the policy could be refined by evaluating whether policy instruments employed by the policy are effective (i.e., technical assistance content, format, or frequency could be adjusted).

Table 7.11. **$CO_2$ removals from improved tillage for ex-post and ex-ante policy periods**

| Policy impact | Reference calculation | WAM EX-POST | WAM EX-ANTE |
|---|---|---|---|
| Total $CO_2$ reduction at the end of the assessment period (Gg $CO_2$) compared to WOM | Ex-post: $\sum_{x=t-20}^{t}(\Delta SOC\ CO_2)_{WAM_x} - \sum_{x=t-20}^{t}(\Delta SOC\ CO_2)_{WOM_x}$<br>Ex-ante: $\sum_{x=t+1}^{t+20}(\Delta SOC\ CO_2)_{WAM_x} - \sum_{x=t+1}^{t+20}(\Delta SOC\ CO_2)_{WOM_x}$ | 146.4 | 143.4 |
| Percent SOC change at the end of the assessment period compared to time t-20 | Ex-post: $\frac{Total\ SOC_{WAM_t} - Total\ SOC_{WAM_{t-20}}}{Total\ SOC_{WAM_{t-20}}}$<br>Ex-ante: $\frac{Total\ SOC_{WAM_{t+20}} - Total\ SOC_{WAM_{t-20}}}{Total\ SOC_{WAM_{t-20}}}$ | 3.9% | 8.3% |

## 7.4 Monitoring policy performance

### 7.4.1 Policy key performance indicators

Users should identify a set of key performance indicators (KPIs) to evaluate policy performance over time. KPIs should include both GHG impact as well as non-GHG metrics that allow tracking of inputs, activities, intermediate effects, or market effects reflecting policy implementation steps and outcomes beyond GHG mitigation.

As part of tracking progress in policy implementation, it is helpful to set targets or anticipated levels for policy KPIs, which can inform further assumptions for estimating the policy's mitigation potential and identify corrective actions. The proposed KPIs for the National Conservation Agriculture Policy have been classified into three main categories. These are: policy impacts, intermediate effects, and inputs and activities.

Policy implementation will be evaluated relative to the start of the policy implementation period with the following KPIs as outlined in **Table 7.12**.

Refer to Section 2.5.1 for an overview and example of KPIs. These are documented during the policy description step of the assessment (**Table 7.1**). If a measure is to be included in country's NDC and KPIs will be used for NDC implementation tracking, the users should make sure that KPIs fulfil the minimum requirements as specified in the modalities, procedures, and guidelines (MPGs) (UNFCCC, 2018).

Additional KPIs are used to evaluate intermediate effects associated with production and manure management to help evaluate if policy inputs and activities are leading to expected results. These KPIs are outlined in **Table 7.13**.

Table 7.12. **Policy impact KPIs for the National Conservation Agriculture Policy**

| Key performance indicator | Target | Achievement goal |
|---|---|---|
| Chance in soil organic carbon | 20% | Year t+40 |

Furthermore, budgetary KPIs will also be tracked to assess policy costs (e.g., per year, quarter, etc.). For instance, extension services have regular budget expenditures to provide technical assistance. Frequently tracking KPIs will help determine where adjustments might be needed. These KPIs are summarised in **Table 7.14.**

The user can also include additional KPIs to evaluate the impact of the policy on SDGs or other interacting activities or policies identified in Section 7.1.6. Examples for the National Conservation Agriculture Policy may include improved water quality and improved profits for farmers from labour savings.

### 7.4.2 Monitoring plan

The users should develop a monitoring plan for tracking the progress of the policy. For the National Conservation Agriculture Program, the national leadership team will develop and implement a monitoring plan and oversee documentation and the process of coordinating with all stakeholders.

To conclude the assessment process, the guidance on summarising the results of the assessment, as well as considering next steps, is in Chapter 9.

Table 7.13. **Policy intermediate effects KPIs for the National Dairy Urea Fertiliser Policy**

| Key performance indicator | Target | Achievement goal |
|---|---|---|
| Proportion of land utilising reduced-till | 25% (ex-post)<br>25% (ex-ante) | Year t+20<br>Year t+40 |
| Proportion of land utilising no-till | 25% (ex-post)<br>50% (ex-ante) | Year t+20<br>Year t+40 |
| Proportion of land sampled following adoption of new practices | 5% for reduced-till<br>10% for no-till | Year t+11 forward for 20 year following new management practice |

Table 7.14. **Policy inputs and activities KPIs for the National Conservation Agriculture Policy**

| Key performance indicator | Target | Achievement goal |
|---|---|---|
| Spend rate of Extension services operational budget to conduct technical assistance and farm visits | No fixed target. Target updates at the beginning of each quarter according to budget allocation | Q1-Q4; Years t+1 – t+40 |
| Spend rate on soil testing activities | No fixed target. Target updates at the beginning of each year according to budget allocation | Year t+11 forward |
| Information campaign reach | Maximise reach based on strategy | Year t+1 – t+40 |

# Chapter 8: Assessing Rice Cultivation Policy Impact



This chapter describes how to conduct a GHG impact assessment for rice cultivation policies. Prior to the assessment, the user has become familiar with key methodological and reporting concepts, identified relevant stakeholders, and considered the objectives of conducting the assessment. The user has also selected a policy for assessment, reviewed the measures likely to be included in the policy, and became familiar with the data types they will need to conduct the assessment.

Refer to Part I and Part II for guidance on planning for the assessment and policy selection and description steps if needed.

Chapter 8 also demonstrates the methodologies using a hypothetical policy example, implemented in a hypothetical country, which is described in the Hypothetical Country section of this guide. In this chapter, the example policy, the National Programme for Sustainable Rice Production, is assessed. The policy includes two mitigation measures, alternate wetting and drying (AWD) and dry direct seeding (DDS) practices. The user should assess the GHG impact of a selected policy with the guidance provided in this chapter and follow the steps described in this example.

Rice is a staple for more than half of the world's population and forms an essential part of the diet in most Asian countries, and it is responsible for 10 percent of global anthropogenic $CH_4$ emissions each year. Through a wide-scale adoption of water management practices, such as AWD, the rice sector could mitigate as much as 48 percent of global methane emissions from paddy rice. However, there is a need for research to help develop guidance and standards for such practices to support adoption of mitigating practices. Studies show that DDS also has the potential to decrease emissions though more research is needed. DDS has additional water-saving benefits and can reduce labour costs making it an attractive management practice for farmers.

## 8.1 Rice policy description and GHG impacts

### 8.1.1 Policy assessment objectives

Users should identify stakeholders affected by the policy and those to be engaged during the policy assessment's planning phase. The stakeholder groups relevant to the National Programme for Sustainable Rice Production are noted in **Table 8.1.**

Further, users should identify assessment objectives before starting the assessment. For the purpose of the example, policymakers identified assessment objectives and held a series of stakeholder consultations to refine the initial assessment objectives. The refined policy assessment objectives were:

- Quantify GHG emission reductions from changes in water management and seeding practices in rice production
- Build support for mitigation measures to be adopted by the decision-makers and farmers
- Track progress toward national goals, e.g., NDC
- Inform policy design

Refer to the ICAT *Stakeholder Participation Guide* in this guide's assessment toolkit. This guide's Appendix B contains additional guidance and resources on stakeholder engagement.

### 8.1.2 Policy description

When starting the assessment, the users should describe the policy in detail. In this chapter's example, the country is currently planning a policy to mitigate emissions from the increased rice production occurring in the country in recent years. Policymakers are currently developing the National Programme for Sustainable Rice Production, which includes two mitigation measures, water management and seeding methodology. The policy supports field research and pilot trials to develop country-specific practice standards and provide technical assistance to farmers to encourage adoption of improved practices. Incentive payments provided to farmers help offset potential operating costs and risks associated with adopting new practices. The policy also has adaptation benefits as adoption of AWD and DDS can reduce water use for rice production by up to 60 percent. The full description of the National Programme for Sustainable Rice Production is in **Table 8.1.**

Refer to Chapter 4 for more information on the process for describing the policy and the Templates section for the policy description template. To effectively carry out an impact assessment, it is necessary to have a detailed understanding and description of the policy being assessed.

Table 8.1. **Description of the National Programme for Sustainable Rice Production**

| Policy description category | Detailed description |
|---|---|
| Name of the policy* | National Programme for Sustainable Rice Production |
| Type of policy* | Research, development and deployment policies<br>Subsidies and incentives |
| Description of specific interventions* | The National Programme for Sustainable Rice Production focuses on two mitigation measures, reducing rice GHG emissions through adoption of AWD and DDS practices. The programme will enable a transition to more sustainable rice production through the following components:<br>▪ Conduct field trials at 5 sites (1 ha each) to improve understanding of the AWD and DDS and develop an implementation pilot and start developing technical guidance and country-specific emission factors (years 1-5)<br>▪ Pilot implementation of AWD and DDS at 10 sites (1 ha each) in farms to grow understanding of practices and refine technical guidance for broader adoption (years 6-10)<br>▪ Develop a technical assistance programme consisting of demonstrations and field days, and management plan preparation based on the technical guidance and knowledge from field trials and the pilot to support broader adoption of AWD irrigation and DDS and assist participants with developing management plans appropriate for their implementation (years 11-20). Demonstrations and field days are to be held at the country's flagship farms managed by extension services or pilot locations. Note: 6 flagship farms were established by the National Agriculture Policy Act of 2020, see Hypothetical Country description for more details<br>▪ Establish and deploy annually the Rice Cultivation Methane and Nitrous Oxide Assessment (RCMNOA) survey. RCMNOA survey will inform extension services' local farm management recommendations and improve activity data collection about rice production (development years 1-5, pilot deployment years 6-10, broad deployment years 11-20)<br>▪ Update management plans to guide implementation of AWD and/or DDS practices (years 11-20)<br>▪ Provide participants with a start-up payment scalable to the size of their rice operation and extent of expected and later demonstrated changes<br>▪ Conduct routine site visits to assist with and monitor the implementation of management plans<br>At least 5 years are planned for field trials, an additional 5 years will be allotted for bigger-scale pilots, with a subsequent 10-year period for delivery of technical assistance and implementation of practices.<br><br>The main policy implementation mechanisms are technical assistance (research, development, and deployment) and the provision of financial incentives (subsidies and incentives), coupled with monitoring and verification of activities and enhanced data collection. |
| Status of the policy* | The policy is being developed, based on the different results from implementing the AWD and DDS practices in research trials globally. More research is needed to develop appropriate technical guidance applicable to local farmers. |

Table 8.1. **Description of the National Programme for Sustainable Rice Production (Continued)**

| Policy description category | Detailed description |
|---|---|
| Date of implementation* | Policy is under development and has not gone into effect yet, implementation to planned to begin in 2030 |
| Date of completion* (if relevant) | Policy activities are planned for a 20-year implementation period |
| Implementing entity* or entities | Ministry responsible for Agriculture |
| Objectives and intended impacts or benefits of the policy* | Improve understanding of and transition to sustainable rice production methods in order to protect the environment, economy, and food security of the nation. Specifically:<br>▪ Reduce total GHG emission from rice cultivation ($CH_4$ emissions to decrease while $N_2O$ emissions are projected to increase)<br>▪ Conserve water due to better irrigation systems, water retentions and reduced losses<br>▪ Accelerate adoption of improved rice cultivation management<br>▪ Increase economic output for rice farmers by improving crop productivity |
| Level of the policy National | National |
| Policy inputs | The following inputs are needed to implement the policy:<br>▪ Funding allocation to support:<br>  ▪ Personnel to provide technical assistance, monitoring, and data management and analysis<br>  ▪ Research grants to conduct field trials<br>  ▪ Funding to conduct pilot programme (farmers to be reimbursed for all expenses)<br>  ▪ Incentives for demonstrated changes in practice, which will cover additional operating costs required to make changes in seeding practices (USD 500/yr) for each participating farmer. Note: incentive levels based on available funding allocations, a typical cost of implementing practices, and expert judgement from survey design professionals<br>▪ Expertise to administer the programme, including:<br>  ▪ Researchers designing and conducting field trials and analysing results<br>  ▪ Dedicated extension agents who will conduct demonstrations, assist farmers in developing management plans and perform farm site visits<br>  ▪ Dedicated agency staff who will administer the pilot and manage data collection and analysis from RCMNOA survey |
| Policy activities | Policy activities include:<br>▪ Conduct field trials<br>▪ Conduct pilot studies on AWD and DDS<br>▪ Develop and distribute the RCMNOA survey<br>▪ Develop technical guidance for and provide technical assistance to develop management plans with AWD and DDS<br>▪ Set up system to administer payments to farmers adopting new practices during the pilot and implementation phases. Conduct site visits to provide technical assistance and verify practices |

Table 8.1. **Description of the National Programme for Sustainable Rice Production (Continued)**

| Policy description category | Detailed description |
|---|---|
| Geographic coverage | Land where rice can be cultivated (30,287 ha) |
| Sectors affected* | Agriculture, rice production |
| Greenhouse gases affected* | $CH_4$, $N_2O$ |
| Other related policies or actions | None |
| Intended level of mitigation to be achieved and/ or target level of other indicators (if relevant)* | The mitigation target of the National Programme for Sustainable Rice Production is to reduce GHG emissions by 10% by time t+20<br><br>Additional targets that support activities to achieve GHG reductions are related to data collection, implementation of technical assistance, and uptake of practices by farmers. By time t+20, the policy aims to have:<br>▪ 30% of farmers respond to RCMNOA survey<br>▪ 50% of farmers attend field days and receive technical assistance<br>▪ 20% of farmers will implement changes on farm |
| Key stakeholders | ▪ Rice farmers<br>▪ Education and research institutions: e.g., National Agriculture Research Institute<br>▪ National government agencies: e.g., Ministry responsible for Agriculture, Ministry responsible for Water Resources<br>▪ Regional and local government entities<br>▪ Government entities responsible for agriculture: e.g., Department of Agriculture Extension<br>▪ Extension services<br>▪ Ministry responsible for the Environment, in charge of coordinating the National Agriculture Inventory<br>▪ NGOs or civil society organisations<br>▪ Communities, indigenous peoples, or marginalised groups that are involved in or are affected by agriculture<br>▪ Producer associations<br>▪ Suppliers of equipment and inputs<br>▪ Rice milling companies |
| Title of establishing legal framework, or other founding documents | Policy still being developed, expected to be adopted through the National Agriculture Policy Act of 2025 |
| Monitoring, reporting and verification procedures | ▪ Completion of RCMNOA survey and supporting records of management plans and practices adopted by farmers<br>▪ Annual farm visits conducted by agricultural extension agents to all farms receiving payment to verify implementation |

Table 8.1. **Description of the National Programme for Sustainable Rice Production (Continued)**

| Policy description category | Detailed description |
|---|---|
| Policy Key Performance Indicators (KPIs) | The proposed KPIs for the National Programme for Sustainable Rice Production include:<br>▪ $CH_4$ and $N_2O$ emissions<br>▪ Emission intensity, GHG emissions per unit of production<br>▪ Water consumption<br>▪ RCMNOA survey response rate<br>▪ Number of farmers receiving technical assistance<br>▪ Proportion of land with verified AWD and/or DDS practices by the end of the policy period<br>▪ Pilot trials conducted<br>▪ Field trials conducted<br>▪ Spend rate of Extension services operational budget to conduct research, technical assistance, and farm visits<br>▪ Spend rate on research activities<br>▪ Value of incentive payments disbursed<br>KPIs and associated target levels are discussed in more detail in Section 8.4.1 |
| Compliance and enforcement mechanisms | Participation in the programme is voluntary. However, to receive incentive payments, farmers must submit the RCMNOA survey annually. Furthermore, compliance is verified through the annual MRV farm visit. Extension agents will monitor the implementation of practices when conducting farm visits. |
| Reference to relevant documents | Technical guidance documents and implementation standards for new practice available for distribution online and at regional extension offices |
| The broader context or significance of the policy | Water management is going to be essential as the world experiences water shortages and droughts as a result of climate change. Rice farmers will have to contend with changing water regimes in their operations and adapt to water-limited growing conditions.<br><br>Consideration of other agronomic and technical practices (e. g., nitrogen application rates, management of residues, etc.) are not directly assessed but they are very important for recommending appropriate practices that will ensure the policy objectives are met. Information collected through the RCMNOA survey will be crucial in tracking policy implementation progress, in particular ensuring that AWD and DDS practices maintain grain yield and reduce $CH_4$ emissions. The use of AWD system and DDS, in particular, show promising results for reducing $CH_4$ emissions but it may come with a trade-off in terms of increasing $N_2O$. Soil $N_2O$ emissions might need to be further mitigated by adjustments to fertilisation practices. |
| Outline of sustainable development impacts of the policy | Increase economic benefit to farmers, reduce land degradation, and conserve water. |
| Other relevant information | Rice cultivation is a multifactor system, so other agronomic practices that affect GHG emissions should be considered as data to assess them becomes available. |

*indicates required reporting under the Enhanced Transparency Framework under the Paris Agreement

Users should describe the selected policy according to the example utilising the template.

### 8.1.3 Intermediate effects and GHG impacts

Once the policy is described, the users must document how all the inputs, activities, and intermediate effects lead to changes in behaviour, technology, processes, or practices. Outlining these changes includes understanding which parameters are affected, what is the direction and magnitude of the effect, and where and when this effect is expected to take place. This process helps to determine the policy scenario for the quantification of GHG impacts. Affected parameters may include market-based factors such as decreased operational costs from decreased labour and water use. Policy activities may also lead to intermediate effects that lead to trade-offs and some may increase GHG emissions.

Consideration of emission trade-offs is particularly important in rice cultivation systems as any change in water management will influence $CH_4$ and $N_2O$ emissions. It is expected that when implementing AWD and DDS practices, $CH_4$ emissions would be reduced while $N_2O$ emissions from soils are expected to increase though the overall GHG emissions are still expected to be mitigated. The assessment quantifies the magnitude of trade-offs in emissions between $CH_4$ and $N_2O$ and is crucial to inform decision-making and to ensure the success of any policy. A description of intermediate effects and associated GHG impacts is the next step of the description process and will help identify and consider such trade-offs.

The inputs, activities, and intermediate effects of the National Programme for Sustainable Rice Production are summarised in **Table 8.2**.

Refer to Chapter 4 for more information on the process for describing the policy intermediate effects and GHG impacts and the Templates section for templates to describe intermediate effects and GHG impacts.

Table 8.2. **Inputs, activities, and intermediate effects (changes in behaviour, technology, processes or practices) resulting from the National Programme for Sustainable Rice Production**

*(I)=input, (A)=activity, (IE)=intermediate effect*

| Inputs, activities, intermediate effects | Detail/ explanation | Affected parameter | Direction | Magnitude | Geographic location | Timing |
|---|---|---|---|---|---|---|
| (I) Allocate funding and hire staff to administer the programme | Fund for research projects and incentive payments is set up; staff with appropriate expertise is available to administer the policy | Personnel can begin to implement activities under the policy | NA | USD 20M | Fields where trials are conducted will be the basis for informing national decisions | Year 1 |

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Table 8.2. **Inputs, activities, and intermediate effects (changes in behaviour, technology, processes or practices) resulting from the National Programme for Sustainable Rice Production. (Continued)**

| Inputs, activities, intermediate effects | Detail/ explanation | Affected parameter | Direction | Magnitude | Geographic location | Timing |
|---|---|---|---|---|---|---|
| (A) Establish policy administrative procedures | A system is set up to fund and conduct field/pilot trials, distribute surveys, conduct farm visits, verify practices, and provide payments to farmers | Distribution of funds for research and incentives, collection of data, administration of policy activities | NA | NA | National | Year 1 and ongoing as pilot and implementation phase begin |
| (A) Conduct field trials and pilots | Research to characterise practice performance, develop practice standards, and collect data for country-specific emission factors | Knowledge base about management practices increases, preliminary data is generated, country's MRV system is strengthened | Increase | 5 field trials and 10 pilot trials will be conducted (1 ha each) | National | Field trials will be completed in years 1-5, pilot trials will be completed in years 6-10 |
| (A) Develop and distribute RCM-NOA survey | Annual survey (Mailing/ online) to collect information about rice production and management is deployed | Creates a reporting mechanism and enables consistent activity data generation enhancing the country's MRV system | Increase | 30% response rate by year 11-20 | National | Year 1-5 development; year 6-10 pilot; year 11-20 broad distribution |
| (A) Extension agents develop technical guidance and practice standards and provide technical support | To increase level of knowledge farmers and help transition farmers in adopting new management practices | Extension agents assist in developing management plans to help farmers adopt new practices | Increase | 50% of rice farmers receive technical assistance | National | Year 1-5: draft guidance<br><br>Year 6-10: final guidance<br><br>Year 11-20: technical support |

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Table 8.2. **Inputs, activities, and intermediate effects (changes in behaviour, technology, processes or practices) resulting from the National Programme for Sustainable Rice Production. (Continued)**

| Inputs, activities, intermediate effects | Detail/ explanation | Affected parameter | Direction | Magnitude | Geographic location | Timing |
|---|---|---|---|---|---|---|
| (A) Extension agents conduct farm visits | Follow-up recommendations and assistance for individual farm plan to change AWD irrigation and DDS. Extension service will validate changes in practices for subsidy payments. | Adoption of new management practices | Increase | 50% of rice farmers receive technical assistance | On-farm | Year 6-10 for pilot, year 11-20 for implementation |
| (IE) Farmers adopt AWD and DDS* | AWD and DDS are implemented to mitigate emissions from rice production | Multiple parameters are affected, including water use, fertiliser application rates, grain yield, and GHG emissions (see **Table 8.3** for details) | Depends on parameter | 20% of all rice production area by end of implementation period | On-farm | Year 11-20 |
| (IE) Decreased labour for seeding | Dry direct seeding reduces the amount of labour that is needed in traditional transplanting method | Operational costs for farmers** | Decrease | Variable | On-farm | Year 11-20 |
| (IE) Increased equipment use for DDS | Machinery is used in direct seeding as opposed to manual transplanting of germinated rice | Fuel consumption, operational costs for farmers** | Increase | 20-30% | On-farm | Year 11-20 |

Table 8.2. **Inputs, activities, and intermediate effects (changes in behaviour, technology, processes or practices) resulting from the National Programme for Sustainable Rice Production (Continued)**

| Inputs, activities, intermediate effects | Detail/ explanation | Affected parameter | Direction | Magnitude | Geographic location | Timing |
|---|---|---|---|---|---|---|
| (IE) Decreased water use | With both AWD and DDS, less water is used during production | Operational costs for farmers** | Decrease | 60% | On-farm | Year 11-20 |
| (IE) Uniform germination and improved grain quality | Dry seeding leads to more uniform germination and growth for rice plants | Profit from grain sales** | Increase | Variable | On-farm | Year 11-20 |

*indicates intermediate effects that are policy mitigation measures
**indicates market-based impacts

Once the policy inputs, activities, and intermediate effects have been documented, as shown in **Table 8.2**, the user can further analyse those that lead to changes in GHG emissions and detail the steps that describe how the changes in GHG emissions occur.

The user should also consider and identify whether the effects associated with policy activities are intended or unintended (Rich, 2014). Intended effects are based on the original objectives of the policy. However, as mentioned in the previous section, intended effects may have trade-offs in emissions. Unintended effects typically represent effects that fall outside of the policy's control and may amplify or diminish the impact of the policy.

The GHG impacts associated with the National Programme for Sustainable Rice Production are summarised in **Table 8.3.**

It is a key recommendation to work with agriculture experts during this part of the assessment step to analyse intermediate effects and identify potential GHG impacts of the policy.

Table 8.3. **GHG Impacts of the intermediate effects of the National Programme for Sustainable Rice Production**

| Intermediate effect* | Subsequent intermediate effects | | | Potential GHG impact |
|---|---|---|---|---|
| | Effect 1 | Effect 2 | Effect 3 | |
| Adoption of AWD | Less water used | Limit anaerobic action of methane bacteria | Avoid evapotrans-piration caused by excess of water | Reduced $CH_4$ emissions and increased direct and indirect $N_2O$ emissions |
| Adoption of DDS | Less water used | Limit anaerobic action of methane bacteria | Better use of nutrients that are applied at seeding time. | Reduced $CH_4$ emissions and increased direct and indirect $N_2O$ emissions |
| Adoption of DDS | Increase in equipment use | Increase in fuel consumption | Increase in fuel combustion | Increased $CO_2$ emissions |

*indicates intermediate effects that are policy mitigation measures

Similar to the example, users should be able to outline the intermediate effects and GHG impacts of the selected policy.

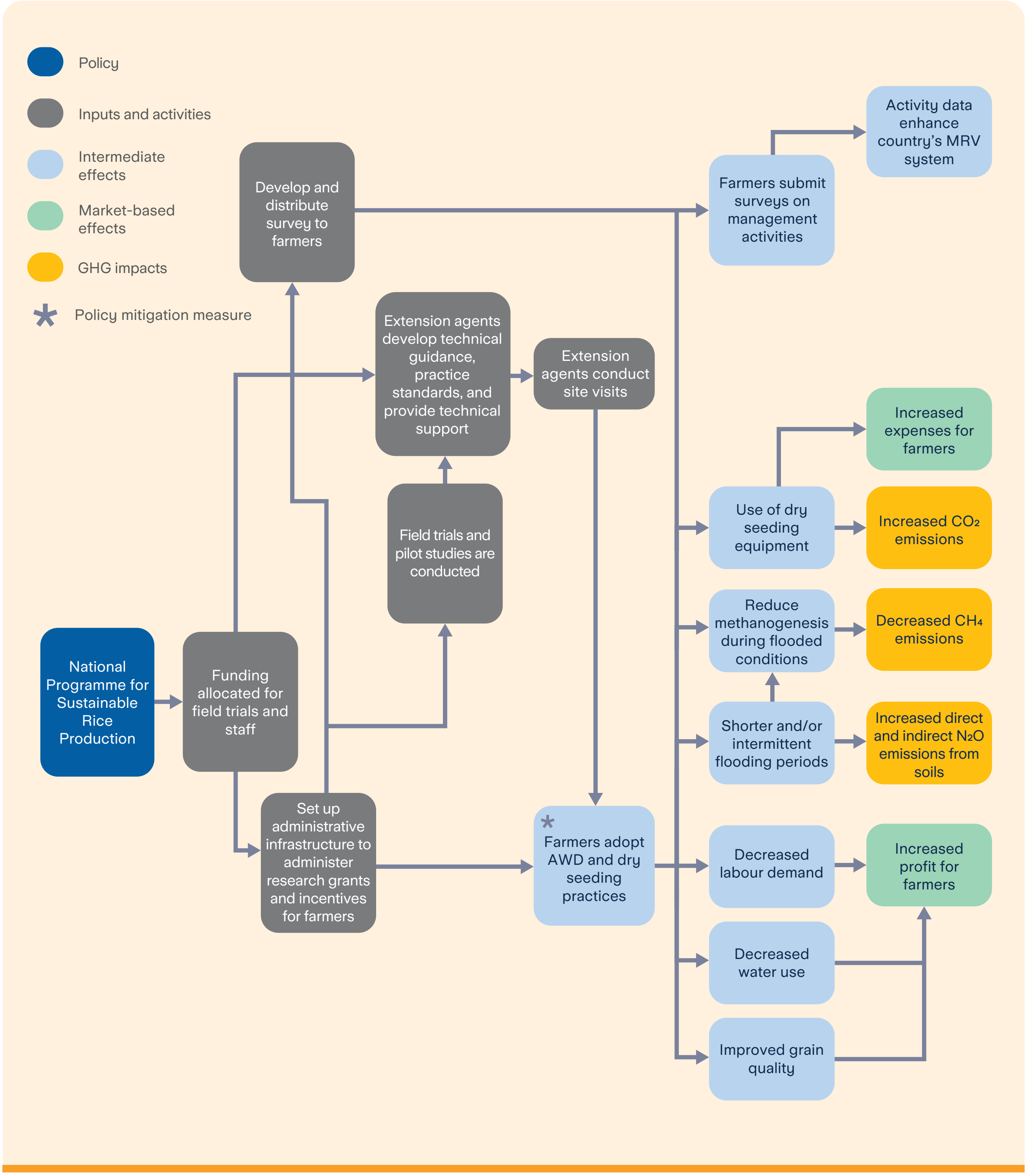
### 8.1.4 Causal chain

A causal chain is a conceptual diagram tracing the process by which the policy leads to GHG impacts through a series of interlinked logical and sequential stages of cause-and-effect relationships. In parallel with the identification of intermediate effects and GHG impacts, the user should prepare a causal chain to better understand, visualise, and communicate how the policy and its corresponding inputs and activities cause intermediate effects and ultimately result in GHG impacts. The causal chain is a visual representation of the information about the policy from **Tables 8.2** and **Table 8.3.** It can also help reveal interdependencies between and the order of implementation of the different activities under the policy that is more challenging to visualise in a table format. The causal chain for the National Programme for Sustainable Rice Production is shown in **Figure 8.1.**

Visualising the policy causal chain is likely to lead to the refinement of the information listed in **Table 8.2** and **Table 8.3.** The causal chain can be a useful tool for engaging stakeholders in understanding policy design and its effects.

Refer to the Templates section for a template to develop a causal chain following the demonstrated example.

**Figure 8.1. The National Programme for Sustainable Rice Production causal chain**



### 8.1.5 Assessment boundary and period

#### Policy assessment boundary

Once all the potential GHG impacts are identified, the user will determine which ones will be included in the assessment boundary. Determining the policy assessment boundary includes a three-part process of estimating:

- the likelihood of GHG impact
- the expected relative magnitude of GHG impact
- the significance of each GHG impact

The user should then select which impacts will be estimated within the assessment boundary. Typically, the user has a limited number of resources to conduct the assessment. This three-part estimation helps the user to prioritise assessing impacts that are likely and major in size. Impacts considered very likely, likely, or possible in combination with their GHG impact being either moderate or major are significant and should be included in the assessment boundary.

For the National Programme for Sustainable Rice Production, all of the GHG impacts identified in **Table 8.3** were considered. The results of this process are outlined in **Table 8.4.** Changes in $CH_4$ and direct $N_2O$ emissions due to implementing AWD are included in the assessment because they were classified as significant. Changes in $CH_4$ emissions due to implementing DDS are included in the assessment because they were classified as significant.

Refer to Chapter 4 for guidance on determining the significance of GHG impacts and the Templates section for templates to determine assessment boundary.

