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Greenhouse Gas Management Institute, Verra

Agriculture Guidance

Guidance for assessing the greenhouse gas impacts of agriculture policies

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How to choose which agriculture impacts and indicators to assess

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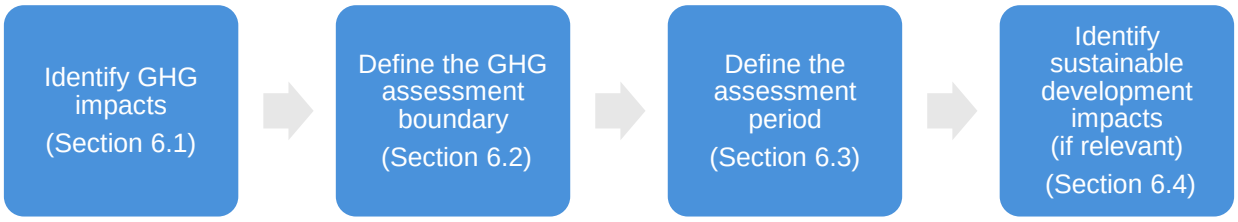
6. Identifying Impacts: How Agriculture Policies Reduce Emissions or Enhance Removals

To estimate the GHG impacts of a policy, it is important to understand how the policy is intended to be implemented and how it will achieve the desired GHG mitigation outcome. A causal chain is a conceptual diagram representing the sequence of changes that are expected to occur as a result of the policy. Implicitly, these changes are relative to a baseline scenario.

This chapter provides guidance for how to develop a causal chain by considering how the policy will be implemented, who will be affected by the policy, what the potential intermediate effects of the policy will be, and how these effects cause GHG impacts. The intermediate effects are mapped in a causal chain to illustrate the logical model for how the policy leads to the intended GHG impacts. The causal chain serves as the basis for defining the GHG assessment boundary. Guidance is also provided for defining the assessment period.

Figure 6.1: Overview of steps in the chapter



Checklist of key recommendations

- Identify all stakeholders affected by, or with influence on, the policy
- Identify the inputs and activities that go into implementing the policy
- Identify all intermediate effects of the policy
- Identify all potential GHG impacts of the policy
- Develop a causal chain

- Include all significant GHG impacts in the GHG assessment boundary
- Define the assessment period

6.1 Identify GHG impacts

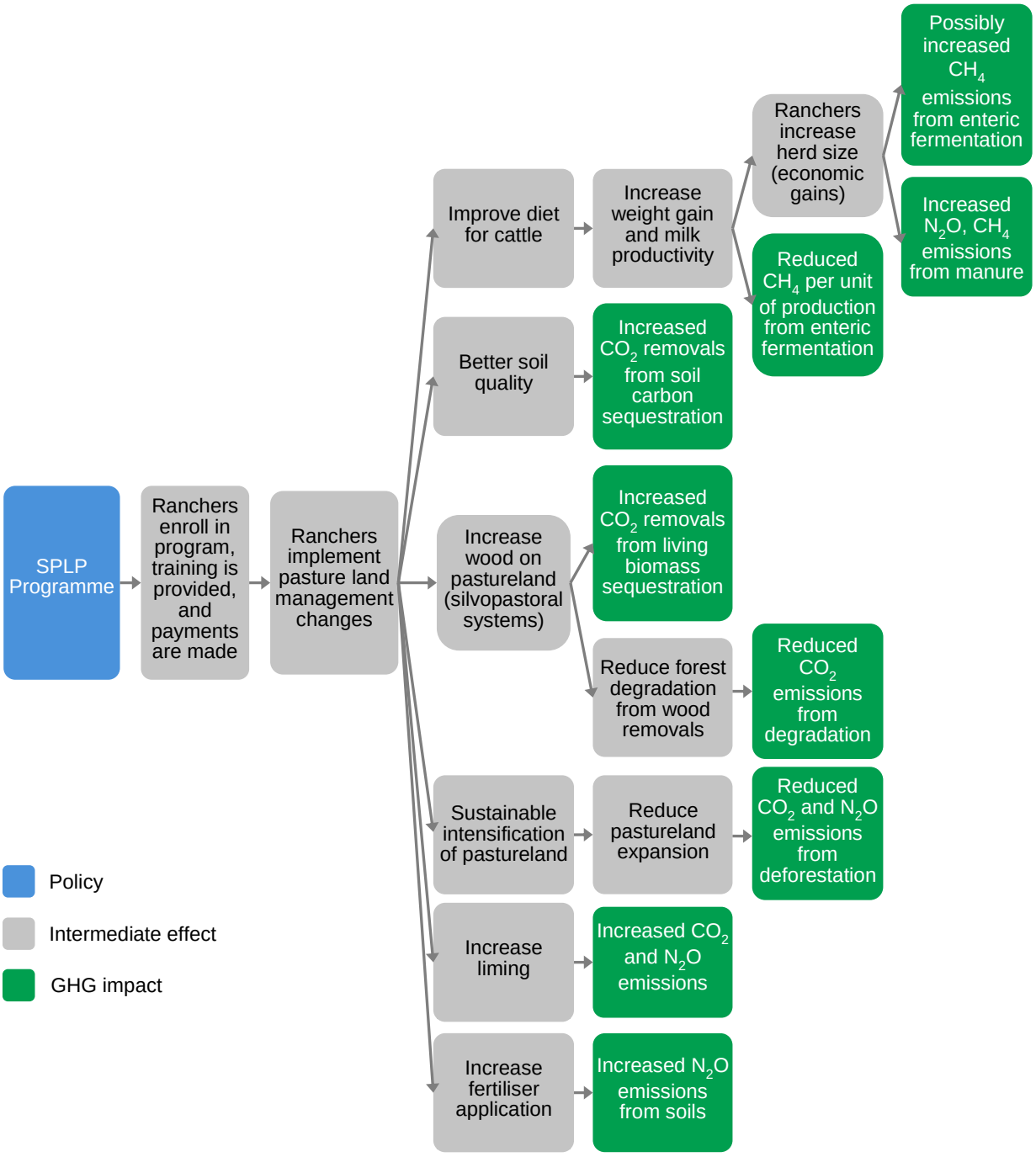
In order to identify the GHG impacts of the policy, it is useful to first identify the stakeholders affected by or with influence on the policy, and the inputs and activities associated with implementing the policy. Inputs are resources that go into implementing the policy, while activities are administrative activities involved in implementing the policy. These inputs and activities 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.