Table 8.4. **Likelihood, magnitude, and significance of GHG impacts of the National Programme for Sustainable Rice Production**

| Mitigation measure | GHG impact | Likelihood | Relative magnitude | Significance |
|---|---|---|---|---|
| AWD | Reduced $CH_4$ emissions from decreased water use | Very likely | Major | Significant |
| AWD | Increased direct $N_2O$ emissions from decreased water use | Likely | Moderate | Significant |
| AWD | Increased indirect $N_2O$ emissions from decreased water use | Unlikely | Unknown | Not estimated (limited research available) |
| DDS | Reduced $CH_4$ emissions from decreased water use | Possible | Major | Significant |
| DDS | Increased direct $N_2O$ emissions from decreased water use | Likely | Unknown | Not estimated (limited research available) |
| DDS | Increased indirect $N_2O$ emissions from decreased water use | Unlikely | Unknown | Not estimated (limited research available) |
| DDS | Increased $CO_2$ emissions from increased equipment use and fuel consumption | Likely | Minor | Not estimated (outside scope) |

For policies that have unintended effects on other agricultural emission sources such as from fertilisers or soil carbon sequestration, refer to Chapter 6 and Chapter 7 of this guide, respectively.

Users should evaluate the intermediate effects and GHG impacts of the selected policy and determine the assessment boundary similar to the example. Emissions from increased fuel consumption are expected to be minor in magnitude and would be reported under the Energy sector. Despite increased fuel emissions, overall GHG emission reduction is expected.

If land use change occurs as a result of the policy, such as conversion of forest land to cropland, users may also refer to the ICAT *Forest Methodology* to estimate associated GHG impacts. Furthermore, assessing unintended effects outside the AFOLU sector (e.g., emissions from fuel combustion) is outside the scope of this guide.

#### Policy assessment period

Ex-ante assessment period is the planned policy implementation period. The National Programme for Sustainable Rice Production has three phases: years 1-5 to conduct field trials on AWD and DDS practices; years 6-10 to pilot practices on farms at a bigger scale and develop practice standards, and years 11-20 for broader adoption of practices. During the second and third phases, technical assistance is provided to support the implementation of AWD and DDS practices. Changes in GHG emissions are expected to occur during years 11-20 of the policy. For the purpose of the example, assessment is being conducted at time t and the assessment period is t – t+20.

### 8.1.6 Other policy synergies and interactions

Users should qualitatively describe potential policy synergies and interactions. Quantitative assessment of interacting policies is beyond the scope of this guide; however, it is important to identify them to inform future policy decisions. Adoption of other agricultural policies and programmes that aim to improve rice production or more efficient fertiliser use in the country may have additional synergistic impacts or may result in trade-offs that counter the emission reduction achieved by a policy such as the National Programme for Sustainable Rice Production.

Rice cultivation policies may have implications for activities and policies related to nutrient management. Changing rice water regimes or seeding practices may lead to adjustments to fertiliser use to maintain crop yield. Other measures that deal with rice production measures, e.g., introducing organic amendments or managing crop residue differently, would alter overall nutrients management practices in the system and can lead to changes in emissions. Rice cultivation also has implications for water use. Practices that involve water management and lead to water savings can support policies that address water conservation activities and climate adaptation measures in agriculture.

Describing the policy and identifying policy interactions lays the groundwork for a more detailed evaluation of policy interactions or non-GHG policy impacts, for example, sustainable development, which the user may conduct in addition to the GHG impact assessment. Agriculture Policy can also lead to improvements in water quality due to reduced soil erosion. Increased organic matter that results from implementing reduced-till and no-till practices is also a promising adaptation option as it can stabilise the soil structure and make soil more resilient to both flooding and drought conditions that are likely to occur as a result of climate change.

Refer to the WRI's Policy and Action Standard in this guide's assessment toolkit for additional resources on assessing policy interactions. Furthermore, refer to the ICAT *Sustainable Development Methodology* for additional resources for assessing sustainable development impacts.

After completing the policy description, the user is ready to quantify the GHG emissions impacted by the policy.

## 8.2 Methodological considerations

### 8.2.1 Methodology for assessing GHG emissions

Users should determine which methodological tier to apply in their assessment based on data availability. This guide recommends reviewing the country's GHG inventory to identify which methodological tier was utilised, because it may highlight the level of data characterisation potentially applicable for use within the assessment. Initially, data availability is the main factor in selecting the calculation tier. If it is determined that emissions constitute a key source category based on key category analysis as described in the IPCC 2006 GL, the country will need to invest in further data collection to use a higher calculation tier. Under the ETF reporting requirements, the emissions associated with rice production are reported in CRT 3C, in GHG Inventory categories 3.C.1a and 3.C.1.b.ii for continuously flooded and intermittently flooded rice with multiple drainage periods, respectively. Direct $N_2O$ emissions from synthetic fertiliser applied for rice cultivation would be reflected in GHG Inventory category 3.D.1.a.

The methodology in this guide is based on the IPCC 2006 GL and 2019 Refinement. The policy assessment example uses methods, equations, default values, and parameters from the 2019 Refinement.

For the purpose of assessing the National Programme for Sustainable Rice Production, country-specific emission factors for different water regimes are not available. Tier 1 is used for estimating the baseline scenario emissions, in the absence of mitigation measures. To capture changes associated with mitigation measures such as seeding methodology, adjustments to emission factors are necessary.

Studies on similar systems were used to adjust default emission factors to reflect changes associated with DDS practices. Therefore, a simplified Tier 2 method was used to estimate policy scenario emissions, when mitigation measures are implemented.

In the assessment, default parameters are based on values for South Asia due to similar climate characteristics assigned to the hypothetical country. When converting $CH_4$ and $N_2O$ to emissions expressed in $CO_2e$, users should, to ensure consistency, utilise the same GWP as the one used in their current GHG inventory to ensure consistency.

Refer to the 2019 Refinement for National GHG Inventories, Volume 4, Chapter 5, Figures 5.2 and Chapter 11, Figure 11.2 and Figure 11.3 in this guide's assessment toolkit to view the tier decision trees for further guidance on choice of method (Chapter 5 for $CH_4$ emissions, Chapter 11 for $N_2O$ emissions). Note that Tier 2 methods for $CH_4$ calculations use the same methodological approach but use country-specific emission factors and parameters and allow inclusion of additional factors for rice cultivar and soil type. Utilising Tier 2 or Tier 3 should result in more accurate estimates.

### 8.2.2 Baseline scenario

The user will need to establish a baseline scenario to estimate GHG emissions without mitigation measures.

First, the user should establish whether and how the rice production area will change over the course of the assessment period. Economic data can be used to infer demand for rice and the potential expansion of production area. When using economic data (e.g., an output or yield), trends in demand are used as a proxy for estimating the expected crop yield in the baseline scenario. Users can use national rice demand forecasts, extrapolate based on historical data on rice demand, or consider trends in GDP, population, or other proxy factors to estimate how demand for rice will change during the assessment period.

Where the above data sources are unavailable, the users can estimate future rice demand or production based on **expert judgement**. Users can consult national economic experts for estimating the sector's market growth, to provide the annual growth rate for demand or consult experts regarding domestic rice consumption projections. Using this as an indicator of expected growth, rice production to meet projected demand can be estimated. The baseline scenario should also capture the current management practices and the extent to which management might change over the assessment period in the absence of mitigation measures.

For the purpose of assessing the National Programme for Sustainable Rice Production, the baseline scenario is termed the scenario without measures (WOM) and is summarised in **Table 8.5.** The baseline is constant as the area under rice cultivation is expected to stay the same. According to expert judgement, due to land availability limitations and other constraints, the growing demand for rice production in the country is expected to be met by increased investment into increasing production efficiency rather than expanding cultivation area, as has occurred in the last 20 years. The baseline scenario assumes there would otherwise be no changes in technology, management practices, or levels of production without the policy. Based on consultations with national rice experts and extension agents, these assumptions were confirmed as reasonable.

Currently, rice is produced using an irrigated continuously flooded with transplanted rice cropping system according to conditions provided in the Hypothetical Country section. In this method, rice nursery and the seedlings are transplanted into flooded fields (Bouman et al., 2007). Trained labour is required for the nursery and the transplanting of seedlings of rice crop (Farooq et al., 2001). Puddled condition of rice field is maintained by applying a uniform quantity of irrigation and mechanical operations in the soil. There is double cropping of rice produced under conventional tillage. The non-flooded pre-season is 70 days on average. All the straw is burned and there are no organic amendments used in the system. Di-ammonium phosphate (DAP) and urea fertilisers are used during production. DAP is applied at the rate of 188 kg/ha for each cultivation season. Urea is applied at the rate of 218.8 kg/ha for each cultivation season. Application rates are based on hypothetical country data and validated by expert opinion. All rice is cultivated by traditional puddled transplanting method. After transplanting of rice nursery, a continuous flooding is maintained for crop establishment and weed control. For traditional production system, about 3,500-4,500 L of irrigation water are utilised for production of 1 kg of rice (Joshi et al., 2013).

Refer to Section 2.3 for an overview of approaches to constructing a baseline.

Refer to this guide's assessment toolkit for resources on baseline projections and potential data sources such as the World Bank Open Data to inform baseline scenario.

### 8.2.3 Policy scenario

The user will need to establish a policy scenario to estimate GHG emissions with mitigation measures.

For the purpose of assessing the National Programme for Sustainable Rice Production, the policy scenario is termed scenario with additional measures (WAM). The area under rice cultivation is expected to stay the same. Rice management changes due to policy are outlined in **Table 8.5**. Rice area where AWD and DDS are adopted is expected to increase by 2 percent each year, starting in year 11 of the policy assessment period. All other management parameters, i.e., residue management and inputs, remain the same.

It is anticipated that AWD and DDS practices will not affect productivity; therefore, emission intensity (i.e., GHG emissions per unit of production) is expected to decrease. Emission intensity is selected as one of the KPIs (see **Table 8.1** and Section 8.4.1) to track policy implementation. The policy scenario assumes there would otherwise be no changes in technology or land use.

Refer to Appendix A for additional guidance on estimating the implementation potential of a policy. Note that users can assess one or more policy scenarios to help refine policy design.

Table 8.5. **Key assumptions for baseline (WOM) and policy (WAM) scenarios**

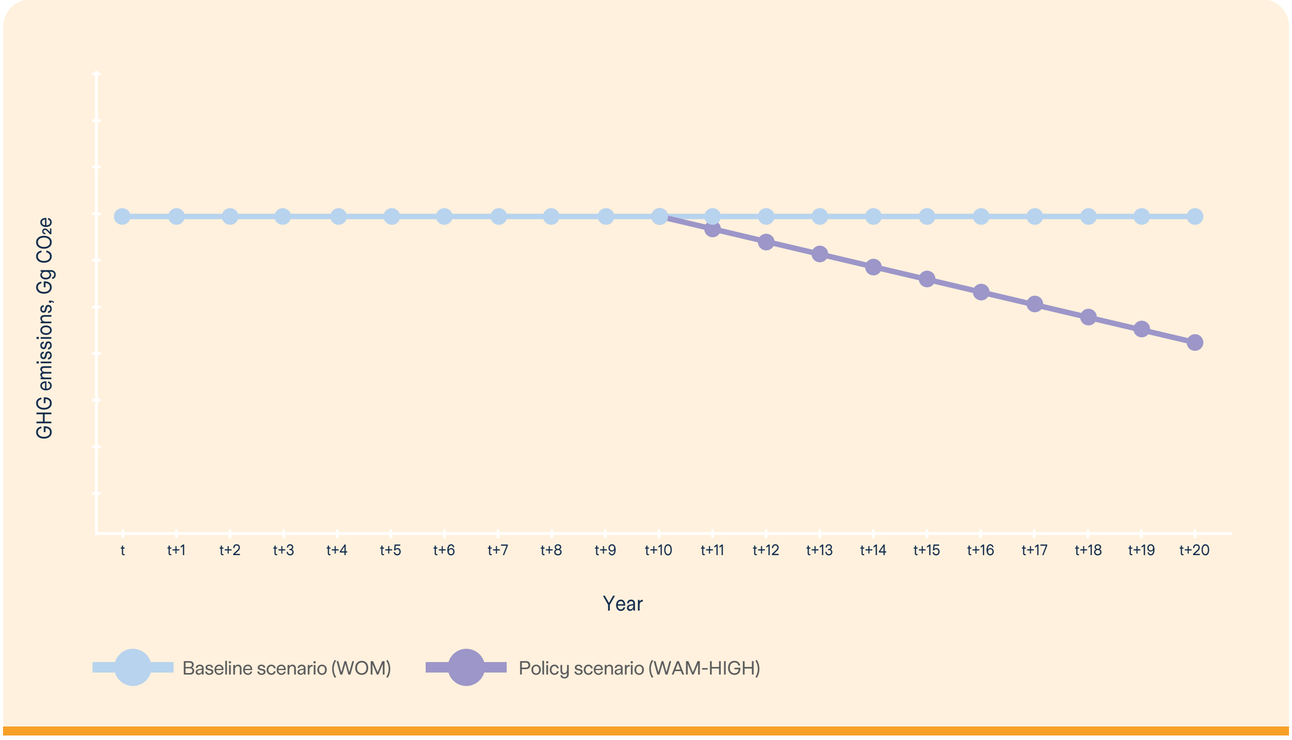
| Scenario description | WOM | WAM |
|---|---|---|
| Rice cultivation area (2 seasons/yr) | 30,282 ha | No change |
| Adoption of AWD and dry seeding practices, starting year t+11, 2% each year | - | 20% of harvested area by the end of policy implementation period |
| Water regime during cultivation | Irrigated, continuously flooded | Irrigated, multiple drainage periods |
| Rice $CH_4$ emission factor reduction from changes in seeding methodology* | - | -80% |

*Tao et al., 2016, daily $CH_4$ average reduction for implementing direct seeding of rice

Assumptions regarding the level of uptake of practices are based on consultation with extension agents. Expected participation and adoption levels are contingent on the establishment of practice standards and effective technical assistance delivery. In addition to applying default emission factors available to reflect emission changes associated with implementing AWD under the policy, peer-reviewed studies served as a basis for determining emission reduction rates for mitigation associated with different seeding methodologies.

A conceptual diagram of the policy impact is demonstrated in **Figure 8.2** for the example with the policy scenarios included in the assessment. The cumulative impact of the policy is determined by summing the annual impact for the duration of the assessment period.

Figure 8.2. **Conceptual diagram showing the relationship between baseline and policy scenario emissions**



The example demonstrates how the users should establish baseline and policy scenarios for the policy selected for assessment.

### 8.2.4 Data for assessment

The users must identify activity data and parameters needed to conduct the assessment and specify, to the extent possible, the sources of the data. For the purpose of assessing the National Programme for Sustainable Rice Production, $CH_4$ emissions and direct $N_2O$ emissions from synthetic N fertiliser are included. As research is conducted in the first 10 years of the policy, data to derive country-specific parameters and emission factors to estimate changes in indirect $N_2O$ emissions will become available.

The information needed to conduct the GHG impact assessment and associated data sources are outlined in **Table 8.6.** Most of the required data were available from the national GHG inventory (e.g., rice cultivation area, climate zones). Activity data used in this example are summarised in the Hypothetical Country section of the guide. Furthermore, by design of the policy, RCMNOA survey will collect necessary water management data, as well as key data on rice production, which will contribute directly to improving the accuracy of $CH_4$ and $N_2O$ estimates in the future (both for this policy and for the national GHG inventory). The 2019 Refinement outlines default emission factors, GHG estimation methods, and other relevant parameters for this estimation (2019 Refinement, Volume 4, Chapter 5 and Chapter 11). Activity data and emission factors used in the calculations are presented in the following sections.

Refer to the Technical Supplement for activity data and emission parameters needed for quantifying GHG emissions associated with rice cultivation mitigation measures for both Tier 1 and Tier 2 methods.

Table 8.6. **Sources of data for rice GHG emission estimation**

| Data type | Data sources |
|---|---|
| Rice land ecosystem classification | Information on cropping systems comes from the national agriculture survey and is validated by national experts. For calculations, users need to have data on:<br>▪ Yield<br>▪ Water regime before and during cultivation: ecosystem and flooding pattern<br>▪ Number of cropping seasons<br>▪ Area harvested (Note: Area harvested = Area in production x cropping seasons)<br>Data can also be obtained from FAO's database, FAOSTAT |
| Cultivation period | Information comes from national agriculture survey; default value available from the 2019 Refinement, Volume 4, Chapter 5, Table 5.11a |
| Crop residue management | Information comes from the national agriculture survey on the fraction of residue<br>▪ Incorporated<br>▪ Burned<br>▪ Grazed<br>▪ Collected |

Table 8.6. **Sources of data for rice GHG emission estimation (Continued)**

| Data type | Data sources |
|---|---|
| Application rate of organic amendments | Information on the type and amount of organic amendments used comes from the national agriculture survey, referred to as ROA. To utilise default conversion rate parameters, categorise organic amendments as:<br>▪ Straw incorporated shortly (<30 days) before cultivation<br>▪ Straw incorporated long (>30 days) before cultivation<br>▪ Compost<br>▪ Farmyard manure<br>▪ Green manure |
| Amount of synthetic N fertiliser applied annually to agricultural land | Information comes from national sales records for synthetic N fertiliser, validated by expert judgement as the same amount as applied. To utilise default disaggregated emission factors, categorise synthetic fertiliser N as:<br>▪ Urea<br>▪ Ammonium based<br>▪ Nitrate based<br>▪ Ammonium-nitrate-based<br>Data can also be obtained from FAO's database, FAOSTAT |
| N content of fertiliser applied | Fertiliser specifications |
| Amount of synthetic fertiliser N applied | Information derived from the amount of fertiliser applied and its N content |
| Biomass characteristics | Information comes from national agriculture survey:<br>▪ Above-ground crop residue amount<br>▪ Below-ground crop residue amount<br>Default Tier 1 parameters come from 2019 Refinement, Volume 4, Chapter 5, Table 11.1A<br>▪ Above-ground crop residue N content<br>▪ Below-ground crop residue N content |
| Combustion factor | $C_f$, 2019 Refinement, Volume 4, Chapter 2, Table 2.6 |
| Emission factors and parameters for $CH_4$ | Default Tier 1 parameters come from 2019 Refinement, Volume 4, Chapter 5<br>▪ Baseline Emission factor, $EF_i$: Table 5.11<br>▪ Scaling factors needed to calculate adjusted EF reflecting management<br>  ▪ $SF_w$: Table 5.12<br>  ▪ $SF_p$,: Table 5.13<br>  ▪ $SF_o$,: Equation 5.3<br>▪ Conversion factor for each amendment type used, CFOA: Table 5.14<br>For country-specific emission factors, refer to IPCC Emission Factor Database |
| Emission factors for direct $N_2O$ emissions | ▪ Emission factor, $EF_{1FR}$ for flooded rice: 2019 Refinement, Volume 4, Chapter 11, Table 11.1<br>For country-specific emission factors, refer to IPCC Emission Factor Database |
| Conversion factor | 2019 Refinement, to convert $N_2O$-N to $N_2O$ emissions, 44/28 |
| GWP factor | 100-year GWP for $CH_4$ and $N_2O$: IPCC Fifth Assessment Report or as in national GHG inventory |

Once the user has determined which methods will be used to calculate emissions and has described baseline and policy scenarios with associated data parameters needed, GHG emissions can be calculated.

## 8.3 Estimating GHG emissions

### 8.3.1 Compile activity data

#### Categorise rice production systems by water regime

The user needs to categorise rice production systems by the water regime used to produce rice. The water regime is defined as a combination of ecosystem type and flooding pattern. Ecosystem type refers to whether rice is cultivated in upland, irrigated, or rainfed and deep-water conditions. Flooding pattern during cultivation is categorised for irrigated and rainfed/deep-water rice ecosystems. Irrigated rice may be continuously and intermittently flooded. Rainfed rice may be fed by regular rain patterns, drought-prone, or cultivated in deep water conditions. The disaggregation of the annual harvest area of rice needs to be done for at least three ecosystem types – upland, irrigated, and rainfed. The user should incorporate as many of the conditions that influence $CH_4$ emissions as possible.

For the purpose of assessing the National Programme for Sustainable Rice Production, there is only irrigated rice production. Additional characteristics of the irrigated rice system needed for estimating emissions from rice are provided in **Table 8.7.**

Refer to this guide's assessment toolkit for more information on rice data categorisation, in particular 2019 Refinement, Volume 4, Chapter 5, Box 5.2.

Table 8.7. **Rice land ecosystem classification and management expected at the start of the assessment period, time t**

| Parameter | Value |
|---|---|
| Water management during cultivation | Irrigated continuously flooded |
| Water regime before cultivation | Non-flooded pre-season < 180 days |
| Yield | 9.8 kg fresh weight/ha |
| Number of seasons | 2 (same management for each season) |
| Application rate of organic amendments, ROA | 0 (no organic amendments are applied) |
| Residue management | 100% burnt |
| Cultivation area | 30,282 ha |

### Characterise inputs

The user needs to categorise the amount and types of inputs used in production.

For the assessment of the National Programme for Sustainable Rice Production, no organic amendments are applied. The straw is burnt, and no additional amendments are used. Synthetic fertiliser application for rice production based on hypothetical country activity data is summarised in **Table 8.8.**

Table 8.8. **Rice fertilisation at the start of the assessment period, time t**

| Parameter | | Unit | Fertiliser | |
|---|---|---|---|---|
| | | | DAP | Urea |
| Application rate N content* | | kg/ha | 188 | 218.8 |
| N content* | | % | 18% | 46% |
| Nutrients application time | N applied at transplanting | kg/ha | 33.8 | 33.5 |
| | N applied 25-30 days after transplanting | kg/ha | - | 33.5 |
| | N applied 45-50 days after transplanting | kg/ha | - | 33.5 |
| Total N applied | | kg/ha | 33.8 | 100.6 |
| Amount of synthetic fertiliser N applied to soils per season | | kg/ha | 134.4 | |
| Annual amount of synthetic fertiliser N applied to soils | | kg/ha/yr | 268.8 | |

* based on molecular weight of N in fertiliser

### 8.3.2 Choose emission factors and parameters

To estimate emissions, the user will need to choose emission factors and parameters for each rice production system category.

Users should select emission factors that match their country's rice production characteristics (e.g., water management, climate). For Tier 1, IPCC default cultivation periods and base emissions factors for rice $CH_4$ emissions are grouped by geographic region.

Tier 2 methods can be utilised to re-assess the GHG impacts of the practices after completion of field trials and pilot trials. utilising country-specific emission factors for improved rice cultivation practices under the policy. Updated assumptions about adoption rates should be utilised, if necessary. For the purpose of assessing the National Programme for Sustainable Rice Production, the parameters used in the assessment are summarised in **Table 8.9**

It is a key recommendation is to select emission factors that best match the characteristics of the rice production system affected by the policy, even if that means choosing an emission factor for a region that is different from where the policy is being implemented.

Table 8.9. **Emission parameters used for the Programme for Sustainable Rice Production emission calculations**

| Emission factors and other parameters | Value | Data source |
|---|---|---|
| Cultivation period | 112 days | 2019 Refinement, Volume 4, Chapter 5, Table 5.11A |
| Emission factors and parameters for $CH_4$ emissions | ▪ Baseline emission factor, $EF_c$: 0.85 kg $CH_4$/ha/day<br>▪ Scaling factor for water regime during cultivation, $SF_w$:<br>  ▪ continuously flooded: 1<br>  ▪ multiple drainage periods: 0.55<br>▪ Scaling factor for water regime before cultivation, $SF_p$:<br>  ▪ non-flooded <180 days: 1<br>▪ Scaling factor for organic amendments, $SF_o$: 1 since no organic amendments are applied<br>▪ Conversion factor for organic amendment, CFOA, to calculate $SF_o$ if organic amendments are applied (not applicable in example calculations) | 2019 Refinement, Volume 4, Chapter 5, Table 5.11, Table 5.12, Table 5.13<br><br>2019 Refinement, Volume 4, Chapter 5, Table 5.14 and Equation 5.3 (organic amendments) |

Table 8.9. **Emission parameters used for the Programme for Sustainable Rice Production emission calculations (Continued)**

| Emission factors and other parameters | Value | Data source |
|---|---|---|
| Emission factors for direct $N_2O$ emissions | Emission factor for flooded rice, $EF_{1FR}$:<br>▪ irrigated continuously flooded: 0.003 kg $N_2O$-N/kg N;<br>▪ irrigated multiples drainage periods: 0.005 kg $N_2O$-N/kg N; | 2019 Refinement, Volume 4, Chapter 11, Table 11.1 |
| Combustion factor | $C_f$: 0.8 | 2019 Refinement, Volume 4, Chapter 2, Table 2.6 |
| Crop residue N content parameters | ▪ Dry matter fraction, *DRY*: 0.89<br>▪ Ratio of above-ground residue to yield, $R_{AG}$: 1.4<br>▪ Ratio of below-ground to above-ground biomass, *RS*: 0.16<br>▪ Above-ground biomass N content, $N_{AG}$: 0.007<br>▪ Below-ground biomass N content, $N_{BG}$: 0.009 | 2019 Refinement, Volume 4, Chapter 11, Table 11.1A |
| Conversion factor | ▪ To convert $N_2O$-N to $N_2O$ emissions, 44/28 | 2019 Refinement, Volume 4, Chapter 11 |
| GWP | ▪ $CH_4$: 28<br>▪ $N_2O$: 265 | 100-year GWP for $CH_4$ and $N_2O$: IPCC Fifth Assessment Report, or as in national GHG inventory |

### 8.3.3 Calculate baseline emissions

#### $CH_4$ emissions

The users should use the data reflecting the baseline scenario to calculate $CH_4$ baseline emissions. **Equations 8.1, 8.2**, and **8.3** are used to calculate $CH_4$ emissions from rice.

Rice $CH_4$ emissions are estimated using **Equation 8.1** by multiplying the daily emission factor by the cultivation period and annual harvested area. If there is double cropping, the harvested area is the area under rice production times the number of cultivation seasons. In its most simple form, this equation is implemented using national activity data and a single emission factor (the latter is calculated in **Equation 8.2**). If there are multiple types of rice production systems in the country (e.g., with different water regimes), they should be disaggregated, estimated using appropriate emission factors, and then summed.

The emission factor ($EF_i$) is calculated using **Equation 8.2**, which adjusts the baseline emission factor based on management practices used for rice cultivation. Note, for Tier 2 calculations, the same approach applies, but country-specific values are used instead. In addition, scaling factors for soil type and cultivar can be added as well.

Equation 8.1. **$CH_4$ emission from rice cultivation (2019 Refinement, Volume 4, Chapter 5, Eq. 5.1)**

$$CH_{4\,Rice} = EF_i \times t \times A \times 10^{-6}$$

*Where:*

$$A = A_r \times s$$

Where:

| | |
|---|---|
| $CH_{4Rice}$ | = annual methane emissions from rice cultivation, Gg $CH_4$/yr |
| $EF_i$ | = adjusted daily emission factor, kg $CH_4$/ha/day |
| $t$ | = cultivation period of rice, day |
| $A$ | = harvested area of rice, ha/yr |
| $A_r$ | = cultivation area of rice, ha/yr |
| $s$ | = number of cultivation seasons |
| $10^{-6}$ | = converting kg to Gg |

Equation 8.2. **Adjusted daily emission factor (2019 Refinement, Volume 4, Chapter 5, Eq. 5.2)**

$$EF_i = EF_c \times SF_w \times SF_p \times SF_o$$

Where:

| | |
|---|---|
| $EF_i$ | = adjusted daily emission factor for a particular harvested area, kg $CH_4$/ha/day |
| $EF_c$ | = baseline emission factor for continuously flooded fields without organic amendments, kg $CH_4$/ha/day |
| $SF_w$ | = scaling factor to account for the differences in water regime during the cultivation period |
| $SF_p$ | = scaling factor to account for the differences in water regime in the pre-season before the cultivation period |
| $SF_o$ | = scaling factor for both type and amount of organic amendment applied (see **Equation 8.3**) |

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To determine the value of $SF_o$, **Equation 8.3** should be applied. When straw is used as an amendment, its application means that straw is incorporated into the soil, not when it is just placed on the soil surface, nor burnt on the field.

For the purpose of estimating baseline $CH_4$ emissions for the National Programme for Sustainable Rice Production, hypothetical country activity data and associated emission parameters are used. In the example baseline scenario, all rice is cultivated under irrigated continuous flooding conditions where all the crop residue is burnt and no additional organic amendments are applied, therefore $SF_o$ equals 1. No adjustments to the baseline emission factor are needed. Rice $CH_4$ emissions are calculated for each year in the assessment period following the example in **Table 8.10**. Full calculations are demonstrated in the Technical Supplement available for download. Note that manual calculations with rounded values as displayed in **Table 8.10** and **Table 8.11**, may result in different values than full calculations in the Technical Supplement.

Equation 8.3. **Adjusted $CH_4$ emission scaling factors for organic amendments (2019 Refinement, Volume 4, Chapter 5, Eq. 5.3)**

$$SF_o = \left(1 + \sum_i ROA_i \times CFOA_i\right)^{0.59}$$

Where:

| | |
|---|---|
| $SF_o$ | = scaling factor for both type and amount of organic amendment applied |
| $ROA_i$ | = application rate of organic amendment i, in dry weight for straw and fresh weight for others, tonne/ha |
| $CFOA_i$ | = conversion factor for organic amendment i (in terms of its relative effect with respect to straw applied shortly before cultivation) as shown in 2019 Refinement, Volume 4, Chapter 5, Table 5.14 |
| $i$ | = represents a type of organic amendment |

Table 8.10. **Sample $CH_4$ calculations for rice for baseline scenario (WOM) at the start of the assessment period, time t**

| Parameter (units) | Description | Value or calculated value |
|---|---|---|
| $EF_c$ (kg $CH_4$/ha/day) | Default emission factor | 0.85 |
| $SF_w$ | Default emission parameter | 1 |
| $SF_p$ | Default emission parameter | 1 |
| $SF_o$ | Calculated emission parameter, **Eq. 8.3** | 1 |
| $EF_i$ (kg $CH_4$/ha/day) | Emission factor adjusted, **Eq. 8.2** | $EF_c \times SF_w \times SF_p \times SF_o = 0.85$ |
| Rice cultivation area, $A_r$ (ha) | Activity data | 30,282 |
| Number of seasons, *s* | Activity data | 2 |
| Harvested area, *A* (ha) | Derived from activity data | $A_r \times s = 60{,}564$ |
| Cultivation period, *t* (days) | Default parameter (could be country-specific) | 112 |
| **Total methane emissions from rice cultivation** | | |
| Annual $CH_4$ emissions (Gg) | $CH_4$ emissions, **Eq. 8.1** | $EF_i \times t \times A \times 10^{-6} = 5.77$ |
| Annual $CH_4$ emissions (Gg $CO_2e$) | Emissions expressed in $CO_2e$ | Annual $CH_4$ emissions (Gg) x 28 = 161.4 |

| **Conversion factors** | |
|---|---|
| Unit conversion, kg to Gg | $10^{-6}$ |
| $CH_4$ GWP | 28 |

The user can follow the example calculations to estimate **$CH_4$** emissions from rice for the selected baseline scenario.

### Direct $N_2O$ emissions from soils

The users should use the data reflecting the baseline scenario to calculate $N_2O$ baseline emissions. The equations to calculate $N_2O$ emissions from rice for the National Programme for Sustainable Rice Production are **Equations 8.4 and 8.5**.

The equation to calculate direct $N_2O$ emissions for the National Programme for Sustainable Rice Production is simplified to the applicable parameters in Equation 6.1. For the National Programme for Sustainable Rice Production, only emissions from N inputs ($N_2O\text{–}N_{N\ inputs}$) are calculated since, in the hypothetical country, rice cultivation occurs on mineral soils and there is no grazing.

Emissions from N inputs ($N_2O\text{–}N_{N\ inputs}$) are composed of the following sources:

- Application of synthetic N fertilisers ($F_{SN}$)
- Application of organic N as fertiliser (e.g., animal manure, compost, sewage sludge, rendering waste) ($F_{ON}$)
- Return to soil of crop residues, both above-ground and below-ground ($F_{CR}$)
- Mineralisation of N associated with loss of soil organic matter due to land use change or management change of mineral soils ($F_{SOM}$)

Direct $N_2O$ emissions from rice are estimated using **Equation 8.4**.

Refer to **Equation 6.1** for the full equation for estimating direct $N_2O$ emissions from agricultural soils.

Equation 8.4. **Direct $N_2O$ emissions from N inputs (2019 Refinement, Volume 4, Chapter 11, Eq. 11.1)**

$$N_2O - N_{N\ inputs} = [(F_{SN} + F_{ON} + F_{CR} + F_{SOM})_{FR} \times EF_{1FR}]$$

Where:

| | |
|---|---|
| $N_2O\text{–}N_{N\ inputs}$ | = annual direct $N_2O$–N emissions from N inputs to managed soils, kg $N_2O$–N/yr |
| $F_{SN}$ | = annual amount of synthetic fertiliser N applied to soils, kg N/yr |
| $F_{ON}$ | = annual amount of animal manure, compost, sewage sludge and other organic N additions applied to soils (Note: If including sewage sludge, cross-check with Waste Sector to ensure there is no double counting of $N_2O$ emissions from the N in sewage sludge), kg N/yr |
| $F_{CR}$ | = annual amount of N in crop residues (above-ground and below-ground), including N-fixing crops, and from forage/pasture renewal, returned to soils, kg N/yr (see **Equation 8.5)** |
| $F_{SOM}$ | = annual amount of N in mineral soils that is mineralised, in association with loss of soil C from soil organic matter as a result of changes to land use or management, kg N/yr |
| $EF_{1FR}$ | = the emission factor for $N_2O$ emissions from N inputs to flooded rice, kg $N_2O$–N/kg N (Disaggregation of $EF_{1FR}$: Use value for multiple drainage for AWD) |

For the purpose of estimating direct $N_2O$ baseline emissions for the National Programme for Sustainable Rice Production, hypothetical country activity data and associated emission parameters are used. In the example, only $F_{SN}$ and $F_{CR}$ terms are determined due to characteristics of the country's rice cultivation practices at the start of the policy implementation period. $F_{SN}$ reflects the N that comes from application of synthetic fertiliser while $F_{CR}$ is from N that comes from crop residue. $F_{ON}$ is zero because no organic amendments are applied. $F_{SOM}$ is zero because there is no N mineralisation due to land use change occurring. To calculate $F_{CR}$, users should utilise **Equation 8.5** and **Equation 8.6**. Note: if calculating amount of N in crop residues for other crops, this calculation should be done for each crop produced.

Rice direct $N_2O$ emissions are calculated for each year in the assessment period following the example in **Table 8.11.**

Equation 8.5. **Calculating N from crop residues (2019 Refinement, Volume 4, Chapter 11, Eq. 11.6)**

$$F_{CR} = [AGR \times N_{AG}(1 - Frac_{Remove} - (Frac_{Burnt} \times C_f)] + [BRG \times N_{BG}]$$

*Where:*

$$BRG = (Crop + AG_{DM}) \times RS \times A \times Frac_{Renew}$$

$$AGR = AG_{DM} \times A$$

$$AG_{DM} = Crop \times R_{AG}$$

Where:

| | |
|---|---|
| $F_{CR}$ | = annual amount of N in crop residues (above and below ground), returned to soils annually, kg N/yr |
| $AGR$ | = annual total amount of above-ground crop residue for crop, kg d.m./yr |
| $N_{AG}$ | = N content of above-ground residues for crop, kg N/kg d.m. |
| $Frac_{Remove}$ | = fraction of above-ground residues of crop removed annually for purposes such as feed, bedding and construction, dimensionless. Survey of in-country experts is required to obtain data. If data for $Frac_{Remove}$ are not available, assume no removal |
| $Frac_{Burnt}$ | = fraction of annual harvested area of crop burnt, dimensionless |
| $Cf$ | = combustion factor, dimensionless |
| $BGR$ | = annual total amount of below-ground crop residue for crop, kg d.m./yr |
| $N_{BG}$ | = N content of below-ground residues for crop, kg N/kg d.m. |
| $Crop$ | = harvested annual dry matter yield for crop, kg d.m./ha (refer to **Equation 8.6**) |
| $AG_{DM}$ | = Above-ground residue dry matter for crop, kg d.m./ha |
| $RS$ | = ratio of below-ground root biomass to above-ground shoot biomass for crop, kg d.m./ha)/(kg d.m./ha) |
| $A$ | = total annual area harvested of crop, ha/yr |
| $Frac_{Renew}$ | = fraction of total area under crop that is renewed annually, dimensionless. For annual crops, $Frac_{Renew}$ = 1 |
| $R_{AG}$ | = ratio of above-ground residue dry matter to harvested yield for crop, (kg d.m./ha)/(kg d.m./ha) |

Equation 8.6. **Dry weight correction (2019 Refinement, Volume 4, Chapter 11, Eq. 11.7)**

$$Crop = Yield_{FRESH} \times DRY$$

Where:

| | |
|---|---|
| *Crop* | = harvested dry matter yield for crop, kg d.m./ha |
| $Yield_{FRESH}$ | = harvested fresh yield for crop, kg fresh weight/ha |
| *DRY* | = dry matter fraction of harvested crop, kg d.m./kg fresh weight |

Table 8.11. **Sample $N_2O$ calculations for rice for baseline scenario (WOM) at the start of the assessment period, time t**

| Parameter (units) | Description | Value or calculated value |
|---|---|---|
| N application rate for synthetic fertiliser, R (kg/ha/yr) | Activity data | 268.8 |
| Rice cultivation area, $A_r$ (ha) | Activity data | 30,282 |
| Harvest area, *A* (ha) | Derived from activity data, see **Table 8.10** | 60,564 |
| $Yield_{FRESH}$ (kg/ha) | Activity data | 9.8 |
| $F_{SN}$ (kg N/yr) | Derived from activity data | $R \times A_r$ = 8,139,802 |
| $F_{ON}$ (kg N/yr) | Default emission parameter, no organic amendments are applied | 0 |
| *Crop* (kg d.m./ha) | Derived from activity data, **Eq. 8.6** | $Yield_{FRESH} \times DRY$ = 8.722 |
| *DRY* (kg d.m./kg fresh weight) | Default emission parameter | 0.89 |
| $AG_{DM}$ (kg d.m./ha) | Derived, **Eq. 8.5** | $Crop \times R_{AG}$ = 12.2108 |
| *AGR* (kg d.m./yr) | Derived | $AG_{DM} \times A$ = 739,535 |
| $N_{AG}$ (kg N/kg d.m.) | Default emission parameter | 0.007 |
| $R_{AG}$ (kg d.m./ha)/(kg d.m./ha) | Default emission parameter | 1.4 |
| *BGR* (kg d.m./yr) | Derived from activity data, **Eq. 8.5** | $(Crop + AG_{DM}) \times RS \times A \times Frac_{Renew}$ = 202,843 |

Table 8.11. **Sample $N_2O$ calculations for rice for baseline scenario (WOM) at the start of the assessment period, time t (Continued)**

| Parameter (units) | Description | Value or calculated value |
|---|---|---|
| $N_{BG}$ (kg N/kg d.m.) | Default emission parameter (for generic grain, rice-specific value not available) | 0.009 |
| *RS* (kg d.m./ha) | Default emission parameter | 0.16 |
| $Frac_{Renew}$ | Default parameter | 1 |
| $Frac_{Removed}$ | Activity data | 0 |
| $Frac_{Burnt}$ | Activity data | 1 |
| $C_f$ | Default emission parameter | 0.80 |
| $F_{CR}$ (kg N/yr) | Derived from activity data and default parameters, **Eq. 8.5** | 2,861 |
| $F_{SOM}$ (kg N/yr) | Derived from activity data and default parameters, no mineralisation is expect-ed to occur | 0 |
| $EF_{1FR}$ (kg $N_2O$-N/kg N input) | Default emission factor | 0.003 |
| **Total $N_2O$-N emissions from rice cultivation** | | |
| Annual $N_2O$-N emissions, $N_2O$-$N_N$ inputs (kg) | $N_2O$-N emissions, **Eq. 8.4** | $(F_{SN} + F_{ON} + F_{CR} + F_{SOM}) \times EF_{1FR}$ = 24.428 |
| **Total $N_2O$ emissions from rice cultivation** | | |
| Annual $N_2O$ emissions (kg) | $N_2O$ emissions | $N_2O$-$N_{N\ inputs}$ x 44/28 = 38,386.8 |
| Annual $N_2O$ emissions (Gg) | $N_2O$ emissions | Annual $N_2O$ emis-sions (kg) x $10^{-6}$ = 0.38 |
| Annual $N_2O$ emissions (Gg $CO_2e$) | Emissions expressed in $CO_2e$ | Annual $N_2O$ emis-sions (Gg) x 265 = 10.2 |

| Conversion factors | |
|---|---|
| Molecular weight ratio, $N_2O$–N to $N_2O$ | 44/28 |
| Unit conversion, kg to Gg | $10^{-6}$ |
| $N_2O$ GWP | 265 |

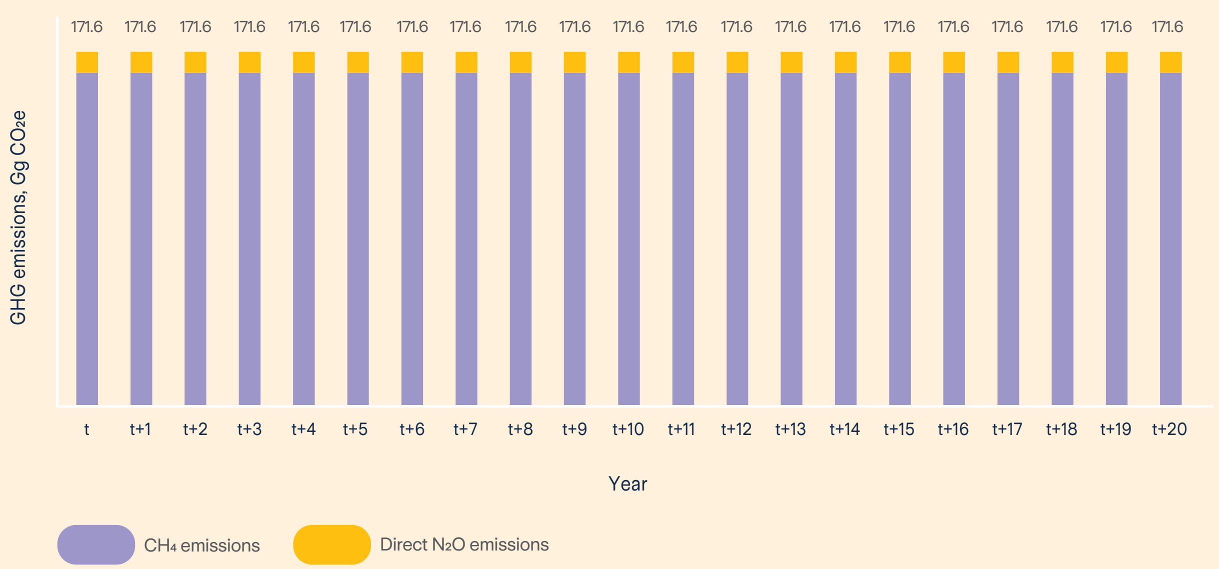
The user can follow the example calculations to estimate direct $N_2O$ emissions from rice for the selected baseline scenario.

Users can also plot the emissions over time to visualise relative magnitudes of each emission source and how it changes over time.

The baseline emission trend for the National Programme for Sustainable Rice is shown in **Figure 8.3**. Annual GHG emissions from rice cultivation are a sum of $CH_4$ emissions from rice and direct $N_2O$ emissions from soil. Using the values determined in **Table 8.10** and **Table 8.11** for time t, the total emissions equal 172 Gg $CO_2e$.

Refer to this guide's assessment toolkit for additional tools to conduct emission calculations, such as the IPCC Inventory Software.

Figure 8.3. **Total baseline emissions from $CH_4$ and $N_2O$**



### 8.3.4 Calculate policy emissions

#### $CH_4$ emissions

To calculate policy scenario emissions, the same methodology is used, however different emission factors would be utilised to reflect the changes expected in the policy scenario. In this example, when applying **Equation 8.2**, a different scaling factor for the water regime, SFW (0.55), would be used to reflect adoption of AWD system. The baseline emission factor is further adjusted down by 80 percent to account for reductions expected from adopting DDS (Tao et.al., 2016).

**Equation 8.7** is then used to calculate $CH_4$ emissions under the policy scenarios.

For the proportion of land where new management practices have not been implemented, **Equation 8.1** and emission factors for the baseline scenario calculations would be used and summed with emissions from area adopting mitigation practices. Emissions are calculated for each year.

Equation 8.7. **$CH_4$ emission from rice cultivation (2019 Refinement, Volume 4, Chapter 5, Eq. 5.1)**

$$CH_{4\,Rice} = EF_i \times t \times A \times 10^{-6} \times (Adoption\%)$$

Where:

| | |
|---|---|
| $CH_{4Rice}$ | = annual methane emissions from rice cultivation (Gg $CH_4$/yr) |
| $EF_i$ | = adjusted daily emission factor (kg $CH_4$ /ha/day) |
| $t$ | = cultivation period of rice (day) |
| $A$ | = annual harvested area of rice (ha/yr) |
| *Adoption%* | = percentage of land where new practices are implemented |

### Direct $N_2O$ emissions

To calculate policy scenario emissions, the same methodology is used, however different emission factors would be utilised to reflect the changes expected in the policy scenario.

In this example, when applying **Equation 8.4**, a different emission factor for the water regime, $EF_{1FR}$ (0.005), would be used to reflect adoption of AWD system.

**Equation 8.8** is then used to calculate $CH_4$ emissions under the policy scenario, for the proportion of land implementing AWD practices.

Equation 8.8. **Direct $N_2O$ emissions from N inputs under the policy scenario (2019 Refinement, Volume 4, Chapter 11, Eq. 11.1)**

$$N_2O - N_{N\ inputs} = [(F_{SN} + F_{ON} + F_{CR} + F_{SOM})_{FR} \times EF_{1FR} \times (Adoption\%)]$$

Where:

| | |
|---|---|
| $N_2O{-}N_{N\ inputs}$ | = annual direct $N_2O$–N emissions from N inputs to managed soils, kg $N_2O$–N/yr |
| $F_{SN}$ | = annual amount of synthetic fertiliser N applied to soils, kg N/yr |
| $F_{ON}$ | = annual amount of animal manure, compost, sewage sludge and other organic N additions applied to soils, kg N/yr (Note: If including sewage sludge, cross-check with Waste Sector to ensure there is no double counting of $N_2O$ emissions from the N in sewage sludge) |
| $F_{CR}$ | = annual amount of N in crop residues (above-ground and below-ground), including N-fixing crops, and from forage/pasture renewal, returned to soils, kg N/yr |
| $F_{SOM}$ | = annual amount of N in mineral soils that is mineralised, in association with loss of soil C from soil organic matter as a result of changes to land use or management, kg N/yr |
| $EF_{1FR}$ | = the emission factor for $N_2O$ emissions from N inputs to flooded rice, kg $N_2O$–N/kg N (Disaggregation of $EF_{1FR}$: Use value for multiple drainage for AWD) |
| *Adoption%* | = percentage of land where new practices are implemented |

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For the proportion of where AWD practices are not used, **Equation 8.4** and emission factors for the baseline scenario calculations would be used. These are then summed together. Emissions are calculated for each year.

Emission reductions observed in the policy scenario are due to the assumptions described in detail in previous sections (see **Table 8.5**). To summarise, the main parameters that change in the policy scenario is the adoption rate of mitigation measures by the farmers and associated proportion of land implementing AWD and DDS practices. When water management changes during cultivation, emission factors for both $CH_4$ and direct $N_2O$ emissions change reflecting a different emission rate for the system.

Users can also plot the emissions over time to visualise relative magnitudes of each emission source and how it changes over time under the policy scenario. The WAM emission trends for the National Programme for Sustainable Rice Production are shown in **Figure 8.4.**

Figure 8.4. **Total policy emissions over time for the WAM scenario**

### 8.3.5 Calculate GHG emissions impact

After calculating emissions for baseline and policy scenarios, the user can determine the effect of the policy on GHG emissions. The GHG emission change achieved by the policy is determined by subtracting GHG emissions at time t+20 for the policy scenario(s) from the baseline scenario. The percent reduction is determined relative GHG emissions at the start of the policy, at time t.

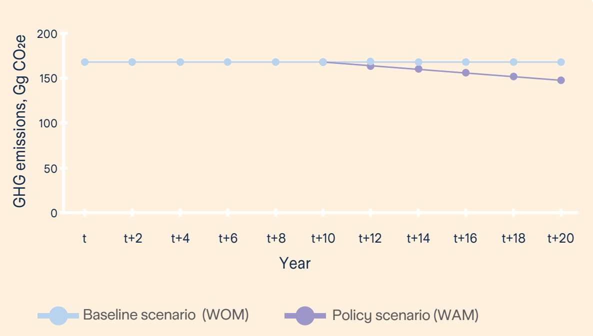
As summarised in **Table 8.12,** the National Programme for Sustainable Rice Production is expected to reduce national rice GHG emissions by 27.4 Gg $CO_2e$ over the duration of the policy period, corresponding to a 16 percent reduction.

The time trend of emissions for baseline and policy scenarios is shown in **Figure 8.5**. Water management can reduce $CH_4$ emissions by 17.8 percent, but the trade-off is the increase in direct $N_2O$ emissions by 13.3 percent. It's important to quantify such trade-offs to inform decision making and policy design.

Table 8.12. **GHG emission reductions from rice for policy period for policy mitigation (WAM) scenario. Note: negative values indicate that emissions increased, which was expected for $N_2O$ emissions.**

| Emission Source | Policy impact | Reference calculation | WAM |
|---|---|---|---|
| Rice $CH_4$ | Rice $CH_4$ reduction (Gg $CO_2e$) reduction at the end of the assessment period compared to WOM | $WOM_{t+20} - WAM_{t+20}$ | 28.7 |
| | Percent reduction from $CH_4$ at the end of the assessment period compared to time t | $\frac{WAM_{t+20}-WAM_t}{WAM_t}$ | 17.8% |
| Soil $N_2O$ | Rice $N_2O$ change (Gg $CO_2e$) reduction at the end of the assessment period compared to WOM | $WOM_{t+20} - WAM_{t+20}$ | -1.36 |
| | Percent change from $N_2O$ at the end of the assessment period compared to time t | $\frac{WAM_{t+20}-WAM_t}{WAM_t}$ | -13.3% |
| Rice $CH_4$ and soil $N_2O$ | Total GHG reduction (Gg $CO_2e$) reduction at the end of the assessment period compared to WOM | $WOM_{t+20} - WAM_{t+20}$ | 27.4 |
| | Percent GHG reduction at the end of the assessment period compared to time t | $\frac{WAM_{t+20}-WAM_t}{WAM_t}$ | 16% |

Figure 8.5. **Projected emission trends for baseline and policy scenarios over time**




Following the assessment, monitoring performance over time will allow policymakers to evaluate whether measures are reaching projected reductions. If not, the policy could be refined by evaluating whether policy instruments employed by the policy are effective (i.e., technical assistance content, format, frequency, or the incentive payment levels could be adjusted).

Data collected during the field trials and pilot phases of the policy can provide country-specific parameters to more accurately evaluate GHG impact, in particular for direct and indirect $N_2O$ emissions from soils, where data is currently lacking.

The user can utilise the same methods to estimate emissions for mitigation scenarios for the selected policy.

## 8.4 Monitoring policy performance

### 8.4.1 Policy key performance indicators

Users should identify a set of key performance indicators (KPIs) to evaluate policy performance over time. KPIs should include both GHG impact as well as non-GHG metrics that allow tracking of inputs, activities, intermediate effects, or market effects reflecting policy implementation steps and outcomes beyond GHG mitigation. Policy implementation will be evaluated relative to the start of the policy implementation period with the following KPIs as outlined in **Table 7.12.**

As part of tracking progress in policy implementation, it is helpful to set targets or anticipated levels for policy KPIs, which can inform further assumptions for estimating the policy's mitigation potential and identify corrective actions. The proposed KPIs for the National Programme for Sustainable Rice Production have been classified into three main categories. These are: policy impacts, intermediate effects, and inputs and activities.

Policy implementation will be evaluated relative to the start of the policy implementation period with the following KPIs as outlined in **Table 8.13.**

For additional guidance on refining policy design, including financial considerations, refer to Appendix A on implementation potential.

Refer to Section 2.5.1 for an overview and example of KPIs. These are documented during the policy description step of the assessment (**Table 8.1**). If a measure is to be included in country's NDC and KPIs will be used for NDC implementation tracking, the users should make sure that KPIs fulfil the minimum requirements as specified in the modalities, procedures, and guidelines (MPGs) (UNFCCC, 2018).

Additional KPIs related to rice production practices are outlined in **Table 8.14**.

Furthermore, budgetary KPIs will also be tracked to assess policy costs and incentive levels (e.g., per year, quarter, etc.). For instance, extension services will have regular budget expenditures to conduct workshops, or trials.

Frequently tracking these KPIs, including incentives distribution, will help determine where adjustments might be needed. For instance, incentive payment levels might need to be adjusted up to increase practice adoption or down to improve cost-effectiveness. These KPIs are summarised in **Table 8.15.**

Table 8.13. **Policy impact KPIs for the National Programme for Sustainable Rice Production**

| Key performance indicator | Target | Achievement goal |
|---|---|---|
| $CH_4$ and $N_2O$ emissions | 10% | Year t+11 – t+20 |
| GHG emissions intensity per unit of production | No target; decrease in $CH_4$ emissions is expected | Year t+11 – t+20 |
| Water consumption | 60% reduction per unit area for rice produced with AWD and DDS | Year t+11 – t+20 |

Table 8.14. **Policy intermediate effects KPIs for the National Programme for Sustainable Rice Production**

| Key performance indicator | Target | Achievement goal |
|---|---|---|
| RCMNOA survey response rate | 30% response rate | Year t+20 |
| Number of farmers receiving technical assistance | 50% of national rice farmers | Year t+20 |
| Proportion of land with verified AWD and/or DDS practices | 20% of total land | Year t+20 |

The user can also include additional KPIs to evaluate the impact of the policy on SDGs or other interacting activities or policies identified in Section 8.1.6. Examples for the National Programme for Sustainable Rice Production may include increased water conservation and improved profits for farmers from labour savings.

### 8.4.2 Monitoring plan

The users should develop a monitoring plan for tracking the progress of the policy. For the National Programme for Sustainable Rice Production, the national leadership team will develop and implement a monitoring plan and oversee documentation and the process of coordinating with all stakeholders.

To conclude the assessment process, the guidance on summarising the results of the assessment, as well as considering next steps, is in Chapter 9.

Table 8.15. **Policy inputs and activities KPIs for the National Programme for Sustainable Rice Production**

| Key performance indicator | Target | Achievement goal |
|---|---|---|
| Spend rate of Extension services operational budget to conduct research, technical assistance, and farm visits | No fixed target. Target updates at the beginning of each quarter according to budget allocation | Q1-Q4; Years t+1-20 |
| Spend rate on research activities | No fixed target. Target updates at the beginning of each year according to budget allocation | Years t+1-10 |
| Value of incentive payments disbursed | No fixed target. Target updates at the beginning of each year according to budget allocation | Years t+11-20 |
| Pilot trials conducted | 5 trials, 1 ha each | Year t+5 |
| Field trials conducted | 10 trials, 1 ha each | Year t+10 |

# Conclusion

Chapter 9: Final steps

# Chapter 9: Final Steps

Conclusion | Chapter 9

9.1 Document results | 9.2 Lessons learned | 9.3 Next steps

This chapter describes the final steps the assessment process and ensure the key elements of the assessment are clearly documented, reflect on meeting the objectives of the assessment, and outline potential next steps for policymakers following the assessment.

## 9.1 Document results

Going through the steps outlined in the previous chapters of this guide likely resulted in numerous documents including policy description, tables and diagrams outlining effects of the policy, compilation of activity data, spreadsheets with calculations, etc. Reporting the results, methodology, and assumptions used is important to ensure the GHG impacts assessment is transparent and gives decision-makers and stakeholders the information they need to properly interpret the results. For guidance on providing information to stakeholders, refer to the ICAT *Stakeholder Participation Guide*, which is available in this guide's assessment toolkit.

When the assessment is complete, the users should create an assessment report documenting the process and the results of the assessment. Compilation of all this information is recommended to facilitate communication of the assessment results with key decision makers and inclusion of the information in national reporting under ETF when compiling BTRs.

## 9.2 Lessons learned

After completing the assessment, it is recommended to consider what was learned from the assessment and how it can help inform future policy design and improve quantification of GHG emissions. Including such reflections in the assessment report is good practice to document the main takeaways from the process. These can include things such as results of the assessment, the process related conducting the assessment, methodological issues/data gaps identified, or even broader lessons related to achieving meaningful climate action by the country. The user is encouraged to document the key lessons learned and share them with relevant policymakers and stakeholders.

### Assessment objectives

When the assessment is complete, it is recommended that the user revisit the objectives of the assessment as well as the intended outcomes of the policy to see if they were achieved. As one of the overarching objectives of the assessment is to quantify GHG emissions associated with the policy, the user should determine if the policy activities will help achieve the emission reduction targets identified. If ex-post assessment is being conducted and emission reduction targets are not met, this can trigger corrective actions as next steps. For ex-ante assessment, identifying when projected reductions are falling short of targets can enable

Refer to the Templates section for a template to develop the policy assessment report. The categories of information required for BTRs and NDCs are highlighted. Also, refer to Case Studies at the end of this guide to see examples of how information about policy impacts may be presented in a brief format.

policymakers to refine the design of the policy, such as the policy instrument or parameters such as incentive levels.

### Data gaps and further assessment refinement

The assessment process can be helpful in revealing data gaps that prevent the team from applying more advanced calculation methods or quantifying GHG impacts. The assessment can help identify key activity data parameters that the country needs to prioritise and collect to conduct more detailed calculations in the future or evaluate policy performance. Tracking activities occurring under the policy, when included in the policy design, can support both, generation of activity data and evaluation of policy performance. For examples, refer to chapters 5-8, where annual surveys, reports, and/or site visits are conducted to verify implementation and collect additional data. Users should compile a list of data needed for the policy assessment and document sources of the data as well as identify strategies to obtain the data if sources of data are not available at the time of the assessment.

### Alignment with country's climate and sector policies and international commitments

Countries are expected to increase their climate action ambition under the Paris Agreement, however, some mitigation measures may have negative effects on food security or economic development of the country – for example, taking degraded land out of production may increase soil carbon sequestration, but limits the area that can be utilised for crop cultivation and loss of economic output. Sometimes, the opposite can also occur, where ensuring food security leads to higher levels of production as well as higher GHG emissions. As such, it is important to identify and understand how impacts of the policy being assessed may support or counter other policies or programmes in the country, such as the Low Emission Development Plan, the National Climate Strategy, and well as country's NDC targets. Quantifying the impact can inform amendments to the policy to ensure sustainable development occurs and is balanced across economic, environmental and social dimensions. Assessment results can also illuminate options for further strengthening NDC targets. Users should consider and document how the results of the assessment relate to the broader context of country's sectoral priorities as well as climate action commitments.

## 9.3 Next steps

Following the assessment, the user can consider the results and lessons learned and utilise that information to determine what next steps could be appropriate to undertake. These can range from additional technical work, addressing the gaps in the country's data collection and management system, or conducting further assessments of the policy. The user is encouraged to identify and discuss next steps that match country's priorities with policymakers and stakeholders.

### Technical review and uncertainty analysis

As the user was planning the assessment process, they considered whether an independent technical review will be pursued. A review process can inform future improvements in the impact assessment. Independent review also increases the transparency and confidence of the policy assessment.

Refer to this guide's assessment toolkit for additional resources on technical review, such as the ICAT *Technical Review Guide.*

Understanding uncertainty is crucial for properly interpreting GHG assessment results. Identifying and documenting sources of uncertainty can help users improve assessment quality and increase the level of confidence in the results. This guide does not provide quantitative guidance on estimating uncertainty. While sources of uncertainty should be identified and described during policy assessment, users can conduct additional uncertainty assessment as well as sensitivity analysis to better understand how sensitive are GHG emissions estimates to particular scenario assumptions and parameters.

Refer to this guide's assessment toolkit for additional resources on uncertainty/sensitivity analysis. Methodological guidance for qualifying or quantifying uncertainty can be found in IPCC 2006 GL Volume 1, Chapter 3, with additional information relevant to policy GHG impact estimation in the Policy and Action Standard, Chapter 12.

### Enhancement of data collection and MRV systems

A common challenge typically faced by teams conducting GHG impact assessment of the policy is the lack of relevant data. Preparing for and conducting the assessment guides users to identify data needs and sources of data. Compiling the data for the assessment is likely to reveal opportunities for improving sectoral MRV systems so data can be collected and managed more systematically and consistently and improve any future assessments. The country may develop survey instruments or data collection templates to facilitate activity data collection that better characterise agricultural activities affected by the policy. Such data collection and management methods may be institutionalised if they are incorporated into policy implementation. As demonstrated in the examples in Chapters 5-8, collecting data as part of policy implementation can support the development of country-specific emission parameters and allow for higher-tier calculations to improve the accuracy of the assessment results in the future.

### Corrective action and policy refinement

Assessment results may indicate that intended reduction goals have not or might not be achieved for the policy scenario outlined in the assessment. In the case of ex-post assessment, corrective actions should be triggered if a threshold level for a KPI is reached. Corrective action may lead to changes in the policy design to bring implementation of the policy on track. For ex-ante assessments, the projected GHG impacts might differ from the expected impacts when policy was initially developed. The policymakers can refine the policy design by evaluating the implementation potential and addressing barriers to implementation (physical, cultural, financial), if they exist.

Refer to Appendix A for additional guidance on evaluating policy implementation potential.

### Other impact assessment

Although the focus of this guide is to provide the user with the tools to assess the impact of a particular agricultural mitigation policy, users can identify interacting policies and consider if it is beneficial to conduct additional assessments for a package of policies. If it is deemed feasible to assess cross-sector impacts together and the degree of interaction between the policies is considered important, the users may consider such an assessment as a next step.

Agricultural policies also have broader sustainable development impacts in addition to their GHG impacts. Assessing sustainable development impacts related to changes in air quality, water quality, health, quality of life, employment, or income may be of interest to policymakers and could be assessed as the next step. Policy descriptions developed as part of GHG impact assessment can also be used as a basis to assess sustainable development impacts or transformational change impacts.

Refer to the WRI's Policy and Action Standard in this guide's assessment toolkit for additional resources on assessing policy interactions. Furthermore, refer to the ICAT *Sustainable Development Methodology* for additional resources for assessing sustainable development impacts.

# Abbreviations and Acronyms

| | |
|---|---|
| **AF** | Adaptation Fund |
| **AFD** | Agence Francaise de Developpement (French Development Agency) |
| **AFOLU** | Agriculture, forestry and other land use |
| **AWD** | Alternate wetting and drying |
| **BNI** | Biological nitrification inhibitors |
| **BTRs** | Biennial Transparency Reports |
| **C** | Carbon |
| **CDB** | Chinese Development Bank |
| **$CH_4$** | Methane |
| **CIF** | Climate Investment Fund |
| **$CO_2$** | Carbon dioxide |
| **$CO_2e$** | Carbon dioxide equivalent |
| **COSOP** | Country Strategy Program |
| **CRTs** | Common Reporting Tables |
| **CTCN** | Climate Technology Centre and Network |
| **CTF** | Common tabular format |
| **d.m.** | Dry matter |
| **DAP** | Di-ammonium Phosphate |
| **DDS** | Dry direct seeding |
| **DMI** | Dry matter intake |
| **EBRD** | European Bank for Reconstruction and Development |
| **EFDB** | Emission factor database |
| **EMMA** | Enteric Methane and Manure Assessment |
| **ETF** | Enhanced Transparency Framework |
| **FAO** | Food and Agriculture Organization of the United Nations |
| **GACMO** | Greenhouse Gas Abatement Cost Model |
| **GCF** | Green Climate Fund |

| | |
|---|---|
| **GDP** | Gross domestic product |
| **GEF** | Global Environment Facility |
| **Gg** | Gigagrams |
| **GHG** | Greenhouse gas |
| **GIZ** | German Agency for International Cooperation |
| **GWP** | Global warming potential |
| **ha** | Hectare |
| **IBRD** | International Bank for Reconstruction and Development |
| **ICAT** | Initiative for Climate Action Transparency |
| **IDA** | International Development Association |
| **IFAD** | International Fund for Agricultural Development |
| **IFC** | International Finance Corporation |
| **IPCC** | Intergovernmental Panel on Climate Change |
| **KfW** | German Development Bank |
| **kg** | Kilogram |
| **KPI** | Key performance indicator |
| **LEDS** | Low Emissions Development Strategy |
| **LTS** | Long term strategy |
| **LULUCF** | Land use, land-use change, and forestry |
| **MDBs** | Multilateral development banks |
| **MIGA** | Multilateral Investment Guarantee Agency |
| **MJ** | Megajoules |
| **MMS** | Manure management system |
| **MPGs** | Modalities, procedures, and guidelines |
| **MRV** | Measurement, reporting and verification |
| **MSMEs** | Micro, Small and Medium-sized Enterprises |
| **N** | Nitrogen |
| **$N_2O$** | Nitrous oxide |
| **NAMA** | Nationally Appropriate Mitigation Action |

| | |
|---|---|
| **NC** | National Communication |
| **NDA** | Nationally Designated Authority |
| **NDC** | Nationally Determined Contribution |
| **NGO** | Non-governmental organisation |
| **Norad** | Norwegian Agency for Development Cooperation |
| **NT** | No-till |
| **OPEC** | Organization of the Petroleum Exporting Countries |
| **RCMNOA** | Rice Cultivation Methane and Nitrous Oxide Assessment |
| **SDGs** | Sustainable Development Goals |
| **SIDA** | Swedish International Development Cooperation Agency |
| **SMEs** | Small and Medium Enterprises |
| **SNI** | Synthetic nitrification inhibitors |
| **SOC** | Soil organic carbon |
| **t** | Tonne |
| **UNDP** | United Nations Development Programme |
| **UNEP** | United Nations Environment Programme |
| **UNFCCC** | United Nations Framework Convention on Climate Change |
| **UNIDO** | United Nations Industrial Development Organisation |
| **US EPA** | United States Environmental Protection Agency |
| **USA** | United States of America |
| **USAID** | United States Agency for International Development |
| **USD** | US dollar |
| **WAM** | With additional measures |
| **WOM** | Without measures |
| **WRI** | World Resources Institute |
| **yr** | Year |

# Glossary

| | |
|---|---|
| **Activities (related to inputs when describing policy)** | Administrative activities involved in implementing the policy or action (undertaken by the authority or entity that implements the policy or action), such as permitting, licensing, procurement, or compliance and enforcement. Examples include provision of technical assistance or incentive payments |
| **Activity data** | Data on the magnitude of a human activity resulting in emissions or removals taking place during a given period of time. Data on land areas, management systems, and fertiliser use are examples of activity data |
| **Assessment boundary** | The scope of the assessment in terms of the range of GHG impacts that are included in the assessment |
| **Assessment period** | The time period over which GHG impacts resulting from a policy are assessed |
| **Assessment report** | A report, completed by the user, that documents the assessment process and the GHG, sustainable development and/or transformational impacts of the policy |
| **Baseline scenario** | A reference case that represents the events or conditions most likely to occur in the absence of a policy (or package of policies) being assessed |
| **Carbon pool** | A system which has the capacity to accumulate or release carbon. The carbon pools involved in C stock changes include soil organic matter, biomass, and dead organic matter |
| **Cash flows** | The net amount of cash and cash-equivalents moving into and out of a business. Positive cash flow indicates that a company's liquid assets are increasing, enabling it to settle debts, reinvest in its business, return money to shareholders, pay expenses and provide a buffer against future financial challenges. Negative cash flow indicates that a company's liquid assets are decreasing. Some stakeholders will not implement an action that has a negative net cash flow at any time |
| **Causal chain** | A conceptual diagram tracing the process by which the policy leads to impacts through a series of interlinked logical and sequential stages of cause-and-effect relationships |
| **Discount rate** | The interest rate you need to earn on a given amount of money today to end up with a given amount of money in the future. The discount rate accounts for the time value of money, which is the idea that a dollar today is worth more than a dollar tomorrow given that the dollar today has the capacity to earn interest |

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| **Emission factor** | A factor that converts activity data into GHG emissions data. |
| **Emission intensity** | GHG emissions per unit of production. |
| **Ex-ante assessment** | The process of estimating expected future GHG impacts of a policy (i.e., a forward-looking assessment) |
| **Expert judgement** | A carefully considered, well-documented qualitative or quantitative judgement made in the absence of unequivocal observational evidence by a person or persons who have a demonstrable expertise in the given field (IPCC 2006). Users can apply their own expert judgement or can consult experts. |
| **Ex-post assessment** | The process of estimating historical GHG impacts of a policy (i.e., a backward-looking assessment) |
| **GHG impacts** | Changes in GHG emissions by GHG sources and carbon pools that result from a policy |
| **Global warming potential** | Global Warming Potentials (GWP) are calculated as the ratio of the radiative forcing of one kilogramme of greenhouse gas emitted to the atmosphere to that from one kilogramme $CO_2$ over a period of time (e.g., 100 years) |
| **Impact assessment** | The estimation of changes in GHG emissions or removals resulting from a policy, either ex-ante or ex-post |
| **Inputs** | Resources that go into implementing the policy, such as financing |
| **Intended effects** | Effects which reflect the original objectives of the policy |
| **Interacting policies** | Policies that produce total effects, when implemented together, that differ from the sum of the individual effects had they been implemented separately |
| **Intermediate effects** | Changes in behaviour, technology, processes or practices that result from the policy, which lead to GHG impacts |
| **Jurisdiction** | The geographic area within which an entity's (such as a government's) authority is exercised |
| **Key performance indicator** | A metric that indicates the performance of a policy |
| **Measure** | Implementation of technologies, processes, or practices outlined in policy instruments aimed at achieving mitigation |
| **Monitoring period** | The time over which the policy is monitored, which may include pre-policy monitoring and post-policy monitoring in addition to the policy implementation period |
| **Negative impacts** | Impacts that are perceived as unfavourable from the perspective of decision-makers and stakeholders |
| **Parameter** | A variable such as activity data or emission factors that are needed to estimate GHG impacts |

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|---|---|
| **Policies and/or actions** | Interventions at various stages along a policy-making continuum, from broad strategies or plans that define high-level objectives or desired outcomes to specific policy instruments to carry out a strategy or achieve desired outcomes |
| **Policy instrument** | A mechanism utilised by a government, institution, or other entity, which may include laws, regulations, and standards; taxes, charges, subsidies, and incentives; information instruments; voluntary agreements; implementation of new technologies, processes, or practices; and public or private sector financing and investment, among others |
| **Policy implementation period** | The time period during which the policy is in effect |
| **Policy scenario** | A scenario that represents the events or conditions most likely to occur in the presence of the policy (or package of policies) being assessed. The policy scenario is the same as the baseline scenario except that it includes the policy (or package of policies) being assessed |
| **Positive impacts** | Impacts that are perceived as favourable from the perspectives of decision-makers and stakeholders |
| **Present value** | The current worth of a future sum of money or stream of cash flows given a specified discount rate. Future cash flows are discounted at the discount rate, and the higher the discount rate the lower the present value of the future cash flows. |
| **Rate of return** | The gain or loss on an investment over a specified time period, expressed as a percentage of the investment's cost. Gains on investments are defined as income received plus any capital gains realised on the sale of the investment. The general equation of the rate of return is: (Gain of Investment – Cost of Investment) / Cost of Investment |
| **Stakeholders** | People, organisations, communities or individuals who are affected by and/or who have influence or power over the policy |
| **Sustainable development impacts** | Changes in environmental, social or economic conditions that result from a policy, such as changes in economic activity, employment, public health, air quality and energy security |
| **Uncertainty** | 1. Quantitative definition: Measurement that characterises the dispersion of values that could reasonably be attributed to a parameter. 2. Qualitative definition: A general term that refers to the lack of certainty in data and methodological choices, such as the application of non-representative factors or methods, incomplete data, or lack of transparency |
| **Unintended effects** | The effects that fall outside of the policy's control and may amplify or diminish the impact of the policy |

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# Hypothetical Country

A hypothetical country described here will be used in Chapters 5-8 to demonstrate the policy assessment methodology. Policies and measures, also hypothetical, described in Chapters 5-8 utilise activity data and emission parameters representing national circumstances and agricultural systems in this hypothetical country.

The hypothetical country is an island nation composed of two provinces, East Province and West Province. East Province is situated primarily in a tropical dry climate and is home to the major settlements in the country. The majority of cropland and pasture is located in the East Province. The West Province has the country's forests and hosts country's rice production areas due the tropical moist climate. Demand for rice has grown over the last two decades resulting in conversion of forest land to cropland in the West Province.

The Ministry responsible for Agriculture develops and administers a number of policies that drive production and contributes to strategic development priorities in the Agriculture sector. The following policies were selected for assessment in Chapters 5-8:

- Chapter 5: National Dairy Methane Reduction Programme
  This policy was adopted in 2020 with implementation set to begin in 2025. Ex-ante assessment will be conducted to project expected emission reduction from the policy for the period of 2025-2035, duration of the policy.

- Chapter 6: National Urea Fertiliser Policy
  This policy was adopted in 2020 with implementation set to begin in 2025. Ex-ante assessment will be conducted to project expected emission reduction from the policy for the period of 2025-2035, duration of the policy.

- Chapter 7: National Conservation Agriculture Policy
  This policy was adopted and implemented in 2000. Ex-post analysis will be conducted for years 2000-2020, and ex-ante analysis will be conducted for years 2020-2040. The policy has no end date, and all land used for annual crops over time is targeted to transition to reduced-till or no-till practices that meet the conservation standard. By 2040, at least 25 percent of land is set to be under reduced-till management and 50 percent of land is set to be under no-till management.

- Chapter 8: National Programme for Sustainable Rice Production
  This policy is currently being designed with a planned start date of 2030. Due to growing demand for rice in the country, this represents an important subsector. The assessment will be ex-ante to project potential emission reductions from new management practices for a 20-year period, which includes 10 years of field trials and pilot studies, and 10 years of implementation.

There are six extension offices in the country, four in East province and two in West province, which provide technical support services to farmers in the country and implement national agriculture programmes. The Ministry responsible for Agriculture passed the National Agriculture Policy Act of 2020 which established the National Dairy Methane Reduction Programme and the National Urea Fertiliser Policy. The Act also established six flagship farms, connected to each extension office in the country. Flagship farms are to be used for training and demonstrations, as well as conducting additional research to improve agricultural practices in the country and support development of country specific emission parameters wherever possible. As the country prioritises the Agriculture sector to reduce emissions and improve agricultural production, the National Dairy Methane Reduction Programme and the National Urea Fertiliser Policy were selected for assessment, in Chapter 5 and Chapter 6, respectively, because they are recently adopted policies intended to mitigate emissions. Policymakers have a keen interest in assessing the new package of policies.

The National Conservation Agriculture Policy (Chapter 7) was selected for assessment because it is one of the earliest policies in the Agriculture sector to focus on environmental outcomes aiming to reduce erosion and water pollution in the country. Because it was adopted a while ago, it allows for ex-post analysis of impacts, helping decision makers understand whether policy objectives are being met. Due to its longevity, the Ministry responsible for Agriculture is supportive and familiar with the policy, which helps gather all the needed information to conduct the analysis. Although soil carbon sequestration was not a direct objective of the policy, with international commitments of the country's NDCs, the government is interested in assessing GHG impacts of the policy and project potential future GHG impacts from the policy.

Finally, the National Programme for Sustainable Rice Production (Chapter 8) was selected for impact assessment. Demand for rice has grown in the past several decades, therefore, it represents an important part of the country's agricultural production. The policy focuses on reducing rice cultivation emissions through improved water management, Alternate Wetting and Drying (AWD) and Dry Direct Seeding (DDS), aiming to keep the same or increase grain yield, in order to reduce rice $CH_4$ emissions predominantly through water management practices. Water conservation efforts are also a component of the national climate adaptation strategy.

Country's land use and agricultural production for year 2020 (assumed the current year when the assessment is conducted) are described below.

### Land representation

| Land use category | East province area (ha) | West province area (ha) | Total area (ha) |
|---|---|---|---|
| Cropland remaining cropland | 145,305 | 34,509 | 179,814 |
| Grassland converted to cropland | 20,324 | - | 20,324 |
| Grassland remaining grassland | 234,900 | 3,209 | 238,109 |
| Cropland converted to grassland | 1,251 | - | 1,251 |
| Forest land remaining forest land | 5,409 | 85,988 | 91,397 |
| Forest land converted to cropland | - | 6,789 | 6,789 |
| Wetlands remaining wetlands | 1,305 | 2,509 | 3,814 |
| Settlements remaining settlements | 2,349 | 705 | 3,054 |
| *Total* | *410,843* | *133,709* | *544,552* |

### Climate and soil characteristics

| Land use category | Province | Climate | Soil type | Management | Area (ha) |
|---|---|---|---|---|---|
| Cropland remaining cropland | East | TRD | HAC | Annual crops | 50,507 |
| | East | TRD | HAC | Perennial crops | 19,974 |
| | East | TRD | HAC | Set aside | 24,980 |
| | East | TRD | VOL | Annual crops | 5,430 |
| | East | TRD | VOL | Perennial crops | 34,210 |
| | East | TRD | LAC | Annual crops | 2,309 |
| | East | TRD | LAC | Set aside | 7,895 |
| | West | TM | LAC | Wetland rice | 23,493 |
| | West | TM | LAC | Sugarcane | 2,005 |
| | West | TM | VOL | Perennial crops | 9,011 |
| Grassland converted to cropland | East | TRD | LAC | Perennial crops | 20,324 |
| Grassland remaining grassland | East | TRD | HAC | Rangeland | 35,490 |
| | East | TRD | VOL | Rangeland | 41,322 |
| | East | TRD | LAC | Rangeland | 158,088 |
| | West | TM | VOL | Managed pasture | 3,209 |
| Cropland converted to grassland | East | TRD | LAC | Managed pasture | 1,251 |
| Forest land remaining forest land | East | TRM | LAC | Evergreen forest | 5,409 |
| | West | TM | LAC | Mixed forest | 2,430 |
| | West | TM | VOL | Evergreen forest | 16,651 |
| | West | TM | LAC | Lowland forest | 66,907 |
| Forest land converted to cropland | West | TM | LAC | Wetland rice | 6,789 |

Note: TRD=Tropical dry, TM=Tropical moist, TRM=Tropical montane; HAC=high activity clay; LAC=low activity clay; VOL=volcanic

### Livestock characterisation

| Land use category | Cattle sub-category | Annual population (number of head) |
|---|---|---|
| Dairy cattle | Dairy: calves < 1-year-old | 369,600 |
| | Dairy: cattle 1-2 years | 436,800 |
| | Dairy: mature cows > 2 years | 621,600 |
| Other cattle | All other cattle | 252,000 |
| Additional cattle characteristics | | |
| Average annual milk production | | 1,825 kg/head/yr for small and medium farms |
| Productivity level | | Low |

### Manure management

| Activity data type | Value |
|---|---|
| Average length of storage | 60 days |
| Intended length of storage with policy | 15 days |
| Proportion of manure managed (and stored) as solids | 80% |
| Proportion of manure managed (and stored) as solids used for fertiliser | 40% |
| Proportion of manure managed (and stored) as solids used for fuel | 40% |
| Proportion of manure left on pasture | 20% |

### Synthetic fertiliser application – annual crops except rice

| Parameter | Units | Value |
|---|---|---|
| Fertiliser | | Urea (N) |
| Annual application rate | kg/ha | 109 |
| N content | % | 46% |

### Synthetic fertilisation application – rice

| Parameter | | Unit | Fertiliser | |
|---|---|---|---|---|
| | | | DAP | Urea |
| Application rate per season | | kg/ha | 188 | 218.8 |
| N content | | % | 18% | 46% |
| Nutrients application time | N applied at transplanting | kg/ha | 33.8 | 33.5 |
| | N applied 25-30 days after transplanting | kg/ha | -- | 33.5 |
| | N applied 45-50 days after transplanting | kg/ha | -- | 33.5 |

### Annual cropland management

| Climate | Soils | Crop rotation | Area (ha) | Full till area % | Reduced till area % | No till area % | Input system type |
|---|---|---|---|---|---|---|---|
| TRD | HAC | corn-soy-alfalfa-alfalfa | 23,738 | 25% | 25% | 50% | Full till: low-input system<br>Reduced-till: high-input system<br>No-till: high-input system |
| TRD | HAC | wheat | 18,183 | 20% | 60% | 20% | |
| TRD | HAC | cassava-beans | 8,586 | 100% | 0% | 0% | |
| TRD | VOL | vegetables | 4,235 | 100% | 0% | 0% | |
| TRD | VOL | cassava-beans | 1,195 | 100% | 0% | 0% | |
| TRD | LAC | wheat | 2,309 | 50% | 40% | 10% | |

### Rice cultivation system and management

| Parameter | Value |
|---|---|
| Water Management During Cultivation | Irrigated continuously flooded |
| Water Regime Before Cultivation | Non-flooded pre-season < 180 days |
| Yield | 9.8 kg fresh weight/ha |
| Number of seasons | 2 (same management for each season) |
| Application rate of organic amendments, ROA | 0 (no organic amendments are applied) |
| Residue management | 100% burnt |
| Cultivation area | 30,282 ha |

# Templates

All templates are available for download.

### Policy Description Template

| Policy description category | Detailed description | To be filled in |
|---|---|---|
| Name of the policy* | Policy name | |
| Type of policy instrument* | The type of policy, such as those presented in Chapter 3, Section 3.2 (e.g., Regulations and standards, Taxes and charges, Trading Programmes, Voluntary agreements or actions, Subsidies and incentives, Research, development and deployment policies, Information instruments) | |
| Description of specific interventions* | The specific mitigation measure carried out as part of the policy | |
| Status of the policy* | Whether the policy is planned, adopted or implemented | |
| Date of implementation* | The date the policy comes into effect (not the date that any supporting legislation is enacted) | |
| Date of completion (if relevant) | If relevant, the date the policy ceases, such as the date a tax is no longer levied or the end date of an incentive scheme with a limited duration (not the date that the policy no longer has an impact) | |
| Implementing entity or entities* | The entity or entities that implement(s) the policy, including the role of various local, subnational, national, international or any other entities | |
| Objectives and intended impacts or benefits of the policy* | The intended impact(s) or benefit(s) the policy intends to achieve (for example, the purpose stated in the legislation or regulation) | |
| Level of the policy | The level of implementation, such as national level or regional level | |
| Policy inputs | Resources that go into implementing a policy such as funding allocated to training and education programmes or expertise needed to carry out policy activities | |
| Policy activities | Administrative activities involved in implementing the policy undertaken by the authority or entity that implements the policy (for example, hiring of additional staff, or offering grants to conduct trainings on new cultivation methods). Include to the extent possible the agency or stakeholders expected to implement the activity. | |

### Policy Description Template (Continued)

| Policy description category | Detailed description | To be filled in |
|---|---|---|
| Geographic coverage | The jurisdiction or geographic area where the policy is implemented or enforced, which may be more limited than all the jurisdictions where the policy has an impact | |
| Sectors affected* | For international reporting purposes, the country needs to specify the sector that the mitigation measure affects - energy, industrial processes and product use, agriculture, LULUCF, or waste. Since this guidance deals with activities affecting the agriculture and LULUCF sectors, the users can further specify which subsectors are affected based on country definitions | |
| Greenhouse gases affected* | Which GHG the policy aims to control, which may be more limited than the set of GHG that the policy affects | |
| Other related policies or actions | Other policies or actions that may interact with the policy being assessed | |
| Intended level of mitigation to be achieved and/ or target level of other indicators (if relevant)* | If relevant and available, the total emissions and removals from the sources and carbon pools targeted; the target amount of emissions to be reduced or removals to be enhanced as a result of the policy, both annually and cumulatively over the life of the policy (or by stated date); and/or the target level of key indicators (such as hectares of land to conserve) | |
| Key stakeholders | Key stakeholder groups affected by the policy | |
| Title of establishing legal framework, or other founding documents | The name(s) of legislation or regulations authorising or establishing the policy (or other founding documents if there is no legislative basis) | |
| Monitoring, reporting and verification procedures | Monitoring, reporting and verification procedures associated with implementing the policy | |
| Policy Key Performance Indicators | Metrics that indicate the state or level of a policy's performance. For mitigation policies included in a country's NDC, the KPIs will be used for NDC implementation tracking and should meet the requirements set in modalities, procedures and guidelines (MPGs) for the transparency framework | |
| Compliance and enforcement mechanisms | Compliance and enforcement compliance procedures, such as reporting requirements to verify implementation and/or penalties for noncompliance, if applicable | |

### Policy Description Template (Continued)

| Policy description category | Detailed description | To be filled in |
|---|---|---|
| Reference to relevant documents | Information to allow practitioners and other interested parties to access any guidance documents related to the policy (for example, through websites) | |
| The broader context or significance of the policy | Broader context for understanding the policy | |
| Outline of sustainable development impacts of the policy | Any anticipated sustainable development benefits other than GHG mitigation | |
| Other relevant information | Any other relevant information such as policy co-benefits, interactions with other policies, barriers to implementation, and/or trade-offs | |

*Indicates required reporting under the Enhanced Transparency Framework under the Paris Agreement

### Policy Inputs, Activities, and Intermediate Effects Template

*Note: Utilise inputs and activities from the policy description template to help fill in this table, some fields might not apply for a given input, activity, or intermediate effect. Include quantitative information when describing the amount of the effect to the extent possible Utilise (I) to designate input, (A) for activity, and (IE) for intermediate effect. Specify if the activity or intermediate effect leads to market-based impacts. Specify also if an intermediate effect reflects the policy mitigation measure*

| Inputs, activities, intermediate effects | Detail/ explanation | Affected parameter | Direction | Magnitude | Geographic location | Timing |
|---|---|---|---|---|---|---|
| *EXAMPLE: (IE) Improved diets for grazing cattle* | *Management changes result in improved quality of forage on pasture.* | *Feed intake in terms of gross energy (MJ per day or kg dry matter per day)* | *Increase* | *Approximately 1 million head (1.2 million hectares of land targeted by the policy with an average of 0.9 head/ hectare)* | *Regions where incentive payments are dispersed* | *5 years after policy implementation start* |
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## Policy GHG Impacts Template

*Note: Utilise intermediate effects from the intermediate effects template to help fill in this table*

| Intermediate effect* | Subsequent intermediate effects | | | Potential GHG impact |
|---|---|---|---|---|
| | Effect 1 | Effect 2 | Effect 3 | |
| *EXAMPLE: Feeding strategies such as improving forage quality, processing feeds to improve digestibility, adding grain-based concentrates to feed, or providing dietary supplements and feed additives* | *Digestibility improved* | *Livestock health improves and livestock grow faster* | *Production efficiency improves* | *Decreased $CH_4$ per unit of production* |
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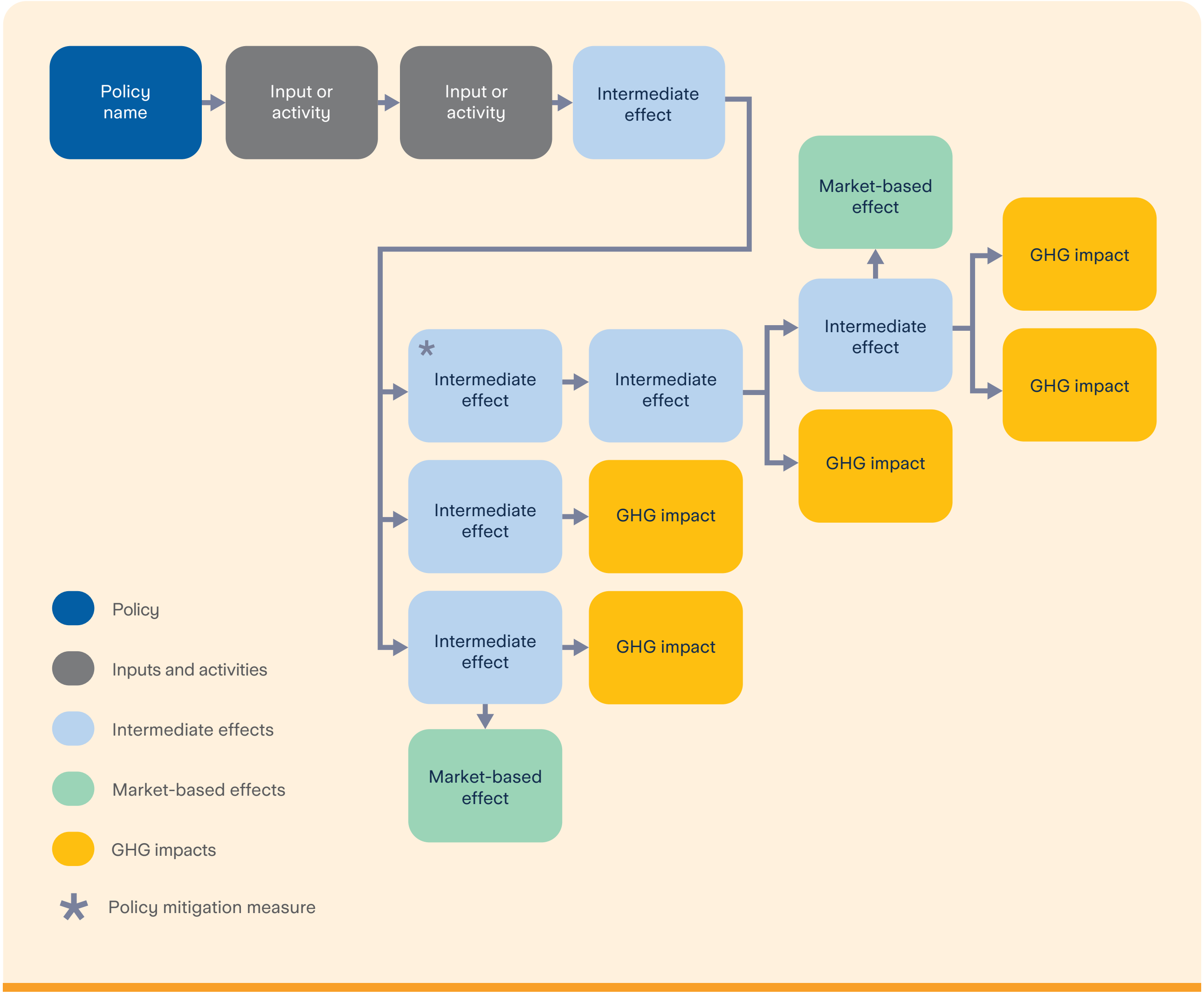
*indicates intermediate effects that are policy mitigation measures

## Policy Causal Chain Template



### Assessment Boundary Template

| **Mitigation measure** | **GHG impact** | **Likelihood** (Very likely, Likely, Possible, Unlikely, Very unlikely) | **Relative magnitude** (Major, Moderate, Minor, Unknown) | **Significance** (Significant – include in the assessment, Not significant – may exclude from the assessment Not estimated – exclude from the assessment when magnitude is unknown or impact is outside the Agriculture sector) |
|---|---|---|---|---|
| *EXAMPLE: Feeding strategies & pasture management* | *Decreased $CH_4$ per unit of production* | *Likely* | *Moderate* | *Significant* |
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## Assessment Reporting Template

| Mitigation measure | GHG impact |
|---|---|
| Assessment objectives | ▪ Assessment objective(s)<br>▪ Intended audience(s) of the assessment |
| Stakeholder participation | ▪ Stakeholder engagement activities undertaken during the assessment |
| General information | ▪ Name of policy*<br>▪ The person(s)/organisation(s) conducting the assessment<br>▪ The date of the assessment<br>▪ Whether the assessment is an update of a previous assessment, and if so, links to any previous assessments |
| Policy description | Description* (refer to Policy Description Template)<br>▪ Policy objectives*<br>▪ Type of policy instrument*<br>▪ Status*<br>▪ Sector(s) affected*<br>▪ Gases affected*<br>▪ Start year of implementation*<br>▪ Implementing entity or entities*<br>▪ Estimates of GHG emission reductions (Gg $CO_2e$) – achieved/ expected*<br>▪ Policy KPIs<br>▪ Other elements of the policy description included in the template |
| Policy impacts | ▪ A causal chain, including a table describing all intermediate effects, refer to the Causal Chain Template and Policy Inputs, Activities, and Intermediate Effects Template<br>▪ A list of all GHG sources and carbon pools that are considered for inclusion in the GHG assessment boundary, refer to the Assessment Boundary Template<br>▪ The assessment period |

**Assessment Reporting Template (Continued)**

| Mitigation measure | GHG impact |
|---|---|
| Baseline scenario and GHG emissions | ▪ Baseline type, e.g., constant, simple trend, advanced trend<br>▪ A description of the baseline scenario and justification for why it is considered the most likely scenario, including existing or planned policies and non-policy drivers<br>▪ The methodology and assumptions used to estimate baseline emissions, including the emissions estimation methods (including any models) used<br>▪ The baseline values for key parameters (such as activity data, emission factors and GWP values) in the baseline emissions estimation method(s) and their sources<br>▪ The methodology and assumptions used to estimate baseline values for key parameters, including whether each parameter is assumed to be static or dynamic, and assumptions regarding other policies/ actions and non-policy drivers that are included in the baseline and affect each parameter<br>▪ Total annual baseline emissions and removals over the GHG assessment period and disaggregated by each GHG source and carbon pool included in the GHG assessment boundary<br>▪ An estimate or description of the uncertainty and/or sensitivity of the results in order to help users of the information properly interpret the results and associated method or approach used to assess uncertainty |
| Policy scenario and GHG impacts/emissions | ▪ A description of the policy scenario(s) and justification for why it is why it was selected. May include more than one if several alternative scenarios are feasible, for example, maximum/optimistic and a more conservative scenario<br>▪ The methodology and assumptions used to estimate policy emissions, including the emissions estimation methods (including any models) used<br>▪ The values for key parameters (such as activity data, emission factors and GWP values) in the policy emissions estimation method(s) and their sources<br>▪ The methodology and assumptions used to estimate values for key parameters, including whether each parameter is assumed to be static or dynamic, and assumptions regarding other policies/actions and non-policy drivers that may affect each parameter<br>▪ For ex-post analysis, the performance of the policy, including whether the inputs, activities and intermediate effects that were expected to occur according to the causal chain, actually occurred<br>▪ Total annual emissions and removals over the GHG assessment period under the policy scenario(s) and disaggregated by each GHG source and carbon pool included in the GHG assessment boundary<br>▪ The method or approach used to assess uncertainty<br>▪ An estimate or description of the uncertainty and/or sensitivity of the results in order to help users of the information properly interpret the results |

### Assessment Reporting Template (Continued)

| Mitigation measure | GHG impact |
|---|---|
| Monitoring performance over time | ▪ A list of the KPIs used to track performance over time and the rationale for their selection<br>▪ Key performance indicator targets and monitoring frequency<br>▪ Monitoring plan status or mechanism (the plan itself could be an appendix of the assessment report) |
| Additional information to report | ▪ The type of technical review undertaken, if applicable<br>▪ Potential policy interactions<br>▪ Lessons learned<br>▪ Next steps |

*Indicates required reporting under the Enhanced Transparency Framework under the Paris Agreement common tabular formats are available in the Guidance for operationalising the modalities, procedures and guidelines for the enhanced transparency framework referred to in Article 13 of the Paris Agreement (UNFCCC, 2021b)

# Appendix

INTRODUCTION
PART I PLAN ASSESSMENT
PART II SELECT AND DESCRIBE POLICY
PART III ASSESS POLICY
CONCLUSION
HYPOTHETICAL COUNTRY
TEMPLATES & APPENDIX
TOOLKIT
CASE STUDIES

# Appendix A: Assessment of Policy Implementation Potential

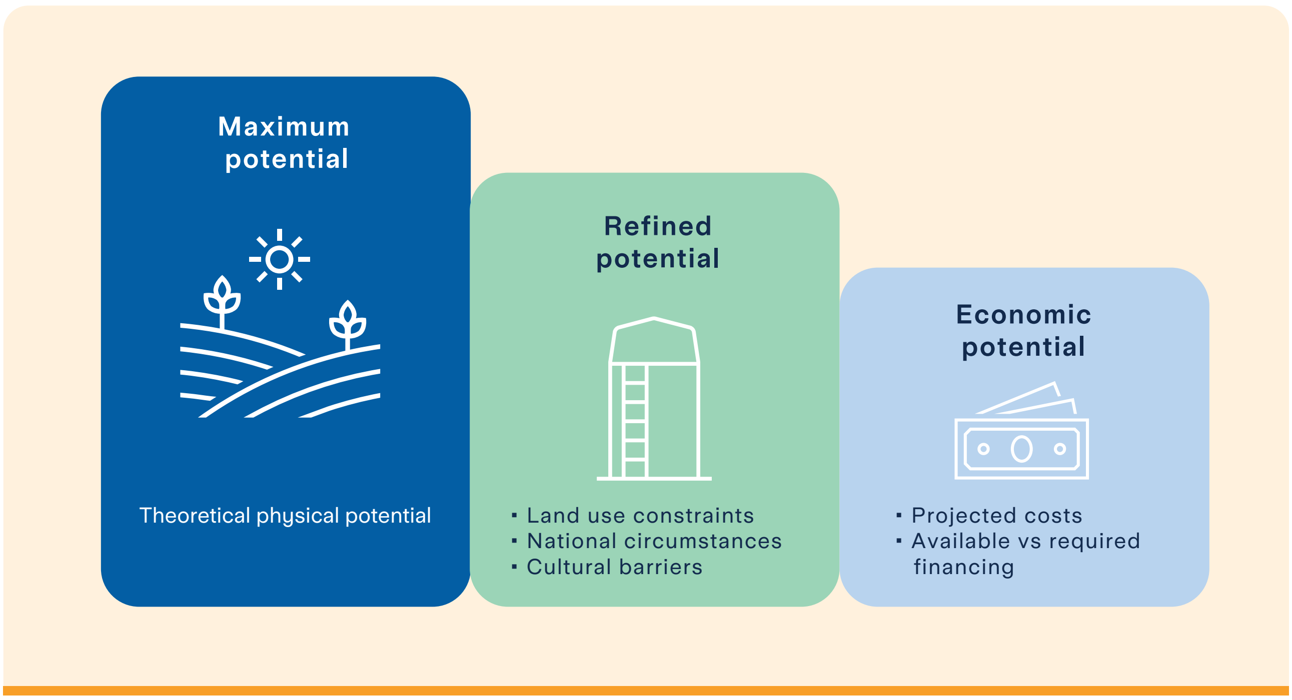
The assessment of the policy's implementation potential is an estimate of likely emission reductions that can be achieved when activities under the policy are implemented. It is an important exercise when a policy is being designed and planned. It can also be useful when the goal is to modify an existing policy, especially if the results of the impact assessment suggest that mitigation measures might fall short of existing targets. The users need to detail policy scenario(s) for the policy they are assessing, which is a set of events or conditions most likely to occur under the policy and/or those that may affect policy outcomes.

The guidance herein focuses first on estimating the maximum implementation potential of the policy to later determine the likely implementation potential. The maximum potential is achieved when the maximum change in production practice or other behaviour change associated with emissions occurs as a result of the policy scenario. The maximum implementation potential of the policy assumes that all inputs, activities and intermediate effects of the policy are highly likely to occur as planned and at the implementation level intended by the policy. It represents the intended policy outcome or policy effectiveness.

The maximum implementation potential is then refined to the likely implementation potential (e.g., most plausible policy scenario) by taking into account factors that could reduce the effectiveness of the policy as shown in **Figure A.1**. Finally, the implementation potential might be further reduced based on associated economic analysis that takes into account available financing and policy cost implementation. Most of the analysis described below will be qualitative and requires **expert judgement,** expert elicitation and/or **stakeholder input**.

To the extent possible, identify a single policy scenario that is considered to be the most likely. In certain cases, multiple policy scenario options may seem equally plausible. Users can develop multiple policy scenarios, each based on different sets of assumptions, rather than just one set. This approach produces a range of possible emissions reduction scenarios. Users can then conduct a sensitivity analysis to see how the results vary depending on the selection of policy scenario options.

Figure A.1. **Refining the maximum implementation potential to the implementation potential**



More guidance about conducting a sensitivity analysis is provided in Policy and Action Standard, Chapter 12, available in the guide's assessment toolkit.

### Determine the maximum implementation potential

For each GHG emission or removal source affected by the policy, choose the activity data associated with that source to assess the implementation potential of the policy. The type of activity data chosen should be a parameter that is expected to change as a result of the policy and be used to estimate GHG impacts. Therefore, the activity data serves as a proxy for the policy outcome. Examples include hectares of land under particular management, livestock population and type, quality and type of fertiliser applied, and water management regime for rice cultivation.

The maximum implementation potential can be estimated based on a number of elements. The options include a mitigation goal, expected adoption of practices or technologies, financial considerations, land area and other resources potential, and expert judgement. Each element is further explained below. The maximum implementation potential can be estimated using a single or combination of elements. A combination will likely yield a better estimate.

### Mitigation goal

When there is an intended level of mitigation and/or an explicit goal for the policy, the goal, along with other details of the policy, can be used to estimate the maximum implementation potential. A mitigation goal may include, among other things, the target amount of emission reductions to be reduced or carbon stocks enhanced as a result of the policy or the total expected emission reductions and removals from a specific GHG source or carbon pool.

Using a stated goal as the main indication of intended policy outcomes or policy effectiveness can be highly uncertain. At a minimum, the mitigation goal needs to be specific enough to reflect an intended level of mitigation.

### Adoption of practices or technologies

In the absence of data that allows estimates of emissions and setting GHG mitigation targets, the policy goal can be activity-based, e.g., the amount of land area under different management or adoption rate of a particular mitigation measure. The mitigation goal may not be in the same units as the activity data, and additional information from surveys and national statistics may be needed to estimate how the goal will translate into actions or land areas. For example, an explicit goal for an agriculture policy could be to have 100 percent of all corn cultivated using no-till methods or 50 percent of rice farmers in the country adopt alternate wetting and drying during cultivation.

The expected level of adoption of the practice or technology that is targeted by the policy can be used to estimate the maximum implementation potential. The main assumption would be that targeted stakeholders will fully engage voluntarily, or fully comply where the policy is mandatory.

It can be used to infer the amount of land area or the number of livestock affected by the policy, such as:

- The stakeholders targeted by the policy
- The average-sized parcel of land owned or utilised by a stakeholder group
- The typical amount of forest products extracted or crops produced per person
- The number of cattle or other animals managed by stakeholders in a specific region

### Land area and other resources potential

Analysing the availability of land is another way to estimate maximum implementation potential, meaning identifying the total area of land upon which there is technical potential for a specific mitigation practice or land-use change to occur. The assumption could be that all agricultural land is affected by the change in management or land use as a result of the policy. Alternatively, the policy might target highly-degraded land for conversion. For example, if a policy aims to convert highly-degraded pasture to productive silvopastoral systems, and there are 50,000 ha of highly-degraded pasture within the policy jurisdiction, assume the policy will result in 50,000 ha of pastureland used for silvopasture.

To use this approach for estimating maximum implementation potential, information on current land management and land uses is needed. Such data can be found in, or derived from, the following sources:

- National land cadastre, country's register of land parcels
- National agricultural census data
- Land-use titles
- Local or regional land registration offices
- Farmer or logger associations

Analysing the technical potential of other resources besides land area can be used to estimate adoption rates for new practices or technologies. For policies that reduce emissions from enteric fermentation, the total number of livestock in the country or the total number of ranchers could be used to analyse the maximum implementation potential. For example, if a policy seeks to increase feed supplement use in dairy cattle, it can be assumed that all dairy cattle within the policy jurisdiction for the defined system type and level of production, will receive the feed supplements as a result of the policy.

### Expert judgement

**Expert judgement** can be paired with any of the approaches above to derive an informed estimate of the maximum implementation potential. Sector specialists (e.g., farmers, ranchers, foresters, scientists who study the technologies or practices promoted by a policy, statisticians, and government staff familiar with the policy) can help to fill gaps in available data or provide a range for the maximum implementation potential. Agriculture experts can also help policy experts estimate effectiveness from estimated ranges.

### Account for policy design characteristics and national circumstances

To refine the estimate of policy implementation potential, users should analyse policy design characteristics and national circumstances that may reduce the effectiveness of the policy, and account for their effect on the maximum implementation potential. This can be done by evaluating a series of factors related to policy design characteristics and national circumstances that may reduce the effectiveness of the policy. Key types of factors include institutional arrangements, participation, compliance, synergies, and risks and barriers affecting policy implementation.

Considering the following factors described, it is recommended policy experts compile and analyse information on the policy design characteristics and national circumstances and refine implementation potential levels accordingly. **Table A.1** can be used for compiling information regarding factors that may impact implementation potential. Information can be gathered through expert elicitations with administration and government experts that are directly or indirectly involved in the policy under consideration, desk reviews, and **stakeholder consultations**.

### Institutional arrangements and national circumstances

Institutional arrangements are formal or informal legal and procedural agreements between agencies executing a policy. They can include arrangements between government agencies or with government and non-government or private sector agencies. National circumstances are the conditions present and relevant for the country's agriculture systems (for the purpose of this guide). They include, among others, the government structure, population profile, cultural context, geographic profile, climate profile, agriculture production types and the structure of the economy.

Lack of a governance structure, coordination between national and subnational levels, and legal basis for providing incentives to stakeholders are critical considerations that can inhibit the successful implementation of the policy if not addressed appropriately. In countries without established institutional arrangements or an effective legal framework to secure the cooperation between different government levels and the involvement of key stakeholders (including private, public or non-governmental), policies will likely be limited in their effectiveness.

### Participation requirements

Participation in the policy, by people or organisations, can be voluntary or mandatory. Voluntary participation relies on the willingness of stakeholders to respond to a policy, offers flexibility in terms of who participates and how, and can involve less oversight and enforcement. In the absence of strong incentives, voluntary participation is unlikely to result in high participation and is more likely to result in a policy whose impacts are indistinguishable from the baseline scenario. Other factors that can help or hinder participation include effective communications and training for target stakeholder groups.

Mandatory participation can be accompanied by specific obligations and can be enforced through strict procedures, including penalties for cases of non-compliance. Mandatory participation works better in cases where the progress of the policy implementation can be effectively monitored and enforced. However, bribery and corruption could reduce the potential impact of the policy.

### Compliance, monitoring, reporting, and verification

Monitoring and enforcement are mechanisms to compel stakeholders to comply with a policy. Monitoring is the process of inspecting that the policy is being implemented and enforcement is an action taken against those who are not in conformance with the policy. The policy may include measures to monitor and/or enforce policy implementation.

When stakeholders understand how the policy implementation will be monitored, compliance is more likely. If monitoring procedures are already in place or are planned (e.g., due to the existence of other similar policies or projects in a region), this can streamline effective policy implementation.

Stakeholders, including those that carry out enforcement at the local level, should be consulted to determine the likelihood that standards, rules, or laws will be enforced. The likelihood of enforcement (e.g., 90 percent chance of enforcement) should then be used to refine the implementation potential of the policy (e.g., reduce the impact by 10 percent). If penalties for non-conformance with the policy are minor, enforcement may not be as effective at ensuring compliance.

### Complementarity and synergies

GHG mitigation policies that contribute to local sustainable development and promote better local conditions are far more acceptable to local communities and usually have a far better chance of uptake and success (e.g., policies that increase farmers' profitability, have health benefits due to reduction of local air pollution, reduce loss of biodiversity, address desertification issues, protect water resources, or improve food security for poor communities).

The implementation of GHG mitigation policies can be positively or negatively affected by other complementary policies. For example, a policy to reduce water pollution from agricultural runoff may drive changes in land management that reduce fertiliser use and increase the use of cover crops, which are practices that can reduce $N_2O$ emissions from soils and increase soil carbon sequestration.

Interventions that provide education and technical assistance do not reduce GHG emissions directly. However, they may be pivotal in developing the capacity of land managers to implement new technologies and practices that reduce GHG emissions. Therefore, the presence of such interventions can be synergistic with GHG mitigation policies.

### Policy implementation risks

Food and forest production are highly susceptible to negative consequences from weather events (e.g., fires, floods, droughts, hurricanes etc.), changing climate conditions, pests and disease and increasing water scarcity. These risks should be considered in the context of the proposed policy.

The assessment should consider the effect of natural events and disasters. If areas that are known to be prone to extreme conditions are included in the geographic scope of the policy, the expected implementation potential of the policy impacts should be reduced because the policy will likely be ineffective in those areas.

The evaluation should also consider the risk that the policy will not be as successful as anticipated at reducing GHG emissions as a result of limited data and research. If identified, the policy should be designed to include appropriate data collection provisions and infrastructure for data management so that the policy can be adjusted through the course of its implementation. Where research and pilot studies have not been conducted, the policy may include such activities to reduce the risk that the implementation of the policy will be hindered by the lack of experience and proof of concept.

### Institutional barriers

Conflicting goals between different ministries and other government agencies could result in overlapping regulations and ambiguous roles and responsibilities of the stakeholders involved. For example, proposed areas for the policy may overlap with other existing types of area protection (e.g., based on national policies or international conventions), which could lead to confusing regulations for specific sites, insufficient monitoring or failure to achieve the intended outcomes of the policy.

Safeguards to prevent discrimination can be built into policies. For example, it can be required that enrolment in programmes such as education opportunities must be diverse in terms of race, ethnicity, and gender as appropriate for the demographic in the local agriculture production context. If safeguards against discrimination do not exist, either as part of the policy being analysed or in institutions involved in implementing the policy, it is possible that discrimination will be a barrier to policy implementation.

### Cultural barriers

The use of language and terminology, e.g., in the delivery of technical assistance, that is not widely understood by the target stakeholders could be a crucial cultural barrier as it could result in communications problems causing misunderstandings, mistrust and non-participation/compliance among the local population.

In some countries, gender considerations can have a significant important effect on the success or failure of the implementation of the policy. It is important to consider who makes decisions about land use actions, and who has access to information and money.

Certain land areas or landmarks have important religious significance for local communities. Policies that may affect ancestral homes or sacred grounds would be more likely to face resistance from indigenous peoples and local communities.

Strong opposition to a policy, for example from a particular stakeholder group or political party, could impede the efforts to secure financing, gain trust, and otherwise implement policy interventions, especially if that group is influential.

Failure to identify and address these cultural barriers will more than likely have detrimental impacts on policy implementation. Effective stakeholder participation from early in policy design is important to identify and address cultural barriers.

### Physical barriers

In mountainous countries or countries with inaccessible regions, policies relating to agriculture and forests should take into account whether certain farms are remote or difficult to access. Minimal existing road networks or insufficient transportation infrastructure would be expected to limit the implementation potential.

### Estimating impact on maximum implementation potential

Using **Table A.1**, users answer each relevant question and score each response based on its potential to have a positive or negative effect on the policy's effectiveness, on a scale of 1 to 4, as follows:

1 = Likely to have a positive (reinforcing) effect

2 = Likely to have no effect (no discernible positive or negative effect)

3 = Likely to have a negative effect

4 = Unknown

Table A.1. **Policy design characteristics and national circumstances affecting implementation potential**

| Policy considerations | Score | Adjustment and rationale |
|---|---|---|
| **Institutional arrangements and national circumstances** | | |
| Can the policy be implemented with existing governance structures, institutional arrangements, and legal mechanisms? | | |
| Is there corruption in the areas or regions under consideration, and if so, how extensive? | | |
| Is there a clear title and rights to stakeholders receiving the benefits offered by the policy? | | |
| How well will the levels of governance that influence land use be able to coordinate to achieve the intended outcome? | | |
| How well can coordination (e.g., resources, enforcement or data sharing) be carried out at subnational levels (e.g., between local municipalities), if necessary, according to the policy? | | |
| **Participation requirements** | | |
| Is participation or compliance with the policy voluntary or mandatory? | | |
| **Compliance, monitoring, reporting, and verification** | | |
| Is there a monitoring programme planned or in place to inspect policy implementation? | | |
| Is there an enforcement measure that is part of the policy? If so, to what degree are similar standards, rules and regulations enforced and how? | | |

Table A.1. **Policy design characteristics and national circumstances affecting implementation potential (Continued)**

| Policy considerations | Score | Adjustment and rationale |
|---|---|---|
| **Complementarity and synergies** | | |
| To what extent will supporting or complimentary policies and actions in effect during the policy implementation period improve policy effectiveness? | | |
| To what extent is the policy part of an interdisciplinary approach linking food security, ecosystem services and/or sustainable development? | | |
| Are there supportive measures in place to build the capacity and technical skills of affected stakeholders who will be implementing the policy? | | |
| **Policy implementation risks** | | |
| To what extent are the intended policy outcomes vulnerable to risks (including natural events and disasters) that could jeopardise or reverse the policy outcomes? | | |
| Have research and pilot studies been conducted in the areas where the policy will be implemented and do they demonstrate that the expected outcomes of the policy are feasible? | | |
| Is there a system to collect activity data associated with policy implementation to track its performance? | | |
| **Institutional barriers** | | |
| Are there any conflicting goals or jurisdictions between ministries or other agencies with respect to the implementation of the policy? | | |
| Is there the potential for institutional racism, gender bias or age discrimination that could limit the policy effectiveness, for example by limiting the participation of certain stakeholders based on their race, ethnicity, religion, gender or age? | | |
| **Cultural barriers** | | |
| Are different languages used in the region where the policy will be implemented? | | |
| Is the policy congruent with cultural or aesthetic norms and values? | | |
| Are there gender issues in access to resources or communication? | | |

Table A.1. **Policy design characteristics and national circumstances affecting implementation potential (Continued)**

| Policy considerations | Score | Adjustment and rationale |
|---|---|---|
| Are there generational differences in work ethics and work approaches that can result in conflicts or disputes among stakeholders that limit the ability to effectively implement the policy? | | |
| Are there any areas or landmarks with religious and/or cultural significance of the region under consideration? | | |
| Is there a stakeholder group that has very strong opposition to the policy? | | |
| **Physical barriers** | | |
| Are land areas proposed for intervention easily accessible? | | |
| Is the necessary physical infrastructure in place for the proposed policy? | | |

The questions can be revised or further questions can be added, as needed, to ensure that the analysis is relevant to policy and national circumstances. Consider and determine to what extent the effects of the factors overlap. An overlapping effect, especially between barriers, should be considered because the combined effects of the barriers together may be greater than or less than the sum of the individual barriers. These overlapping effects should be appropriately accounted for when calculating the potential effect of all factors.

During the data-gathering phase, it is recommended that information also be collected on any other relevant policies in the country that might help overcome specific barriers. Where such policies exist, the scoring should be changed accordingly.

**Adjust implementation potential**

Once policy design characteristics and national circumstances have been scored, evaluate the overall distribution of scores:

- A distribution with many scores of 1 or 2 indicates less need to refine the estimated maximum implementation potential of the policy.
- A distribution with many scores of 3 or 4 could suggest a downward adjustment of the maximum implementation potential or gathering more information and reassessing the impact, especially for scores of 4.

Carefully review each score of 3. Consider and, if possible, estimate to what extent the factor will decrease policy effectiveness. In cases where quantifiable information is not available, estimated adjustments to policy effectiveness may be made using **expert judgement** based on the best available information. While it may be subjective, this is more conservative than not making an adjustment where the factor considered is likely to have a negative effect. Describe and justify the reduction. In addition, look for crucial problems that have the potential to render the policy ineffective. If even one crucial problem is identified, it is recommended to reconsider the policy design. It is recommended to identify, where possible, potential corrective action to minimise the negative impacts. For example, after following the guidance in this section the user may reduce the geographic scope of impact, reduce the expected adoption rates or delay the timing of the implementation of a policy.

For scores of 4, attempt to gather enough information to assess the effect of the factor. If that is not possible, it is conservative to assume it will have a negative effect. A positive impact may reinforce the implementation of the policy through, for example, synergetic effects between policies. Where a situation may increase policy effectiveness, it is conservative to not estimate any potential positive impact or make any positive adjustments to the expected policy outcomes. Use **Table A.1** to document implementation adjustments and rationale.

### Assess financial characteristics

Determining the cost of implementing mitigation practices or using technology (e.g., $/head to provide a feed supplement to livestock) can help determine the total financing required for the policy. Gaps in financing might result in an adjustment of the maximum implementation potential or additional activities to procure financing for the policy. Information on the unit cost of implementing new technologies or practices might be available through studies that have been commissioned and funded by the government, an international organisation or academia. Where unit cost information is not available, other sources can be used as a first approximation, including the following:

- Consultations with stakeholders on costs in different parts of the country and for different activities (such information could also be derived from scientific journals)
- Figures obtained from marginal abatement cost curve models or from articles or studies published in scientific journals

Where unit cost estimates, i.e., fixed and variable costs it takes to produce a crop or a product, are derived from global data, journals or studies relating to other countries, users should ensure that unit cost information is suitable or representative of national circumstances. Users also need an indication of the financial resources that will be allocated to a specific policy from the national budget and other funding sources (e.g., private sector, national or international donors, or international or regional funds) to estimate implementation potential from financial data.

### Costs and benefits for stakeholders

When developing and describing the policy, stakeholders who are affected by the policy are identified. In particular, **stakeholders** that implement changes in practices, technologies or land use in response to the policy should be consulted when assessing implementation potential and related financial considerations. Each stakeholder group should be included in the financial analysis and the net costs and benefits for each group considered separately. Where there is not sufficient data and information to analyse all stakeholder groups separately, at a minimum include the following groups in the analysis:

- Stakeholders with official land tenure rights or de facto control of lands addressed by the policy
- Stakeholders that use the lands addressed by the policy but have limited actual control over the lands

It can be difficult to distinguish between stakeholders with official tenure to land and stakeholders that use the lands affected by the policy without tenure. In such cases, focus on the main stakeholder group that is expected to implement the mitigation measures.

Refer to this guide's assessment toolkit for additional resources on cost-benefit analysis, such as the Guide to Cost-Benefit Analysis of Investment Projects.

### Calculate cash flows

In a basic implementation cost analysis, net cash flows are estimated for a typical stakeholder in each stakeholder group under baseline and policy scenarios. Net cash flow is the net amount of cash and cash equivalents moving into and out of a business. It is best if the financial feasibility analysis is done in the local currency to avoid the risk of currency fluctuations altering the conclusions of the analysis. If foreign investment is required, or if loans are denominated in a foreign currency, it is still best to do the analysis in the local currency and then convert the results to the foreign currency.

To calculate net cash flows, all costs and revenue streams should be accounted for. Depending on the scope of the policy, the costs and revenues will differ, as will the best sources to estimate them. Information on the unit cost of implementing new technologies or practices might be available through studies that have been commissioned and funded by the government, an international organisation or academia. Where unit cost information is not available, consultations with **stakeholders** on costs in different parts of the country can be useful. **Expert judgement** may also be needed to provide estimates for costs. Where unit cost estimates are derived from global data, journals or studies relating to other countries, users should ensure that unit cost information is suitable or representative of national circumstances.

Where inflation is likely (e.g., over longer periods of time), apply a discount rate and calculate a net present value for the cash flows to take into account the future value of money. The discount rate is the interest rate you need to earn on a given amount of money today to end up with a given amount of money in the future. Different stakeholders should have different discount rates. For example, the discount rate for a government is generally much lower than a discount rate for a corporation, and the discount rate for a corporation that has access to capital is often much lower than the discount rate of a smallholder farmer. Non-discounted values can be used if significant inflation is not expected during the analysis period (e.g., five years or less).

All costs relevant to the policy´s implementation should be considered. Depending on the type of activity, typical cost types are outlined in **Table A.2.**

Table A.2. **List of different costs to be considered when assessing policy implementation costs**

| Cost type | Item (unit) | Description |
|---|---|---|
| General | Land (USD/ha) | Cost to purchase or lease land |
| Livestock-related | Animal Feed (USD/ton) | Cost to purchase animal feed |
| Livestock-related | Fencing (USD/m/yr) | Cost to install fencing for cattle |
| Livestock-related | Animal Health (USD/head) | Cost of care (veterinarian, medication, etc.) per animal |
| Agronomy-related | Fertiliser (USD/ha) | Cost to purchase fertilisers |
| Agronomy-related | Seeds (USD/yr) | Cost to purchase seeds |
| Agronomy-related | Pesticides (USD/ha) | Cost to purchase pest control |
| Farm operation | Water (USD/ha) | Costs for water/irrigation |
| Farm operation | Electricity (USD/yr) | Utility costs in farm |
| Farm operation | Machinery (USD/yr) | Cost to purchase, lease or maintain machinery |
| Farm operation | Fuels (USD/yr) | Cost to purchase fuels |
| Farm operation | Labour (USD/yr) | Wages |
| Farm operation | Taxes (USD/yr) | Taxes to be paid for land, machinery or other activities |
| Farm operation | Permits (USD/yr) | Operating permits |
| Financial | Financing costs (USD/yr) | Interest rates, origination costs, etc. |

Carbon pricing is an instrument that captures the external costs of GHG emissions and ties them to their sources through a price. There is a growing consensus among both governments and businesses on the fundamental role of carbon pricing in the transition to a decarbonised economy (World Bank, Carbon Pricing Dashboard). Policy incentives may be based on the emission reductions achieved through practice implementation and carbon crediting mechanisms acting as a source of revenue for farmers.

To estimate net cash flows:

- Estimate baseline scenario costs and revenues using present-day data for a typical stakeholder that will take part in the policy, repeating this separately for each stakeholder group. Consider the following:
  - The use of land under consideration without the policy (e.g., what is produced on the land and how much, considering, for example, animal farming, croplands, set-asides or logging).
  - The average cost and revenue for land categories. Estimates can be based on groups of land categories, for example, use average expense and income from all cropland areas. The user may group fallow land and set-asides and derive average values for those lands.
  - The baseline scenario net cash flow (i.e., revenues minus costs) over the assessment period for each stakeholder group.
- Estimate the policy scenario costs and revenues over the assessment period for each stakeholder group. Consider the following:
  - The amount and type of government or private funding committed to implementing the policy
  - The cost to the stakeholder to implement the policy
  - The revenues that the stakeholder will gain from the policy
- Estimate the net cash flow for a typical stakeholder in the policy scenario for each stakeholder group.

### Estimate policy costs

Compare the net cash flow for the baseline scenario with that for the policy scenario for each stakeholder group and policy activity to assess the required financing for the policy. This may be the case if the cash flow for the policy scenario is less than the cash flow for the baseline scenario, is negative, or does not exceed a given threshold for the rate of return.

### Adjust implementation potential

Based on the results of the policy financial assessment, decide whether the implementation potential of the policy will be affected, especially if additional financing is unavailable. The following considerations may influence how the implementation potential of the policy can be adjusted:

- Where the policy does not appear to provide sufficient incentive for stakeholders to participate or otherwise respond to the policy, incentive amounts can be increased leading to a decrease in implementation potential if fewer farmers are able to adopt the practice under the policy.
- In addition to costs and revenues, the financial analysis should consider the relative timing of costs and revenues, and the capital needed to achieve these cash flows. If costs occur before revenues, stakeholders must have access to funds to pay the costs or they may not behave as expected. Delays in revenue relative to expenditures can create a significant barrier to implementation. Delaying the harvest season can be a barrier to food-insecure households that do not have other crops to eat during the delay.
- In general, unless the policy increases net revenue to stakeholders, or reduces their risks, the policy is unlikely to be adopted voluntarily.
- Investors, farmers, landowners and other stakeholders are often risk averse. Some policies offer stakeholders a positive financial return, yet still fail to be adopted, because stakeholders view returns as too uncertain or risky. For example, they may not be confident payments in the future will be made, contracts will be honoured, or the policy will have ongoing political and budgetary support. As a result, assessing simple return on investment

alone may not give a reliable indication of the likelihood of policy adoption. Financial risk can be quantitatively incorporated into the analysis by increasing stakeholders' discount rates or qualitatively considered by consulting stakeholders on their likely response to specific real-world policy incentives.

- Some changes may have non-obvious costs. For example, a change may involve significant management labour costs to revise organisational processes or training new workers that are needed to provide different skills to the organisation.
- It may be important to identify other financial considerations and sectoral policies and trends that may affect the outcome of the financial feasibility of the policy, and to consider whether these sectoral policies or trends reinforce or counteract the intended implementation (e.g., through price signals and consumer behaviour).

If the cost of implementation is high, participation levels may be reduced to keep the policy on budget. This would result in a further adjustment of the implementation potential of the policy. **Table A.3** below can be used to summarise the results of the implementation potential analysis.

Table A.3. **Refined implementation potential estimation template. This table can have additional columns added based on how many different factors are expected to impact implementation potential, one likely being related to economic feasibility.**

| Activity data affected by policy | Maximum implementation potential | Reduction in policy effectiveness due to factor X (% or amount) | Refined implementation potential | Additional reduction in policy effectiveness due to factor Y (% or amount) | Further refined implementation potential based |
|---|---|---|---|---|---|
| *Example: Implemen-tation area (ha)* | *1,200,000* | *10%* | *1,080,000* | *200,000* | *880,000* |
| *Example: Number of animals (head)* | *1,000,000* | *15%* | *850,000* | *50,000* | *800,000* |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |

Refer to this guide's assessment toolkit for additional resources on mitigation potential and abatement cost analysis, such as the Greenhouse Gas Abatement Cost Model (GACMO).

# Appendix B: Connection to other ICAT Assessment Guides

### Stakeholder participation during the assessment process

This appendix provides an overview of the ways that stakeholder participation can enhance the process for assessment of GHG impacts of agricultural policies. **Table B.1** provides a summary of the steps in the assessment process where stakeholder participation is recommended and why it is important, explaining where relevant guidance can be found in the ICAT *Stakeholder Participation Guide.*

Table B.1. **List of steps where stakeholder participation is recommended in the impact assessment**

| Chapter/step in this guidance document | Why stakeholder participation is important at this step | Relevant chapters in Stakeholder Participation Guide |
|---|---|---|
| Planning stakeholder participation (Chapter 2) | ▪ Build understanding, participation and support for the policy among stakeholders<br>▪ Ensure conformity with national and international laws and norms, as well as donor requirements related to stakeholder participation<br>▪ Identify and plan how to engage stakeholder groups who may be affected or may influence the policy<br>▪ Coordinate participation at multiple steps for this assessment with participation in other stages of the policy design and implementation cycle and other assessments | Chapter 4 – Planning effective stakeholder participation<br>Chapter 5 – Identifying and understanding stakeholders<br>Chapter 6 – Establishing multi-stakeholder bodies<br>Chapter 9 – Establishing grievance redress mechanisms |
| Setting objectives of policy GHG impact assessment (Chapter 2) | ▪ Ensure that the objectives of the assessment respond to the needs and interests of stakeholders | Chapter 5 – Identifying and understanding stakeholders |
| Estimating the baseline scenario and emissions (Chapter 2 – overview, Chapters 5-8 assessment) | ▪ Inform assumptions on existing and planned policies | Chapter 8 – Designing and conducting consultations |
| Monitoring performance over time (Chapter 2) | ▪ Ensure monitoring frequency addresses the needs of decision-makers and other stakeholders | Chapter 8 – Designing and conducting consultations |

Table B.1. **List of steps where stakeholder participation is recommended in the impact assessment (Continued)**

| Chapter/step in this guidance document | Why stakeholder participation is important at this step | Relevant chapters in Stakeholder Participation Guide |
|---|---|---|
| Describing policy (Chapter 4 – overview, Chapters 5-8 assessment) | ▪ Identify the full range of stakeholder groups affected by or with influence on the policy<br>▪ Enhance completeness by identifying expected intermediate effects and impacts for all stakeholder groups<br>▪ Identify and address possible unintended or negative impacts early on<br>▪ Improve and validate the causal chain with stakeholder insights on cause-effect relationships between the policy, behaviour change and expected impacts | Chapter 8 – Designing and conducting consultations |
| Assessing implementation potential of the policy (Appendix A) | ▪ Inform estimates of the policy's implementation potential<br>▪ Gain insights into a policy's specific local context and impacts<br>▪ Identify and address potential cultural and other barriers to policy implementation | Chapter 8 – Designing and conducting consultations |
| Reporting on assessment results (Chapter 9) | ▪ Raise awareness of the GHG benefits and build support for the policy<br>▪ Inform decision-makers and other stakeholders about impacts to facilitate adaptive management<br>▪ Increase accountability and transparency and thereby credibility and acceptance of the assessment | Chapter 7 – Providing information to stakeholders |

### Identifying sustainable development impacts

Refer to the ICAT *Sustainable Development Methodology* for guidance on conducting an assessment of sustainable development impacts. **Table B.2** below lists examples of sustainable development impacts that may be associated with agriculture policies, categorised according to the ICAT *Sustainable Development Methodology.* The Sustainable Development Goals (SDGs) most directly relevant to each impact category are indicated in parentheses.

Table B.2. **Examples of sustainable development impacts relevant to agriculture policies**

| Dimension | Groups of impact categories | Impact categories |
|---|---|---|
| Environmental impacts | Air | ▪ Air quality<br>▪ Visibility<br>▪ Odours |
| | Water | ▪ Availability of freshwater (SDG 6)<br>▪ Water quality (SDG 6, SDG 14)<br>▪ Biodiversity of freshwater and coastal ecosystems (SDG 6, SDG 14) |
| | Land | ▪ Biodiversity of terrestrial ecosystems (SDG 15)<br>▪ Depletion of soil resources (SDG 15)<br>▪ Land-use change, including deforestation, forest degradation, and desertification (SDG 15)<br>▪ Soil quality (SDG 2)<br>▪ Soil erosion |
| | Waste | ▪ Treatment of solid waste and wastewater (SDG 6) |
| | Other/cross-cutting | ▪ Resilience of ecosystems to climate change (SDG 13)<br>▪ Energy (SDG 7)<br>▪ Depletion of non-renewable resources<br>▪ Toxic chemicals released to air, water, and soil<br>▪ Terrestrial and water acidification (SDG 14)<br>▪ Infrastructure damages from acid deposition |

Table B.2. **Examples of sustainable development impacts relevant to agriculture policies (Continued)**

| Dimension | Groups of impact categories | Impact categories |
|---|---|---|
| Social impacts | Health and well-being | ▪ Hunger, nutrition, and food security (SDG 2)<br>▪ Access to safe drinking water (SDG 6)<br>▪ Access to land (SDG 2) |
| | Education and culture | ▪ Capacity, skills, and knowledge development (SDG 4, SDG 12)<br>▪ Climate change education, public awareness, capacity-building and research |
| | Institutions and laws | ▪ Strengthening land tenure<br>▪ Public participation in policy-making processes<br>▪ Access to information and public awareness (SDG 12) |
| | Welfare and equality | ▪ Poverty reduction (SDG 1)<br>▪ Protection of poor and negatively affected communities (SDG 12)<br>▪ Gender equality and empowerment of women (SDG 5)<br>▪ Indigenous rights |
| | Labour conditions | ▪ Labour rights (SDG 8)<br>▪ Quality of jobs (SDG 8)<br>▪ Fairness of wages (SDG 8) |
| | Communities | ▪ Community/rural development |
| | Peace and security | ▪ Resilience to climate change, including adaptation to dangerous climate change and extreme weather events (SDG 13) |
| Economic impacts | Overall economic activity | ▪ Economic activity (SDG 8)<br>▪ Economic productivity (SDG 8, SDG 2) |
| | Employment | ▪ Jobs (SDG 8)<br>▪ Wages (SDG 8)<br>▪ Worker productivity |
| | Business and technology | ▪ New business opportunities (SDG 8)<br>▪ Innovation (SDG 8, SDG 9)<br>▪ Competitiveness of domestic industry in global markets |
| | Income, prices and costs | ▪ Income (SDG 10)<br>▪ Prices of goods and services<br>▪ Costs and cost savings<br>▪ Market distortions (SDG 12)<br>▪ Internalisation of environmental costs/externalities<br>▪ Cost of policy implementation and cost-effectiveness of policies |
| | Trade and balance of payments | ▪ Balance of trade (imports and exports)<br>▪ Foreign exchange<br>▪ Government budget surplus/deficit |

### Technical review process

This section of the appendix provides an overview of the technical review process which can improve its transparency and accuracy. **Table B.3** provides a summary of the types of technical reviews that may be implemented, the selection of which will be based on review objectives. Refer to the ICAT *Technical Review Guide* for more details.

Table B.3. **Types of technical reviews to be completed after the impact assessment**

| Review type | Description | Considerations for selection |
| --- | --- | --- |
| First party | This type of technical review is carried out by the user – that is, the same government agency that is responsible for the implementation of the policy and/or the impact assessment. | ▪ Mechanism for internal improvement<br>▪ Reviewing an ex-ante impact assessment or an early-stage review of progress of implemented policies<br>▪ Reviewers from the user organisation will have more familiarity with the review objectives |
| Second party | This type of technical review is performed by a person or organisation that has an interest in, or affiliation with, the user. | ▪ Provides a greater level of independence between the user and reviewer<br>▪ Conducted by an internal independent regulatory body of the government or a consultant who has an interest in, or affiliation with, the policy design or implementation, but is not the actual party responsible for design or implementation.<br>▪ Reviewers have a good understanding of the organisation or government responsible for the assessment report, as a result<br>▪ of their prior affiliation with the user.<br>▪ Typically have a strong technical expertise and understanding of the policy that was assessed<br>▪ Allows close collaboration between the user and reviewer where independence is less of a priority, encourages learning and improvement. |
| Third party | This type of technical review is performed by a person or organisation that is independent from the user, in terms of commercial, financial and legal interests. | ▪ Occurs through either independent verification or technical expert review or analysis<br>▪ Allows for a higher degree of objectivity, leading to increased credibility of the assessment report to external stakeholders<br>▪ Enhances transparency, helps identify areas for improvement, as well as capacity-building needs |

# Toolkit

The assessment toolkit provides resources that support the assessment methodology presented in this guide. The toolkit includes short descriptions of references, databases, and tools and their applicability in the policy assessment process. It includes materials that provide input data, emission factors, and other parameters to supplement local data. It also identifies other reference materials to inform the work of measuring, reporting, and verifying GHG emissions. The toolkit is not an exhaustive list of all resources available, but rather a selection of those commonly used. Where other resources exist, especially those that are policy-specific or country-specific, they should also be considered for use.

This guide collectively refers to these materials as the assessment toolkit. Specific resources listed in this toolkit are indicated by the tools symbol throughout the guide.

| The GHG Protocol Policy and Action Standard | reference |
|---|---|
| Institution: | World Resources Institute (Rich, 2014) |
| Purpose: | As a basis for this guide, the Policy and Action Standard provides additional details on various components of the assessment process |
| Description: | The Policy and Action Standard provides a standardised approach for estimating and reporting the change in GHG emissions and removals resulting from different policies and actions. |
| Link for access: | https://ghgprotocol.org/policy-and-action-standard |

| Working paper: Monitoring Implementation and Effects of GHG Mitigation Policies: Steps to Develop Performance Indicators | reference |
|---|---|
| Institution: | World Resources Institute (Singh and Vieweg, 2016) |
| Purpose: | Helps determine parameters to track policy performance when selecting a policy to assess. |
| Description: | The paper outlines three steps in developing indicators for monitoring performance: formulating a list of possible indicators, selecting indicators to monitor performance, and collecting and monitoring data. |
| Link for access: | https://www.wri.org/research/monitoring-implementation-and-effects-ghg-mitigation-policies-steps-develop-performance |

| UNFCCC resources and supporting materials | reference database |
|---|---|
| Institution: | United Nations Framework Convention on Climate Change (UNFCCC) |
| Description: | The UNFCCC provides a series of materials, including methodologies to develop baseline and mitigation scenarios; a database with agriculture-related GHG emissions and guidance on institutional arrangements needed for emissions' international reporting.<br><br>▪ Compendium on Greenhouse Gas Baselines and Monitoring: This compendium can be used when assessing emission reductions from national-level mitigation actions and provides an overview of the main approaches for developing baseline and mitigation scenarios at the national level (i.e., for the entire economy), and guidance on how to select the most suitable baseline approaches based on the national circumstances of a country. This report provides additional guidance on developing baselines when conducting the assessment (UNFCCC, 2016).<br><br>Link for access: https://unfccc.int/files/national_reports/non-annex_i_natcom/cge/application/pdf/final-compendium-mitigation-actions.pdf<br><br>▪ UNFCCC Greenhouse Gas Data Interface: This free database gathers gross and net national emissions, including national agricultural emissions and national AFOLU/LULUCF emissions. The data is compiled using each Party's most recent National Communication (NC), Biennial Update Report (BUR), or Common Reporting Format (CRF) table submitted to the United Nations Framework Convention on Climate Change (UNFCCC). This database can be used to consider key emission sources and identify relevant policies during the Policy Selection stage of the assessment.<br><br>Links for access: https://di.unfccc.int/time_series<br><br>▪ UNFCCC Consultative Group of Experts Toolbox for Institutional Arrangements: This toolbox provides a handbook on institutional arrangements and enhancing MRV systems in six languages, a compilation of case studies, and a listing of additional technical resources. This guidance can be used when determining data needs for the assessment and policy performance monitoring.<br><br>Links for access: https://unfccc.int/CGE/IA |

| ICAT Toolbox | reference tool |
|---|---|
| Institution: | Initiative for Climate Action Transparency (ICAT) |
| Description: | This platform offers a set of open-source tools and methodologies on a wide range of topics developed by the ICAT's implementing and supportive partner institutions.<br><br>▪ Policy assessment guides: Methodology guidelines to help countries assess the climate impacts of selected policies and actions. These guidelines include methodologies to estimate GHG impacts for various sectors, including this guide on agriculture; cross-cutting impacts, including sustainable development, transformational change and non-state and subnational actions; and process-related guidelines looking into stakeholder participation and the technical review process. These guides can be used to assess mitigation policy from the sustainable development perspective or provide additional guidance on components of the assessment described in this guide. The guides more relevant for the users of this guide and referenced here include:<br>  ▪ Introduction to the ICAT Assessment Guides: provides an introduction to the purpose of the guides and an overview of the scope of each guide and when to use it.<br>  ▪ Sustainable Development Methodology: provides a methodology to assess development impacts of a policy, beyond its climate mitigation impact. This includes, for example, potential changes in air pollution, job creation, improved health, access to energy, poverty reduction, protection of ecosystems, and others.<br>  ▪ Stakeholder Participation Guide: provides a methodology to implement effective participatory processes which is centred around six basic key elements.<br>  ▪ Technical Review Guide: provides guidance for planning and conducting technical reviews. The guide outlines three different approaches for review and provides guidance on selecting the most appropriate type of review.<br>  ▪ Forest Methodology: provides guidance for assessing the GHG impacts of policies that impact carbon stocks. While the focus is on afforestation and/or reforestation, sustainable forest management and avoided deforestation and/or degradation, the same methodology can be applied when land is converted as a result of changes in the agricultural systems.<br><br>Link for access: https://climateactiontransparency.org/our-work/icat-toolbox/assessment-guides/<br><br>▪ COMPASS toolbox: A selection of climate scenario modelling tools to support the assessment and understanding of the impacts of climate action and policies. Of particular relevance for this guide is the PROSPECTS+ tool which is a sector-level, bottom-up Excel tool which uses decarbonisation-relevant activity and intensity indicators to track and project GHG emissions trends. It covers all emissions-generating sectors, including agriculture. This tool can be used to create the baseline scenario, when limited historical and projections data is available in the country.<br><br>Link for access: https://climateactiontransparency.org/our-work/icat-toolbox/compass-toolbox/ |

| IPCC Guidelines and supporting materials for the AFOLU sector | reference database tool |
|---|---|
| Institution: | Intergovernmental Panel on Climate Change (IPCC) |
| Description: | The IPCC provides methodology guidelines (including emissions inventory tables), technical reports, emission factors and other relevant materials for countries to estimate national GHG emissions inventories.<br><br>▪ 2006 Guidelines for National Greenhouse Gas Inventories: includes sectoral methodologies recommended by legal documents for estimating GHG inventories, as well as worksheets in MS Excel format as supporting material to assist the emissions estimation. These guidelines were updated through the "2019 Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories" methodology report, to reflect new scientific and other technical advances. Furthermore, the 2013 Supplement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories: Wetlands provides additional guidance for calculating emissions related to agricultural activities on organic soils. The 2006 Guidelines and 2019 Refinement are the basis for the assessment presented in this guide and a technical reference for the methodology described in this guide (IPCC, 2006).<br>Link for access: https://www.ipcc-nggip.iges.or.jp/public/index.html<br><br>▪ Emission factor database (EFDB): Open access database where users can find emission factors and other parameters with background documentation or technical references that can be used for developing emission factors and parameters for estimating greenhouse gas emissions and removals. IPCC does not vet materials posted to the EFDB. The database builds on peer-reviewed data from journals and other publications, including National Inventory Reports. This can be used in the assessment when users are considering going beyond default emission factors used in Tier 1 calculations.<br>Link for access: https://www.ipcc-nggip.iges.or.jp/EFDB/main.php<br><br>▪ Technical reports: The IPCC prepares Assessment Reports about the state of knowledge on climate change, its causes, potential impacts and response options. There are also Special Reports, focused on a specific topic and Methodology Reports, which provide practical guidelines for calculating national emissions inventories. Most recent and relevant reports for the AFOLU sector include:<br>  ▪ 6th Assessment Report (IPCC, 2022)<br>  ▪ Climate Change and Land Special report (IPCC, 2020)<br>  ▪ Policies, Instruments and Co-operative Arrangements report (Gupta et al., 2007)<br>Link for access: https://www.ipcc.ch/reports/<br><br>▪ Inventory Software: The IPCC Inventory Software includes modules to estimate historical emissions in all sectors. For the AFOLU sector in particular, the software applies Tier 1 methods to all categories, while Tier 2 methods are only available for the agriculture-related categories of the AFOLU sector. The software's objective is to enable filling out the 2006 IPCC Guidelines category worksheets with the sector's activity and emission factor data. The software also supports other functions related to database administration, quality control, data export/import and data reporting. This tool can be used to conduct the assessment calculations.<br>Link for access: https://www.ipcc-nggip.iges.or.jp/software/index.html |

| Livestock Activity Data Guidance (L-ADG) | reference |
|---|---|
| Institution: | FAO and Global Research Alliance on Agricultural Greenhouse Gases (Wilkes et al., 2020) |
| Purpose: | To provide additional guidance for utilising more advanced calculation methods. |
| Description: | Guidance to support countries in improving the accuracy of the livestock emission estimates, including emissions from enteric fermentation, manure management and manure left on pasture. It proposes methods for countries to move from Tier 1 to Tier 2 based on a systematic assessment of often existing data. Tier 2 methods allow to better reflect changes in livestock emissions as a result of implementing mitigation policies and measures. |
| Link for access: | https://www.fao.org/publications/card/en/c/CA7510EN/ |

| Guide to Cost-Benefit Analysis of Investment Projects | reference |
|---|---|
| Institution: | The European Commission (European Commission, 2015) |
| Purpose: | To provide additional guidance for estimating cost of policy implementation |
| Description: | This is a guide on the foundations of investment project evaluation, in the context of the EU Cohesion Policy. The cohesion policy is the European Union's strategy to promote and support the 'overall harmonious development' of its Member States and regions. The guide does not require a specific background in financial and economic analysis and can be a useful resource to identify costs and revenues, calculate discounted cash flows, and implement other aspects of project financial and economic feasibility analysis. |
| Link for access: | https://op.europa.eu/en/publication-detail/-/publication/120c6fcc-3841-4596-9256-4fd709c49ae4 |

| GHG Data management tool | reference tool |
|---|---|
| Institution: | The Food and Agriculture Organization of the United Nations (FAO) |
| Purpose: | This can be used both as a reference for identifying needed activity data and as tool to compile information about activity data sources. |
| Description: | This excel-based resource helps GHG inventory compilers manage the information related to the activity data and parameters for all sectors, including for agriculture, forestry and other land use (AFOLU). The agriculture excel file contains a comprehensive list of activity data and parameters that must be collected to estimate emissions from all categories within these sectors. This tool must be used in conjunction with the 2006 IPCC Guidelines that provide more explanations on the information needed. |
| Link for access: | The user can download the tool: https://www.fao.org/fileadmin/user_upload/climate_change/etf/docs/GHG_DataManagementTool.zip<br>A guidance note is available at: https://www.fao.org/3/cb7400en/cb7400en.pdf |

| FAOSTAT | database |
|---|---|
| Institution: | The Food and Agriculture Organization of the United Nations (FAO) |
| Purpose: | This dataset can be used as a source of activity data when planning for the assessment. |
| Description: | FAOSTAT is a statistical database from FAO and provides free access to food and agriculture data for over 245 countries and territories and covers all FAO regional groupings from 1961 to the most recent year available (2019/2020 at the time of this publication). The dataset provides information on agricultural emissions, production, trade, investments, and employment. The dataset tool allows searching or analysis of specific indicators or commodities. This is one of the most complete available free datasets related to agriculture and food systems. |
| Link for access: | https://www.fao.org/faostat/en/#home |

| International Fertiliser Association database (IFASTAT) | database |
|---|---|
| Institution: | International Fertiliser Association (IFA) |
| Purpose: | This dataset can be used as a source of activity data for assessing policies related to fertiliser management |
| Description: | The IFASTAT database features statistical information on fertiliser & raw materials supply and fertiliser consumption. It includes 15 years of global data on production, trade and supply; and 45 years of data on plant nutrient consumption. Access to regional data is freely available, but country-specific data and charts are only accessible for IFA members. |
| Link for access: | https://www.ifastat.org/ |

| DATAMAN - Database of Greenhouse Gas Emissions from Manure Management | database |
|---|---|
| Institution: | AgResearch, with funding from the New Zealand Government in support of the Global Research Alliance (GRA) |
| Purpose: | This database can be used to inform activity data and emission factors related to manure management |
| Description: | The database contains emissions data from all stages of manure management (housing, storage, land application and direct deposition by livestock). The user needs to register to be able to access, view and download the datasets. For each category (field, storage and housing), the platform displays the data as a table, but also offers insights on the number of observations e.g., by country or by animal, and some visualisations of the data presented in histograms. |
| Link for access: | https://www.dataman.co.nz |

| Harmonized World Soil Database v 1.2 | reference database |
|---|---|
| Institution: | FAO with IIASA, ISRIC-World Soil Information, Institute of Soil Science, Chinese Academy of Sciences (ISSCAS), and the Joint Research Centre of the European Commission (JRC) |
| Purpose: | This resource contains information about soils to support land stratification. |
| Description: | This database combines four other databases, namely the European Soil Database (ESDB), the 1:1 million soil map of China, various regional SOTER databases (SOTWIS Database), and the Soil Map of the World. It includes over 15,000 different soil mapping units with the information contained within the 1:5,000,000 scale of the FAO-UNESCO Soil Map of the World. Broadly, the database includes global terrain slope and aspect data, including elevation and slope; land use and land cover data, including seven major land cover/land use categories presented as a percentage share of the total area; and soil qualities for crop production parameters, including seven key soil qualities important for agriculture activities. |
| Link for access: | https://www.fao.org/soils-portal/data-hub/soil-maps-and-databases/harmonized-world-soil-database-v12/en/ |

| World Bank Open Data | database |
|---|---|
| Institution: | The World Bank |
| Purpose: | This dataset can be used as a source of contextual sector data when selecting policy and establishing a baseline during the assessment. |
| Description: | This platform offers free access to statistics and data from a number of macro, financial and sector databases. The user can search for indicator names, countries or topics and gets a list of matching results. Only one indicator can be displayed at a time. Data pages allow the option to download all displayed data in bulk. The dataset includes past data for a set of agriculture indicators for each country (crop and livestock production index, % of agricultural land area, share of agriculture in GDP) which can be used to inform current activity levels and future projections. |
| Link for access: | https://data.worldbank.org/ |

| EX-Ante Carbon-balance Tool (EX-ACT) | tool |
|---|---|
| Institution: | Food and Agriculture Organization of the United Nations (FAO) |
| Purpose: | This tool can be used to estimate the mitigation potential of any type of land use related intervention, at any stage of implementation (ex-ante, during, and ex-post). |
| Description: | This open-source, Excel-based tool is structured around the IPCC guidelines to report emissions of the AFOLU sector. The tool estimates GHG emissions reduction and carbon sequestration potential of AFOLU projects and policies. The main output is the carbon balance and avoided emissions from the project or policy selected, plus the carbon fluxes and carbon balance by module.<br>The EX-ACT tool requires quite detailed input data, including e.g., changes in productivity levels or yields as a result of the mitigation policy being evaluated. Not all components need to be filled in for the tool to provide results (can be limited to a subsector of interest). The tool has eight input modules: i) description of the project or policy to be evaluated; ii) Land-use changes; iii) cropland management; iv) grassland and livestock; v) forest management; vi) inland wetlands and waterbodies; vii) coastal wetlands and fisheries; viii) other inputs and investments. |
| Link for access: | The user must register to download the tool: https://www.fao.org/in-action/epic/ex-act-tool/suite-of-tools/ex-act/en/.<br>A user guide is available at: https://www.fao.org/3/cc0142en/cc0142en.pdf and https://www.fao.org/3/cb5559en/cb5559en.pdf |

| Nationally Determined Contribution Expert Tool (NEXT) | tool |
|---|---|
| Institution: | Food and Agriculture Organization of the United Nations (FAO) |
| Purpose: | This tool is a GHG accounting tool to support annual environmental impact assessment for the agriculture, forestry and other land use (AFOLU) sector. |
| Description: | This open-source, Excel-based tool is structured around the IPCC guidelines, including the 2019 Refinement to the 2006 IPCC guidelines, to develop a 30-year time-series of annual and cumulated estimates of carbon removal and GHG emissions reductions from climate actions. The tool is designed to provide results that aligns with the provisions of the Paris Agreement's enhanced transparency framework and supports the tracking of NDC as required by the modalities procedures and guidelines (MPGs). The NEXT tool requires users to provide a set of basic information per activity, which is the area (or quantity of inputs, numbers of heads or livestock), the start and end of the climate action, and the land management practices. |
| Link for access: | The user can download the tool: https://www.fao.org/climate-change/our-work/what-we-do/ndcs/research-tools/next/en/<br>A user guide is available at: https://www.fao.org/documents/card/en/c/cc0568en |

| Global Livestock Environmental Assessment Model – interactive (GLEAM-i) | tool |
|---|---|
| Institution: | Food and Agriculture Organization of the United Nations (FAO) |
| Purpose: | This tool can be used to inform the preparation of national livestock emissions inventories, as well as for evaluation of mitigation options related to animal husbandry, feed and manure management. |
| Description: | GLEAM-i is an open-source, livestock-specific tool to calculate livestock emissions using IPCC Tier 2 methods. This tool is complementary to the EX-ACT model and it includes modelling for cattle, sheep, goats, chicken, pigs and buffaloes. The tool is divided into three main modules or entry points to reduce emissions: herds, feed and manure. |
| Link for access: | https://www.fao.org/gleam/resources/en/ |

| Food, Agriculture, Biodiversity, Land-Use, and Energy (FABLE) calculator | tool |
|---|---|
| Institution: | The FABLE Consortium, as part of the Food and Land-Use (FOLU) Coalition |
| Purpose: | This tool can be used to develop baseline scenarios in ex-ante policy assessment to inform emission projections. |
| Description: | The FABLE Calculator is an Excel accounting tool to study the potential evolution of food and land-use systems over the period 2000-2050. The tool assumes agriculture as the main driver of land-use change and provides a platform to model the impact of different policies and changes in the drivers of these changes. It includes data for 76 agricultural products (crop and livestock) and relies extensively on the FAOSTAT (2020) database for input data, although this can be manually replaced with national or subnational data by the user. As output, the calculator generates the level of agricultural activity, land use change, food consumption, trade, GHG emissions, water use and biodiversity conservation for the defined scenarios. Results are shown in a 5-year time-series.<br>A strength of this tool is that it can include impacts of climate change on crop yields, as well as changes in demand (based on dietary shifts), imports, exports and food waste, which is often missing in other tools. A limitation is that the forestry sector is not yet fully considered, as parts of GHG emissions sources and sinks are not covered (e.g., managed forests and woody products). The tool is complex, therefore fully understanding the computations and being able to make changes require time and training. Training materials are progressively being made available |
| Link for access: | The user can download the open-source calculator, tool documentation & description and join a discussion forum at: https://www.abstract-landscapes.com/fable-calculator |

| Agriculture and Land Use (ALU) national greenhouse gas inventory software | tool |
|---|---|
| Institution: | Colorado State University |
| Purpose: | To help users and inventory compilers estimate agriculture and land use emissions in line with the 2006 IPCC Guidelines. The software can also use the inventory data as a baseline for projecting emission trends associated with management alternatives and estimating mitigation potentials. |
| Description: | This software provides a platform to estimate emissions for the AFOLU sector, in line with the 2006 IPCC Guidelines. The software divides the inventory analysis into steps to facilitate the compilation of activity data, assignment of emission factors and completion of the calculations. The software also provides two approaches to estimate mitigation potentials, namely through the "practice-based" approach or the "whole session approach". The first one accounts for changes due to technological advances or conservation management; the second is related to changes in activity data or emission factors, all based on the user's inputs and assumptions. |
| Link for access: | https://www.nrel.colostate.edu/projects/alusoftware/home |

| CCAFS Mitigation Options Tool for Agriculture (CCAFS-MOT) | tool |
|---|---|
| Institution: | The CGIAR (Consultative Group on International Agricultural Research) Research Program on Climate Change, Agriculture and Food Security (CCAFS). |
| Purpose: | This tool can be used when evaluating a set of mitigation options and when limited input data is available; it allows for comparison and prioritisation of mitigation options. |
| Description: | This Excel-based tool provides a platform to estimate GHG emissions mitigation potential for several crops and livestock management practices in different geographic regions. The CCAFS-MOT tool brings together several empirical models to estimate GHG emissions from different agricultural practices and suggests mitigation options that are compatible with the current food production system. The tool's main output is a range of potential mitigation options, organised according to their mitigation potential.<br>The tool requires detailed input data, divided into five main data input sections (sheets). Many of the required inputs can be selected from a drop-down menu and the tool includes default values for some of the required indicators (in case data is not available at the national level):<br>▪ General input (country, climate, soil details, land use change, and ecological zone)<br>▪ Crops (type, yield and residue, tillage, cover crop, type and amount of organic fertiliser, crop duration, synthetic fertiliser and where the fertiliser is produced)<br>▪ Rice (type, yield and residue, specific climate categorisation, baseline management, soil management, and details on organic and synthetic fertiliser used)<br>▪ Grassland (grazed, un-grazed, type, yield and residue, details on baseline management practices, soil, and details on organic and synthetic fertiliser used)<br>▪ Livestock (type, production system, body weight and product). |
| Link for access: | The Excel-based tool can be downloaded from: https://cgspace.cgiar.org/handle/10568/67027 (Oct 2018). A user guide is available at: https://cgspace.cgiar.org/handle/10568/67027 |

| The Greenhouse Gas Abatement Cost Model (GACMO) | tool |
|---|---|
| Institution: | UNEP Copenhagen Climate Centre |
| Purpose: | This model can be used to develop a baseline, a mitigation scenario or to compare mitigation potentials and costs of the seven options included for the Agriculture sector. |
| Description: | The GACMO Model consists of a 40-sheets Excel file that can be downloaded from the website to calculate GHG emissions from a start year until 2020, 2025, 2030, and 2050 under a baseline or a mitigation scenario. The outputs of the model are an Abatement Revenue Curve and a table providing an overview of the cost and mitigation impact of 115 climate mitigation actions organised in 24 types (including agriculture, biomass energy, forestry, solar, wind, etc.). For agriculture specifically, the mitigation options included are rice crops, zero tillage, cover crops, nitrification inhibitors, covering slurry stores, fat supplementation in ruminants' diets, and tobacco curing. |
| Link for access: | https://unepccc.org/publications/the-greenhouse-gas-abatement-cost-model-gacmo/ |

# Case Studies

# MEXICO: Subnational Mitigation Actions for the Regeneration of Landscapes

## COUNTRY CONTEXT

The majority of Mexico's rangelands, 9.9 million hectares of natural grasslands and 6.1 million hectares of induced grasslands, is used for livestock production. Although there is no precise data on the number of cattle under regenerative practices in Mexico, the 2007 Agricultural, Livestock and Forestry Census of the National Institute of Statistics and Geography (INEGI) indicates that only 19% of cattle in the country utilise managed grazing. On the contrary, 55 percent of cattle are managed exclusively with free grazing. This type of operation leads to continuous overgrazing, degraded pasture, risk of desertification, loss of forage capacity, invasion of shrub plants, and a decrease in habitat quality for wildlife. The Nationally Appropriate Mitigation Action (NAMA) of *Subnational Mitigation Actions for the Regeneration of Landscapes* provides a model mitigation action that can be adopted nationally to address this problem and transition the livestock subsector to regenerative practices.

The implementation of holistic management in rangelands is considered a conditional measure for the Agriculture sector in Mexico's Nationally Determined Contributions (NDC). According to the National Institute of Ecology and Climate Change (INECC), the carbon sequestration potential of implementing this mitigation action in all areas with degraded soils due to overgrazing is 5,600,000 $ktCO_2e$ by 2030.

This policy contributes to several areas of the National Climate Change Strategy Vision such as establishing livestock production schemes that reduce emissions and sequester carbon in grazing lands and identifying, strengthening, or generating economic and financial instruments that encourage the restoration, conservation, sustainable use and resilience of ecosystems and the services they provide. Additionally, it contributes to several of Mexico's adaptation goals, including integrated water management and diversification of sustainable agricultural activities.


## POLICY ASSESSMENT OBJECTIVES

- Demonstrate to subnational governments planned grazing's potential as a strategy to achieve mitigation targets
- Provide state governments with reliable data on GHG impact for reporting mitigation actions at the state, national, and international levels
- Develop and validate a soil carbon quantification model under regenerative practices
- Generate knowledge of impacts that support the practice of regenerative practices to enhance water retention and store carbon
- Validate a methodology that can be replicated in other Mexico states for GHG impact quantification from soil regeneration
- Strengthen state climate action plans with the quantification of emission reductions resulting from regenerative practices
- Attract financing by demonstrating expected future results
- Report and communicate the impacts of implemented policies and actions

## POLICY DESCRIPTION

*Required for reporting under the Enhanced Transparency Framework under the Paris Agreement*

<table>
<tr><td>Name of policy</td><td>Subnational Mitigation Actions for the Regeneration of Landscapes</td></tr>
<tr><td>Description</td><td>The policy was adopted as a pilot and early action in 2016 in 5 states. The mitigation measure focuses on planned grazing on cattle ranches. The policy will consist of the following components:<br>▪ Characterise the grazing system in each state to define parameters of the intervention such as the species and breeds needed for improved pasture<br>▪ Train and provide technical support to ranch owners through courses, workshops, and support from state extensionists to develop management plans<br>▪ Provide financial support to ranchers to implement management plans and develop needed infrastructure<br>▪ Conduct regular visits to monitor implementation of management plans, provide ongoing advice and verify ranch reports<br>▪ Participants submit annual reports on the implementation of their management plans, including information required for estimating GHG impacts<br>▪ Additional incentives such as payments for ecosystem services may be provided<br>Activities are funded and administered at the state level. At the time of the assessment, 2019, it was projected that actions will be adopted in a total of 13 states</td></tr>
<tr><td>Policy Objectives</td><td>▪ Mitigate climate change through the regeneration of more than one million hectares of grazing land and strengthen state climate action plans<br>▪ Increase carbon stocks of soil organic carbon and roots<br>▪ Improve water holding capacity<br>▪ Improve and maintain the ecological health of ranches<br>▪ Increase livestock productivity and profits<br>▪ Generate knowledge about regenerative practices<br>▪ Generate tools and methodologies that facilitate implementation and demonstrate results in the field<br>▪ Contribute to the goals established in Mexico's NDC<br>▪ Strengthen public policies supporting rural populations in adopting regenerative practices to improve agricultural soils<br>▪ Align public policies that focus on recovering natural capital, healthy food production and increased livestock productivity<br>▪ Strengthen regional resilience</td></tr>
<tr><td colspan="2">Implementing entity: Sierra Gorda Ecological Group, I.A.P.; Bosque Sustentable, A.C.; State Governments and civil society partners; Ministry of Agriculture and Rural Development (SADER)</td></tr>
<tr><td colspan="2">Type of instrument: Taxes and fees; Subsidies and incentives; Financing and investment; Voluntary actions; Training and technical assistance</td></tr>
<tr><td colspan="2">Status & start year of implementation: Adopted; 2016 in the states of Chihuahua, Sonora, Querétaro and San Luis Potosí; 2017 in Nuevo Leónand 2018 in Guanajuato. Projected to be implemented in additional states starting in 2020</td></tr>
<tr><td colspan="2">Sector(s) affected: Agriculture, livestock; LULUCF – grassland remaining grassland</td></tr>
</table>

Refer to Chapter 4 in the ICAT Agriculture Methodology for guidance on policy description steps and templates

**Policy Key Performance Indicators (KPIs):**

- Number of subnational actions for planned grazing
- Number of climate funds established with a subaccount or funding for planned grazing
- Amount of funding allocated to the funds for planned grazing
- Amount of funding allocated to planned grazing from budget or other sources
- Amount of matching funding from federal programmes
- Number of hectares of grazing lands with planned grazing
- GHG impact
- Number of landowners receiving support to improve their grazing land management
- Value of support received by participating landowners

## GHG MITIGATION EFFECTS OF THE POLICY

*Required for reporting under the Enhanced Transparency Framework under the Paris Agreement*

| | |
|---|---|
| **Gases affected** | GHG emissions to be included within the policy assessment boundary:<br>▪ $CH_4$ from enteric fermentation<br>▪ $CO_2$ from soil sequestration<br>Other emissions likely to be affected, but not quantified include:<br>▪ $CO_2$ from biomass<br>▪ $CH_4$ and $N_2O$ from manure on pasture<br>▪ $N_2O$ emissions from agricultural soils |
| **Estimates of GHG emission reductions (kt $CO_2$e) – achieved/expected** (Inventory reporting categories) | Achieved emission reductions: **629.4 Gg $CO_2$e** from 2016 to 2018<br>Expected emissions reduced by **57,172.0 Gg $CO_2$e** from 2019 to 2040<br>GHG Inventory categories affected:<br>▪ 3A1a (Enteric fermentation – beef cattle)<br>▪ 4C1 (Grassland remaining grassland) |

## METHODOLOGICAL CONSIDERATIONS AND ASSUMPTIONS

**Methodology**: IPCC 2006 Guidelines, Tier 1 methodology and associated default soil carbon stock reference values, default stock change factors; national emission factor for enteric fermentation of 56 kg $CH_4$ per animal per year was used.

**Timeframe:** Ex-post analysis is conducted for 2016-2018, when policy was piloted in five states; ex-ante analysis is conducted for 2019-2040 with projection for policy implementation in 13 states.

**Baseline scenario:** Simple trendline baseline was used for cattle population (1.3 percent annual growth), average of 0.1155 head of cattle per hectare was used as the initial value; constant baseline for soil carbon stock and biomass for moderately degraded grassland.

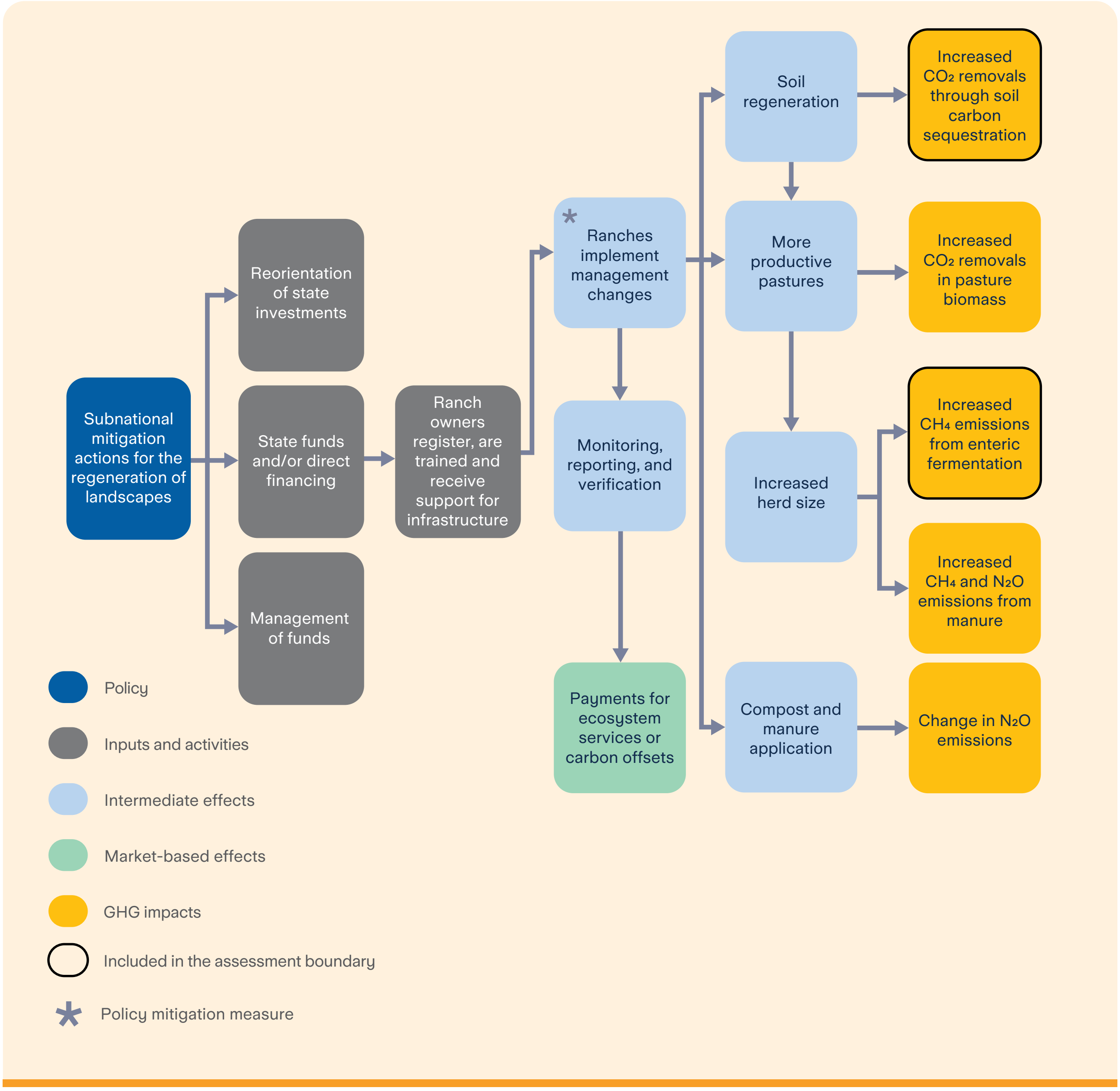
**Policy scenario:** cattle herd size will increase 4.13 percent annually for 10 years (expert judgement), pasture management will improve on 1.1 million hectares of grazing land by 2040.

**Activity data:**

- Beef cattle population headcount (national agriculture surveys and data provided by ranchers)
- Land stratification and area (national agriculture surveys and data provided by ranchers)
- Pasture management regime (national agriculture surveys and data provided by ranchers)

## POLICY CAUSAL CHAIN

Causal chain for the implementation of Subnational Mitigation Actions for the Regeneration of Landscapes policy for Mexico. The outlined GHG impacts represent those included in the assessment boundary to be quantified in the assessment (likely to occur and expected to be moderate or major in magnitude).


Subnational mitigation actions for the regeneration of landscapes
Reorientation of state investments
State funds and/or direct financing
Management of funds
Ranch owners register, are trained and receive support for infrastructure
* Ranches implement management changes
Monitoring, reporting, and verification
Payments for ecosystem services or carbon offsets
Soil regeneration
More productive pastures
Increased herd size
Compost and manure application
Increased CO2 removals through soil carbon sequestration
Increased CO2 removals in pasture biomass
Increased CH4 emissions from enteric fermentation
Increased CH4 and N2O emissions from manure
Change in N2O emissions
Policy
Inputs and activities
Intermediate effects
Market-based effects
GHG impacts
Included in the assessment boundary
Policy mitigation measure

### BASELINE SCENARIO

The baseline emissions are expected to increase due to increasing beef cattle population. The total cumulative GHG emissions during the assessment period are **4,599.6 Gg $CO_2e$** in emissions.

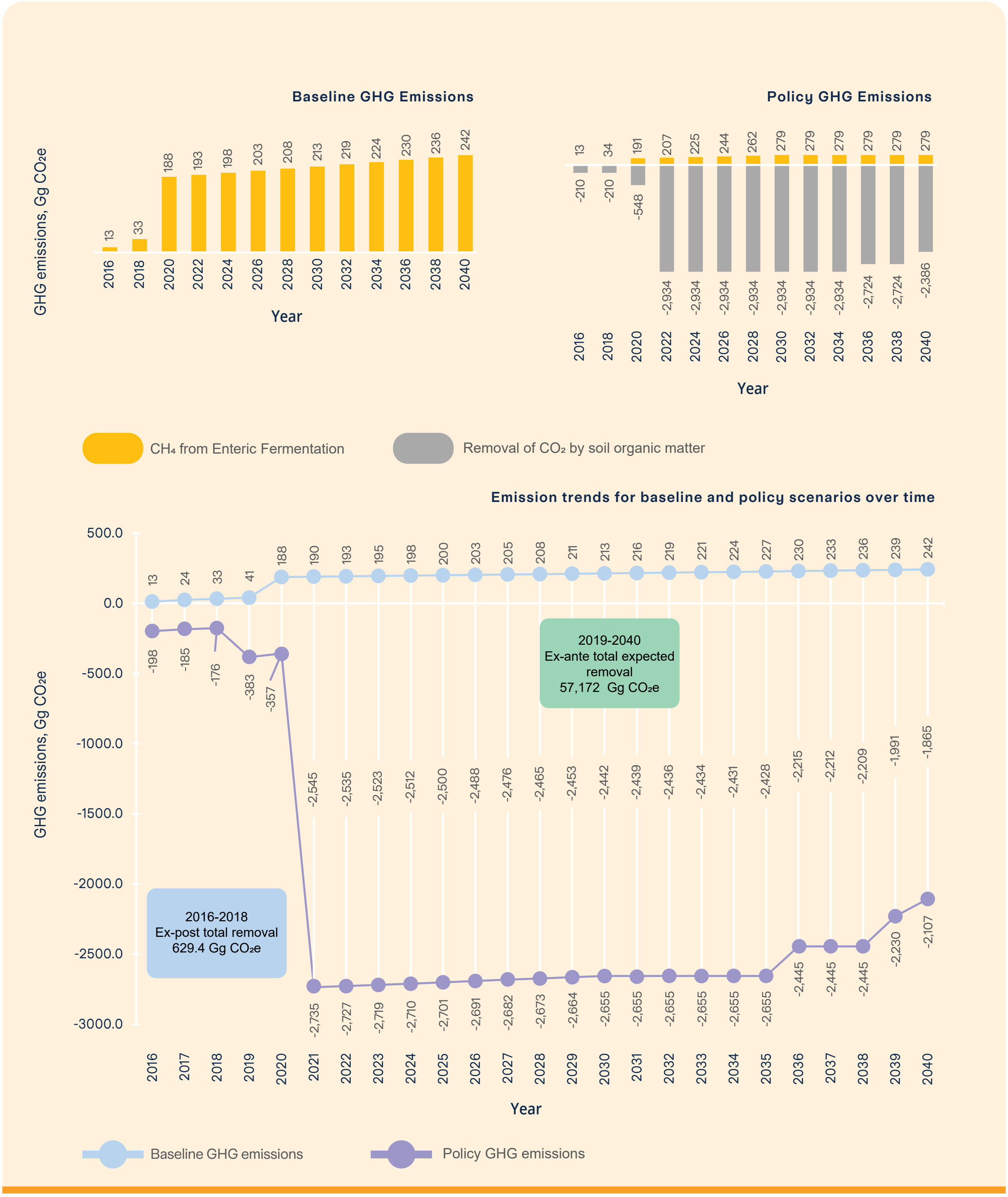
| Emission source/sink | Ex-post emissions (Gg $CO_2e$) | Ex-ante emissions (Gg $CO_2e$) |
|---|---|---|
| Enteric fermentation | 69.8 | 4,529.8 |
| Soil organic carbon | No change | No change |

### POLICY SCENARIO

The GHG emissions after policy implementation decrease due to removal of carbon through soil sequestration despite increasing emissions from increased beef cattle population. The total cumulative GHG removal during the assessment period is estimated to be **53,201.6 Gg $CO_2e$**.

| Emission source/sink | Ex-post emissions (Gg $CO_2e$) | Ex-ante emissions (Gg $CO_2e$) |
|---|---|---|
| Enteric fermentation | 71.8 | 5,414.6 |
| Soil organic carbon | -631.3 | -58,056.7 |

The emissions reduction achieved during the pilot and early actions, 2016-2018, is **629.4 Gg $CO_2e$**. The emission reduction projected to occur 2019-2040 is **57,172.0 Gg $CO_2e$**, with the total cumulative emissions reduction from the policy being **57,801.4 Gg $CO_2e$** during the assessment period.



## LESSONS LEARNED

- The projection of cattle numbers is challenging as planned grazing and regenerative management of grazing lands involve the development of management activities adapted to the environmental conditions of each ranch and the particular resources and needs of each rancher.
- The Non-State and Subnational Action Guidance of ICAT was used to compare the potential of the regenerative planned grazing component of the NAMA to contribute to the NDC goals of Mexico under the Paris Agreement. The analysis found that the policy could contribute 41% of the unconditional goal for the Agriculture sector in 2030.
- The financing model of establishing special fees or taxes at the state level to finance climate action has been very successful in the pilot state of Querétaro, which established a special fee paid by vehicle owners when renewing their license plates. The state has also announced a new carbon tax that will go into effect in 2023 that will include the option for affected businesses to reduce their tax payments through offset mechanisms, including offsets generated from the regenerative management of grazing lands.
- Upon the launching of its new platform for the reporting of subnational climate change actions, the federal Ministry of Environment and Natural Resources (SEMARNAT) indicated its acceptance of ICAT methods for assessing GHG impacts.

## POLICY SUSTAINABLE DEVELOPMENT IMPACTS

Sustainable development impacts were assessed as part of a complementary assessment of transformational changes. The following areas of impact were identified and are likely to have an effect on the sustainable development goals below:

- Increased economic activity for local and regional populations
- Increased income of participating ranches
- Change in expenses of participating ranches
- Improved ecological community dynamics
- Improved water cycle
- Improved quality of life


For a full description of the policy, intermediate effects, and GHG impacts, see Mexico's ICAT Agriculture Policy Assessment Report, Transformational Change Assessment Report, and Non-State and Subnational Action Assessment Report.

# FIJI: 5 Year Strategic Development Plan 2019-2023. Strategic Priority 4: Establish and Improve Commercial Agriculture

## COUNTRY CONTEXT

Fiji is an island country in Melanesia, part of Oceania in the South Pacific Ocean, consisting of 332 islands of which only a third are inhabited. The Fiji population is concentrated on the two major islands with 90 percent of the people living in coastal areas. Fiji's geographical location and the importance of natural resources to its main economic sectors makes Fiji highly vulnerable to natural hazard and climate change. This has significant implications for Fiji's economic growth as the country relies heavily on its natural resources for its economic development. The country's primary industries include fisheries, forestry, and agriculture.

Over recent years, the rate of growth in agricultural production has stagnated and failed to keep pace with the needs of a rapidly growing population in the country, resulting in a progressive increase in importing of food. Livestock imports increased from 55.1M FJD in 2000 to 97M FJD in 2008. Low agriculture productivity has a serious implication on the country's ability to produce enough food for its growing population and thus, undermines food security. The Strategic Priority 4 (SP4) of Fiji's 5-Year Strategic Development Plan aims to increase local livestock production to meet the local demand for meat consumption, thus, enhancing food security and reducing dependency on imported goods. An increase in livestock production will reduce the costs associated with importing meat products, enhancing Fiji's Gross Domestic Product (GDP). The Government of Fiji applied the methodology outlined in the ICAT Guide for Agriculture to assess the impact of SP4 on greenhouse gas


(GHG) emissions, of which the outcomes and lessons learned are described in this case study.

## POLICY ASSESSMENT OBJECTIVES

- Quantify the policy impacts of implementing SP4 on GHG emissions
- Identify policy impact indicators and develop technical guidance for tracking sustainable development and GHG impacts
- Develop recommendations for including Agriculture sector policies in Fiji's enhanced Nationally Determined Contribution (NDC)

## POLICY DESCRIPTION

*Required for reporting under the Enhanced Transparency Framework under the Paris Agreement*

| | |
|---|---|
| **Name of policy** | 5 Year Strategic Development Plan 2019-2023<br>Strategic Priority 4: Establish and Improve Commercial Agriculture (Strategic Theme: Farmer Technical Capacity) |
| **Description** | The policy will provide technical interventions such as improved breeding and genetic stock for livestock, improved quality livestock feed, the development of rehabilitation centres to monitor animal health and productivity, and methane capture through biogas digesters. Activities under the policy include:<br>▪ The provision of enhanced quality breeds of beef & dairy cattle, sheep, goat, swine, and poultry to increase livestock production.<br>▪ Use of Juncao grass to produce quality livestock feed.<br>▪ Reduce incidences of animal diseases through systematic Brucellosis and Tuberculosis Eradication Campaign (BTEC) and animal disease management.<br>▪ Installation of biogas digesters on piggery and poultry farms. |
| **Policy Objectives** | To enhance economic growth and create job opportunities by increasing Fiji's commercial agriculture production of livestock (beef cattle, dairy cattle, sheep, goat, poultry, and swine) by 10% and reducing agriculture imports by 5% by the end of 2023. Furthermore, the policy aims to reduce reliance on fossil fuels and wood for cooking by utilising methane captured through the biogas digesters. |
| **Implementing entity:** Ministry of Agriculture | |
| **Type of instrument:** Financing and Investment | |
| **Status & start year of implementation:** Adopted, implementation started in 2019 | |
| **Sector(s) affected:** Agriculture, livestock | |

Refer to Chapter 4 in the ICAT Agriculture Methodology for guidance on policy description steps and templates

**Policy Key Performance Indicators (KPIs):**
*(Note: these KPIs were identified as part of the assessment, for the purpose of enabling tracking of policy performance over time, e.g., as part of a monitoring plan.)*

- Average annual livestock population (head per year)
- Average animal weight per category (kg)
- Average animal growth rate (weight gain) per category (kg per day)
- Average animal milk production per category (kg per head per day)
- Fractional usage of MMS (manure management system type) for each species/ livestock category
- Average animal lifespan per category (yr)

## GHG MITIGATION EFFECTS OF THE POLICY

*Required for reporting under the Enhanced Transparency Framework under the Paris Agreement*

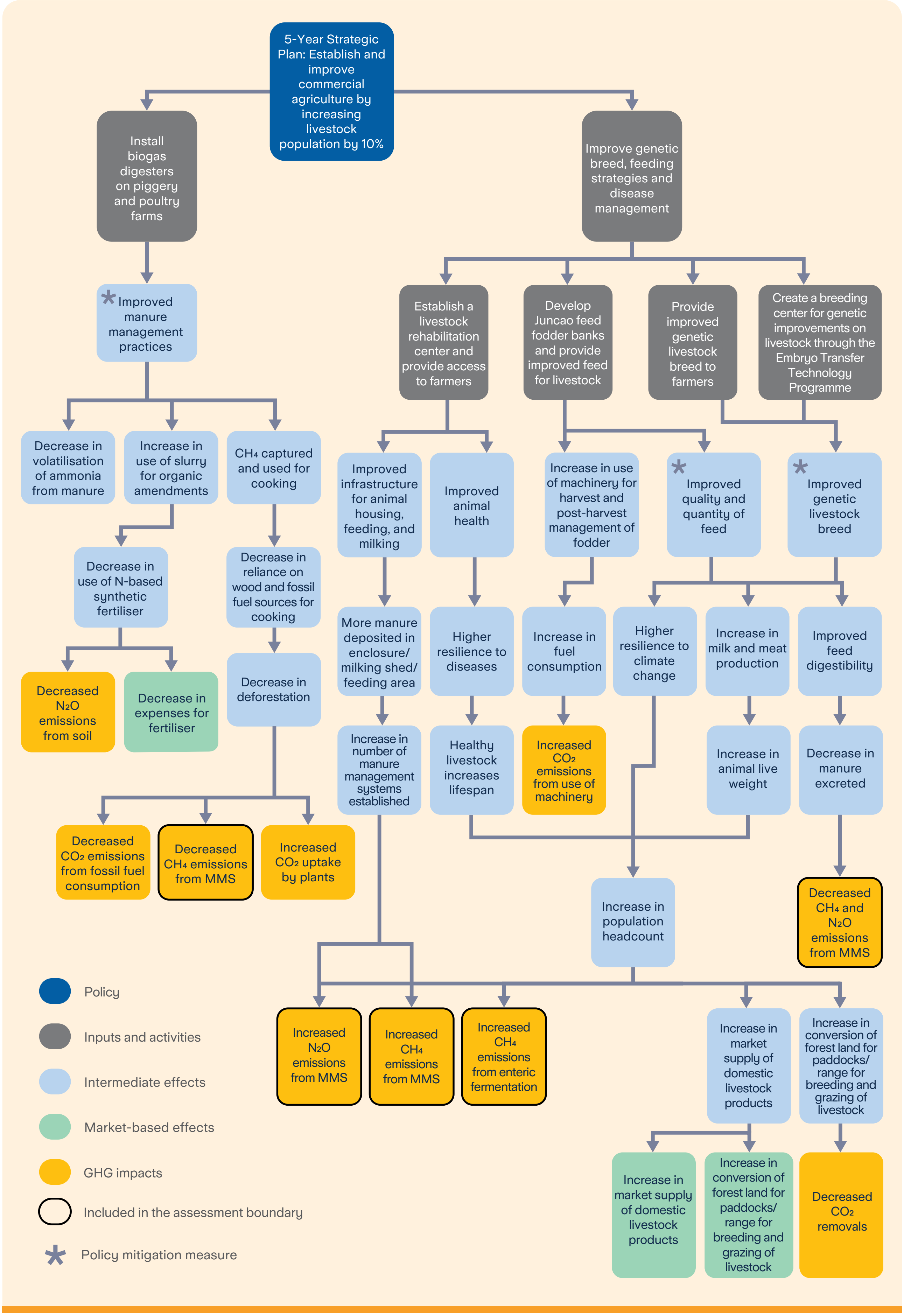
| | |
|---|---|
| **Gases affected** | Reducing GHG emissions was not the main target of this policy. However, these are the GHG emissions identified by the assessment as being affected by the policy and included within the policy assessment boundary:<br>▪ $CH_4$ from enteric fermentation from cattle, swine, and poultry<br>▪ $CH_4$ and $N_2O$ from manure management from swine and poultry<br>Other emissions likely to be affected, but not quantified are:<br>▪ $CO_2$ emissions from machinery use<br>▪ $CO_2$ removals and storage in woody biomass of plants<br>▪ $N_2O$ emissions due to nutrient management and cattle manure left on pasture |
| **Estimates of GHG emission reductions (Gg $CO_2e$) – achieved/expected** (Inventory reporting categories) | Emissions will increase by **123.58 Gg $CO_2e$** during the assessment period. This indicates a 10% increase in cumulative emissions upon implementation of the policy.<br>GHG Inventory categories affected:<br>▪ 3A1 (Enteric fermentation – cattle, further broken down by categories)<br>▪ 3A3 (Enteric fermentation – swine)<br>▪ 3A4g (Enteric fermentation – poultry)<br>▪ 3B(a) – Manure management, $CH_4$<br>   ▪ 3B1 (Manure management – cattle)<br>   ▪ 3B3, 3B4g (Manure management – swine, poultry)<br>▪ 3B(b) – Manure management, $N_2O$<br>   ▪ 3B1 (Manure management – cattle)<br>   ▪ 3B3, 3B4g (Manure management – swine, poultry) |

## METHODOLOGICAL CONSIDERATIONS AND ASSUMPTIONS

- **Methodology:** IPCC 2006 Guidelines, Tier 1 methodology. Emission factors for cattle were adjusted from defaults to better represent Fiji cattle milk productivity (refer to Fiji's Agriculture Livestock Emissions Guidance Document & User Manual for details, link below)
- **Baseline scenario:** simple trendline baseline, decreasing livestock population based on historical data,1995-2020
- **Timeframe:** ex-ante analysis of the policy starting in 2020, beginning of implementation, and projected to 2030, aligning with NDC timeframe
- **Policy scenario:** livestock population will increase by 2.5% per year (10 percent increase by 2023) and remain at the level afterward, productivity will also increase
- **Activity data:** for each livestock category (cattle, swine, poultry):
    - Population headcount (info from national agriculture survey)
    - Typical Animal Mass, TAM (info from national agriculture survey)
    - Excretion rate (IPCC defaults)

## POLICY CAUSAL CHAIN

Causal chain for the implementation of the livestock policy for Fiji. The outlined GHG impacts represent those included in the assessment boundary to be quantified in the assessment (likely to occur and expected to be moderate or major in magnitude).


5-Year Strategic Plan: Establish and improve commercial agriculture by increasing livestock population by 10%
Install biogas digesters on piggery and poultry farms
Improve genetic breed, feeding strategies and disease management
* Improved manure management practices
Establish a livestock rehabilitation center and provide access to farmers
Develop Juncao feed fodder banks and provide improved feed for livestock
Provide improved genetic livestock breed to farmers
Create a breeding center for genetic improvements on livestock through the Embryo Transfer Technology Programme
Decrease in volatilisation of ammonia from manure
Increase in use of slurry for organic amendments
CH4 captured and used for cooking
Improved infrastructure for animal housing, feeding, and milking
Improved animal health
Increase in use of machinery for harvest and post-harvest management of fodder
* Improved quality and quantity of feed
* Improved genetic livestock breed
Decrease in use of N-based synthetic fertiliser
Decrease in reliance on wood and fossil fuel sources for cooking
More manure deposited in enclosure/ milking shed/ feeding area
Higher resilience to diseases
Increase in fuel consumption
Higher resilience to climate change
Increase in milk and meat production
Improved feed digestibility
Decreased N2O emissions from soil
Decrease in expenses for fertiliser
Decrease in deforestation
Increase in number of manure management systems established
Healthy livestock increases lifespan
Increased CO2 emissions from use of machinery
Increase in animal live weight
Decrease in manure excreted
Decreased CO2 emissions from fossil fuel consumption
Decreased CH4 emissions from MMS
Increased CO2 uptake by plants
Increase in population headcount
Decreased CH4 and N2O emissions from MMS
Policy
Inputs and activities
Intermediate effects
Market-based effects
GHG impacts
Included in the assessment boundary
* Policy mitigation measure
Increased N2O emissions from MMS
Increased CH4 emissions from MMS
Increased CH4 emissions from enteric fermentation
Increase in market supply of domestic livestock products
Increase in conversion of forest land for paddocks/ range for breeding and grazing of livestock
Increase in market supply of domestic livestock products
Increase in conversion of forest land for paddocks/ range for breeding and grazing of livestock
Decreased CO2 removals

## BASELINE SCENARIO

The baseline emissions are expected to decrease due to declining livestock populations. Emissions by the end of the assessment period are summarised below:

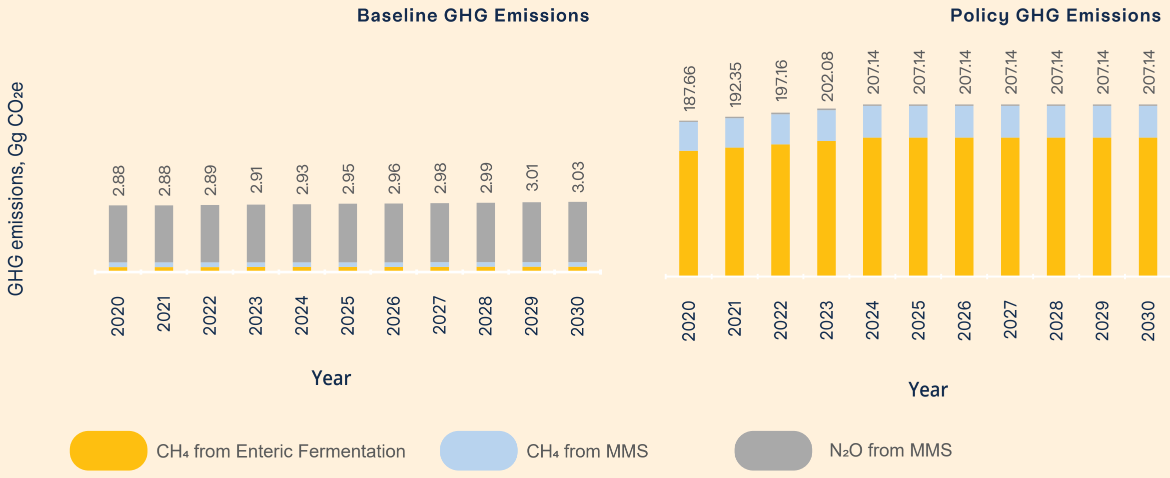
| Emission source | Ex-ante emissions (Gg $CO_2e$) |
|---|---|
| Enteric fermentation, $CH_4$ | 52.78 |
| Manure management, $CH_4$ | 29.02 |
| Manure management, $N_2O$ | 1.76 |
| Total | 83.56 |

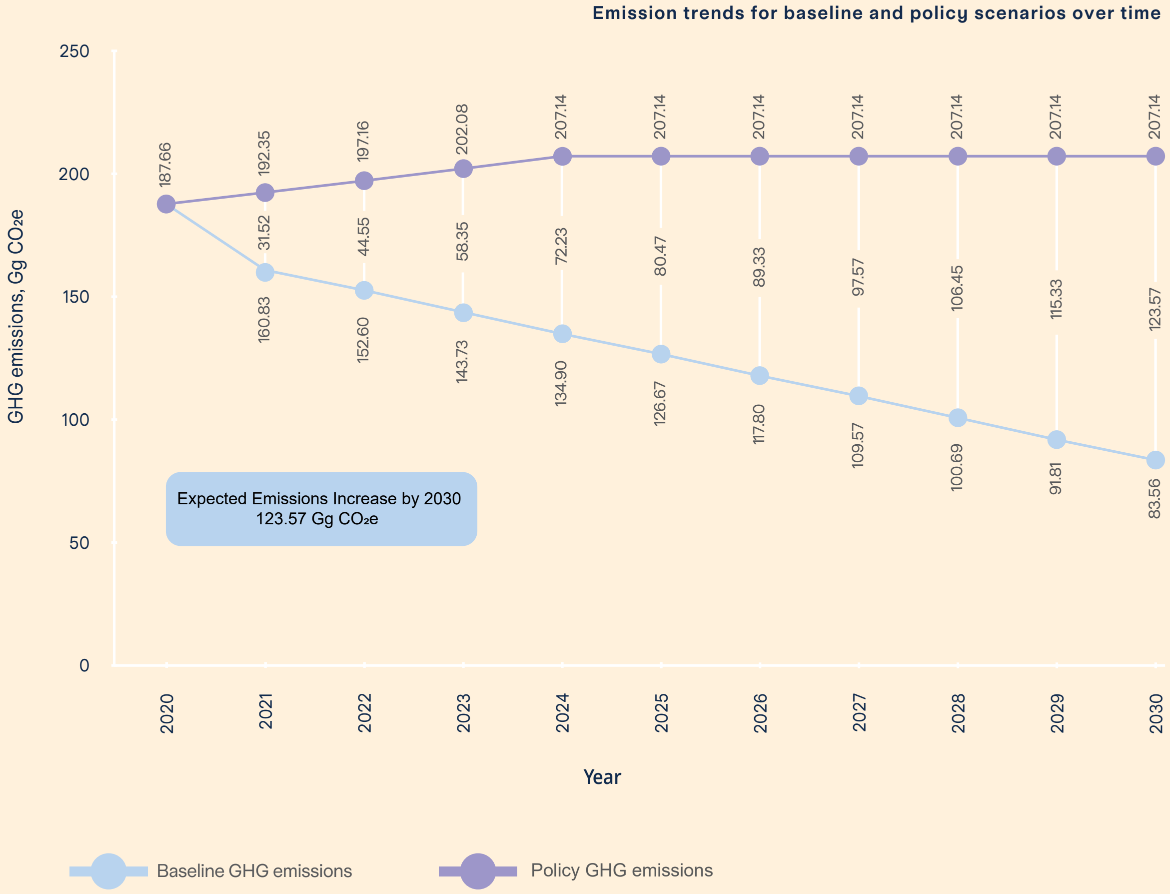
## POLICY SCENARIO

The GHG emissions, after policy implementation, increase due to increasing livestock population and increased productivity. Emissions by the end of the assessment period are summarised below:

| Emission source | Ex-ante emissions (Gg $CO_2e$) |
|---|---|
| Enteric fermentation, $CH_4$ | 167.1 |
| Manure management, $CH_4$ | 38.16 |
| Manure management, $N_2O$ | 1.87 |
| Total | 207.14 |

The change from the policy is an increase in emissions by **123.58 Gg $CO_2e$** at the end of the assessment period. This indicates a **10 percent** increase in emissions upon implementation of the policy.



## POLICY SUSTAINABLE DEVELOPMENT IMPACTS

The SP4 is expected to have a significant impact on several sustainable development goals (SDGs) in Fiji. While GHG emissions will increase (SDG 13), the policy will have a positive impact on improving food security (SDG 2), improving water quality (SDG 6), and providing economic opportunities for Fijian farmers (SDG 8). The policy also provides technical support to farmers (SDG 4). SDGs shown below are expected to be impacted:


## LESSONS LEARNED

Additional prioritisation approach was needed to select a policy for assessment as agricultural policies are not necessarily focused on emission reductions. Agricultural policies may not be designed to mitigate emissions but understanding their impact on emissions is critical. It will typically be important to consider agriculture GHG impacts alongside SD impacts for a complete picture of how agriculture policies affect both mitigation and adaptation to climate change through increased resilience and food security.

The increase in emissions occurring in the Agriculture sector has implications for the broader objectives outlined in Fiji's NDC. Specifically, the Low Emissions Development Strategy (LEDS) for Fiji, referenced in Fiji's updated NDC aims to reach net zero carbon emissions by 2050 across all sectors of its economy considering projected reductions also occur in the Agriculture sector from enteric fermentation as well as manure management. The estimated LEDS target for GHG emissions from enteric fermentation and MMS indicates a decrease in emissions for the period 2020–2030. However, the trend for GHG emissions estimated under policy assessment shows an increase in emissions for the same period. The results indicate that the implementation of the livestock policy will greatly deviate from the emission targets to reduce emissions in Fiji's LEDS and would require the incorporation of possible GHG mitigation actions to counter the GHG impacts arising from the policy.

For the full policy description and outline of the policy intermediate effects and GHG impacts, see Fiji's Agriculture Policy Assessment Report. For additional methodological information see Fiji's Agriculture Livestock Emissions Guidance Document & User Manual developed as an output of the ICAT project.

# FIJI: National Rice Development Strategy

## COUNTRY CONTEXT

Fiji is an island country in Melanesia, part of Oceania in the South Pacific Ocean consisting of 332 islands of which only a third are inhabited. The Fiji population is concentrated on the two major islands with 90 percent of the people living in coastal areas. Fiji's geographical location and the importance of natural resources to its main economic sectors makes Fiji highly vulnerable to natural hazard and climate change. This has significant implications for Fiji's economic growth as the country relies heavily on its natural resources for its economic development. The country's primary industries include fisheries, forestry, and agriculture.

Rice in Fiji has a multi-dimensional role: as the foundation of food security, economic growth, and social stability. Over the years, the rice industry has been increasingly weakened as rice area and production declined while the rice yield growth has been stagnant or marginal. In the 1980s, Fiji maintained a self-sufficiency level of 66%; however, its current self-sufficiency level is 17.5%. Additionally, Fiji imports more than 80% of the rice to meet the total rice demanded annually at a cost of 42M FJD. To meet the growing needs of the population, it is necessary to produce more rice in the future. This is a serious challenge as several biotic, abiotic, and social factors continue to limit productivity. Some of these challenges include a decrease in land and water resources, scarce and costly labour, use of single-base fertilisers, high incidence of pests and diseases, the rising cost of agro-inputs, and impacts of climate change.

To ensure food security concerns, Fiji must align national goals with achieving self-sufficiency in rice production. The National Rice Development Strategy is developed by the Ministry of Agriculture's Research Division to investigate cultivating rice nationally to meet growing demand and reduce the reliance on imported rice. This strategy is planned and in the adoption stage by the Ministry.


## POLICY ASSESSMENT OBJECTIVES

- Quantify the policy impacts on GHG emissions
- Identify policy impact indicators and develop technical guidance for tracking sustainable development and GHG impacts
- Develop recommendations for including Agriculture sector policies in Fiji's enhanced Nationally Determined Contribution (NDC)

## POLICY DESCRIPTION

*Required for reporting under the Enhanced Transparency Framework under the Paris Agreement*

| | |
|---|---|
| **Name of policy** | National Rice Development Strategy |
| **Description** | Under the policy, the Ministry of Agriculture will:<br>▪ Improve productivity through the introduction of improved rice varieties, purification of seeds, and crop breeding<br>▪ Improve seed production capacity for the quality of rice seeds and expansion of rice production area<br>▪ Expand area of rice production by having participating farmers plant a minimum of 5 acres of rice<br>▪ Provide technical training to farmers to produce rice and supply farmers with starter irrigation kits (e.g., irrigation pumps, pipe, and water tanks), small to medium-sized dryers and bags for dried paddy packing and storage<br>▪ Improve mechanisation support for rice farming efficiencies and strengthen technology integration with best farmer practices<br>▪ Establish a performance-based rebate system to incentivise production, when 8 tonnes or more of paddy rice is provided to Fiji Rice<br>▪ Encourage smallholders to form clusters and or cooperatives to qualify for assistance<br>▪ Conduct a market demand consumer preference survey<br>▪ Support research and development to enhance production through technological interventions focusing on new rice cultivar varieties |
| **Policy Objectives** | This policy aims to support Fiji in achieving rice production self-sufficiency in 5 years following policy implementation start by increasing the local rice production consistently each year and enhancing rice yield in both wetland and dryland areas, as well as expanding the land area under rice cultivation. Improved varieties, good seeds, and efficient nutrient and water management are key technologies to accelerate rice productivity in Fiji. The policy will:<br>▪ Encourage private companies to invest in the seed business<br>▪ Motivate large-scale landowners to lend leases to tenants<br>▪ Increase investment in infrastructure |
| **Implementing entity:** Ministry of Agriculture | |
| **Type of instrument:** Subsidies and incentives to rice growers, use of improved varieties | |
| **Status & start year of implementation:** The policy is planned and in the stage of adoption/ implementation; date of implementation is to be determined | |
| **Sector(s) affected:** Agriculture, rice cultivation | |

Refer to Chapter 4 in the ICAT Agriculture Methodology for guidance on policy description steps and templates

**Policy Key Performance Indicators (KPIs):**
*(Note: these KPIs were identified as part of the assessment, for the purpose of enabling tracking of policy performance over time, e.g., as part of a monitoring plan)*

- Total area of rice cultivation (ha)
- Number and length of season (count, days)
- Amount of synthetic fertiliser and urea applied (kg per ha)
- Production and yield of rice (tonnes per ha)
- Water regime (volume of irrigation and drainage)

## GHG MITIGATION EFFECTS OF THE POLICY

*Required for reporting under the Enhanced Transparency Framework under the Paris Agreement*

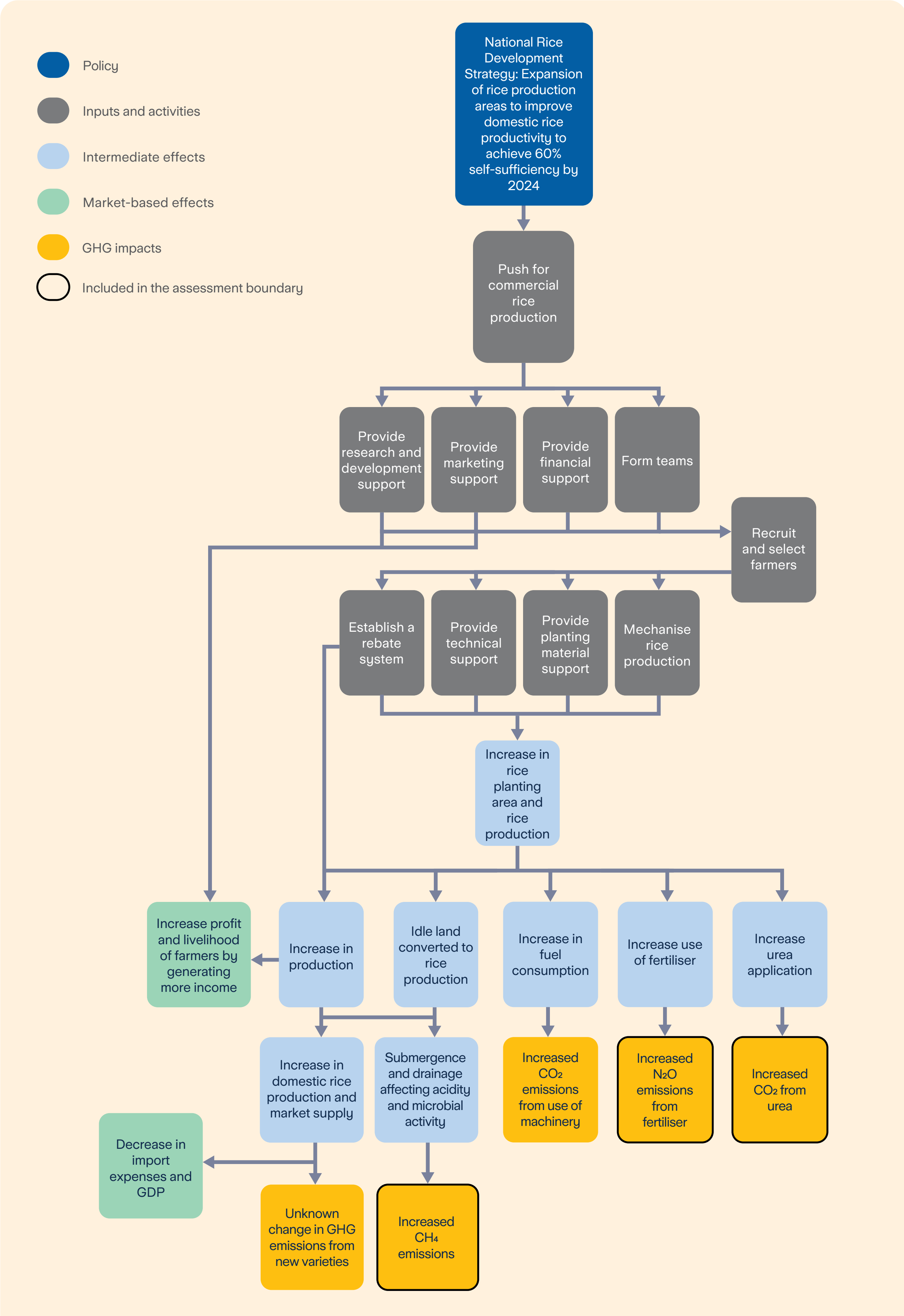
| | |
|---|---|
| **Gases affected** | Reducing GHG emissions was not the main target of this policy. However, these are the GHG emissions to be included within the policy assessment boundary:<br>▪ $CH_4$ from rice cultivation<br>▪ $N_2O$ emissions due to nutrient management<br>▪ $CO_2$ emissions due to application of urea<br>Other emissions likely to be affected, but not quantified include:<br>▪ $CO_2$ removals and storage in soil<br>▪ $CO_2$ emissions associated with machinery use |
| **Estimates of GHG emission reductions (Gg $CO_2$e) – achieved/expected** (Inventory reporting categories) | Emissions will increase by **6.9 Gg $CO_2$e** during the assessment period. This indicates a 245% increase in cumulative emissions upon implementation of the policy. See analysis below:<br>GHG Inventory categories affected:<br>▪ 3C (subcategory depends on water management system, e.g., irrigated, rain-fed wetland and rain-fed dryland)<br>▪ 3D1 and 3D2 for direct and indirect $N_2O$ emissions from fertiliser, respectively<br>▪ 3H for $CO_2$ emissions from urea application |

## METHODOLOGICAL CONSIDERATIONS AND ASSUMPTIONS

- **Methodology:** IPCC 2006 Guidelines, Tier 1 methodology, and associated default emission factors
- **Baseline scenario:** simple trendline baseline (historical data on rice production area, amount of fertiliser and urea applied)
- **Timeframe:** ex-ante analysis of the policy starting in 2020 and projected to 2030, aligning with the NDC timeframe
- **Policy scenario:**
  - Individual farmers will continue to receive land preparation and harvesting support at the current subsidised rates
  - Rice production is expected to increase from a rice planting area of 2,316 to 8,000 ha
- **Activity data:**
  - Area of rice production (info from national agriculture survey)
  - Annual amount of synthetic fertiliser applied (info from national agriculture survey)
  - Annual amount of urea applied (info from national agriculture survey)

## POLICY CAUSAL CHAIN

Causal chain for the implementation of the livestock policy for Fiji. The outlined GHG impacts represent those included in the assessment boundary to be quantified in the assessment (likely to occur and expected to be moderate or major in magnitude).


Policy
Inputs and activities
Intermediate effects
Market-based effects
GHG impacts
Included in the assessment boundary
National Rice Development Strategy: Expansion of rice production areas to improve domestic rice productivity to achieve 60% self-sufficiency by 2024
Push for commercial rice production
Provide research and development support
Provide marketing support
Provide financial support
Form teams
Recruit and select farmers
Establish a rebate system
Provide technical support
Provide planting material support
Mechanise rice production
Increase in rice planting area and rice production
Increase profit and livelihood of farmers by generating more income
Increase in production
Idle land converted to rice production
Increase in fuel consumption
Increase use of fertiliser
Increase urea application
Increase in domestic rice production and market supply
Submergence and drainage affecting acidity and microbial activity
Increased $CO_2$ emissions from use of machinery
Increased $N_2O$ emissions from fertiliser
Increased $CO_2$ from urea
Decrease in import expenses and GDP
Unknown change in GHG emissions from new varieties
Increased $CH_4$ emissions

### BASELINE SCENARIO

The baseline emissions are expected to slightly increase due to a slight increase in the rice production area. Emissions by the end of the assessment period are summarised below:

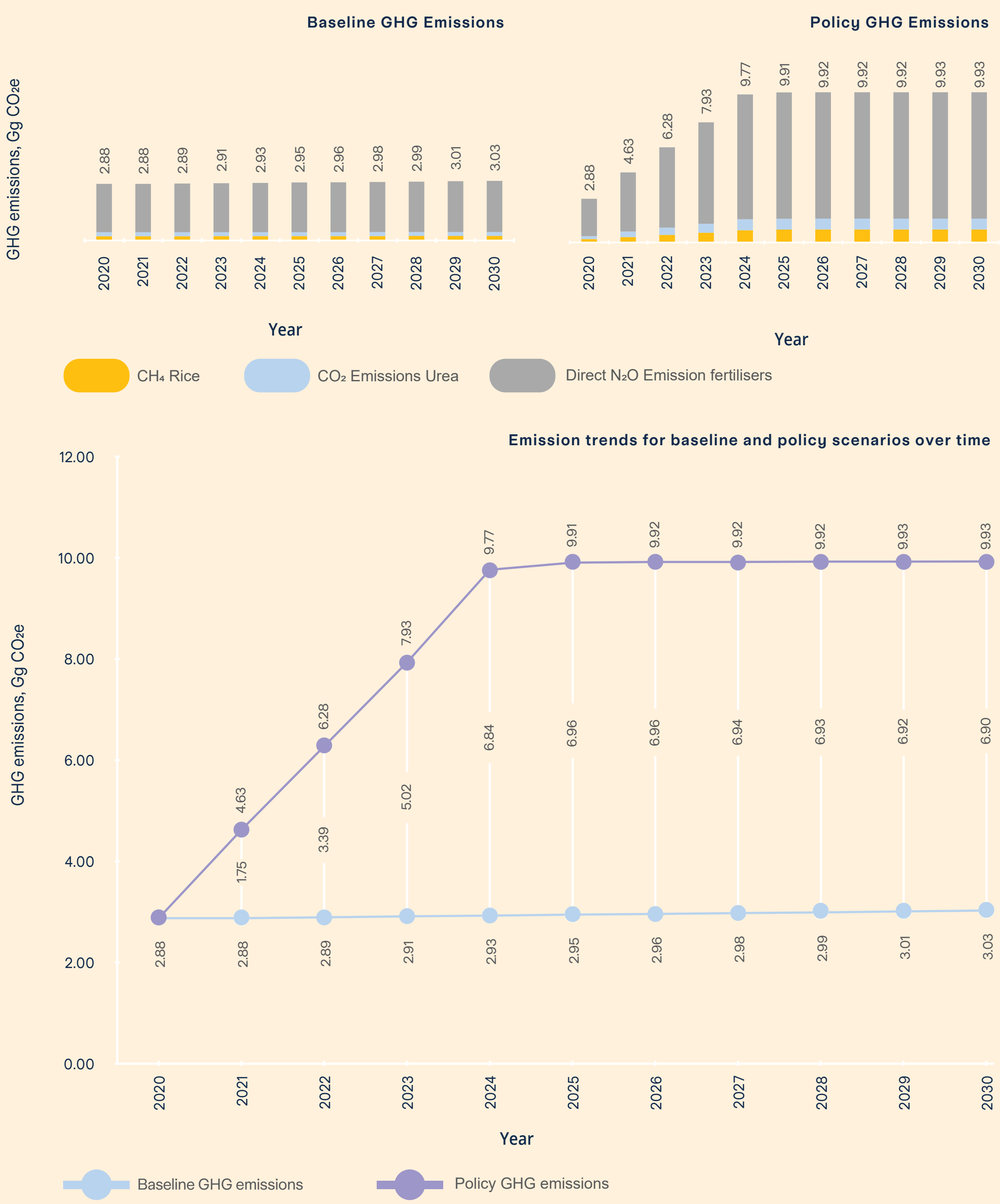
| Emission source | Ex-ante emissions (Gg $CO_2e$) |
|---|---|
| Rice cultivation, $CH_4$ | 0.229 |
| Urea application, $CO_2$ | 0.2 |
| Fertiliser application, $N_2O$ | 2.596 |
| Total | 3.03 |

### POLICY SCENARIO

The GHG emissions after policy implementation increase due to increasing rice production area. Emissions by the end of the assessment period are summarised below:

| Emission source | Ex-ante emissions (Gg $CO_2e$) |
|---|---|
| Rice cultivation, $CH_4$ | 0.85 |
| Urea application, $CO_2$ | 0.72 |
| Fertiliser application, $N_2O$ | 8.33 |
| Total | 9.93 |

The total cumulative emissions increase from the policy is **6.9 Gg $CO_2e$** during the assessment period. This indicates a **245 percent** increase in cumulative emissions upon implementation of the policy.



## POLICY SUSTAINABLE DEVELOPMENT IMPACTS

The National Rice Development Strategy is expected to have a significant impact on several sustainable development goals (SDGs) in Fiji. While GHG emissions will increase (SDG13), the policy will have a positive impact on improving food security (SDG 2) and providing economic opportunities for Fijian farmers (SDG 1 & 8). The policy also provides technical support to farmers (SDG 4). SDGs shown below are expected to be impacted:


## LESSONS LEARNED

An additional prioritisation approach was needed to select a policy for assessment as agricultural policies are not necessarily focused on emission reductions. Agricultural policies may not be designed to mitigate emissions but understanding their impact on emissions is critical. It will typically be important to consider agriculture GHG impacts alongside SD impacts for a complete picture of how agricultural policies affect both mitigation and adaptation to climate change through increased resilience and food security.

As the assessment indicates, Fiji's National Rice Development Strategy will lead to an increase in emissions, therefore, additional actions will be needed to ensure sustainable rice production occurs. A more detailed assessment will be needed to assess the impacts of additional measures such as the use of organic fertilisers and different water management. Furthermore, additional research and application of a Tier 2 approach will be needed to understand the effect of changing rice cultivar varieties on emissions as well as production. Given the importance of rice, it is critical to establish management strategies that can maintain high yields while limiting negative environmental effects and maximising its beneficial advantages. The broad challenges of water consumption, nutrient use efficiency, and greenhouse gas emissions are all major drivers of the rice system for long-term sustainability. Fiji's rice farmers rely primarily on uncertain monsoon rainfall; but, due to recent climate change, the monsoon has become increasingly erratic, resulting in crop failure or low harvest, causing widespread food insecurity. Introducing more sustainable rice cultivation practices will not only help mitigate GHG emissions but will also help farmers adapt to a changing climate and growing conditions.

There is no mention of mitigation targets for the Agriculture sector in Fiji's NDC although it comprises approximately 25 percent of the national GHG emissions. The Fiji Low Emission Development Strategies (LEDS) suggests that under a very high-ambition scenario, $CH_4$ emissions from rice are not projected to change in the future, while at the same time, emissions from the application of synthetic fertilisers are expected to be reduced by 1 percent by 2035.

The LEDs also indicate that emissions from the use of synthetic fertilisers will be reduced by changing fertiliser rates and types, adjusting the time of application, and increasing the precision of application. It is evident that with the implementation of this policy, however, emissions from fertiliser application are likely to increase, therefore, there is a need to improve nutrient management in order to maintain the target outlined in Fiji's LEDs and achieve mitigation goals for the Agriculture sector by 2050.

For the full policy description and outline of the policy intermediate effects and GHG impacts, see Fiji's Agriculture Policy Assessment Report. For additional methodological information see Fiji's Agriculture Livestock Emissions Guidance Document & User Manual developed as an output of the ICAT project.

Agriculture Methodology: Assessing the
Greenhouse Gas Impacts of Agricultural Policies

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