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. 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. It allows users to visually understand how policies lead to changes in emissions. An example causal chain is provided in Figure 6.2.

The sections below provide guidance on identifying intermediate effects (through identifying stakeholders, and inputs and activities), identifying potential GHG impacts, and developing a causal chain. This then provides the basis for defining the GHG assessment boundary (Section 6.2)

The causal chain is also used to estimate the GHG impacts of the policy ex-ante following the guidance in Chapter 8. Monitoring the intermediate effects can allow users to evaluate the performance of the policy and to attribute GHG impacts to policy implementation.

Figure 6.2: Example of a causal chain



6.1.1 Identify intermediate effects

In order to identifying intermediate effects, first identify the stakeholders of the policy, then the inputs and activities associated with implementing the policy. Following this, identify and describe the intermediate effects of the policy. These three steps are described below.

Step 1: Identify stakeholders

It is a *key recommendation* to identify all stakeholders affected by, or with influence on, the policy. Stakeholders can be people, organisations, communities or individuals. Stakeholders include different agencies and levels of government, as well as civil society and private sector organisations. Stakeholders may be affected by the policy or may influence the policy. Some typical stakeholders for the agriculture sector include:

- Farmers and ranchers
- Producer associations
- 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
- Commercial forest companies
- Other companies
- Informal forest businesses
- National and subnational government agencies
- Government entities responsible for forest and/or agriculture and livestock management
- Financial institutions
- Consumers

Identifying stakeholders is necessary for estimating the likely implementation potential of the policy in Chapter 8, where barriers to implementation and economic implications of a policy from the perspective of stakeholders are evaluated.

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. The ICAT *Stakeholder Participation Guidance* provides information on how to identify stakeholders (Chapter 5), including marginalised people or groups. Users may also identify affected stakeholders from existing stakeholder mapping exercises.

Step 2: Identify inputs and activities

It is a *key recommendation* to identify the inputs and activities that go into implementing the policy. Table 6.1 provides definitions and examples of inputs and activities.

Where feasible, when describing inputs specify the amount of money that goes into implementing the policy and is paid out as part of the administrative activities. Identifying inputs and activities is necessary for conducting the economic feasibility of the policy in Chapter 8.

Table 6.1: Summary of inputs and activities

	Definition	Examples
Inputs	Resources that go into implementing a policy	• Money allocated to training and education programmes • Money allocated to research programmes • A new programme authorised out of the national budget • Private financing secured to co-fund a government programme
Activities	Administrative activities involved in implementing the policy (undertaken by the authority or entity that implements the policy)	• A government agency offers payments for tree planting • A government agency establishes tree nurseries • A government agency pays communities to develop grazing management plans and offers payment for fences for implementation of those grazing management plans. • Grants offered to extend training in new cultivation methods • Additional staff hired to work with farmers on technology transfer • Prohibitions placed on tree cutting for a given size class • Enforcement of forestry standards improved • A government agency eases credit access for technology adoption by farmers and ranchers

Step 3: Identify and describe intermediate effects

It is a *key recommendation* to identify all intermediate effects of the policy. Intermediate effects can be characterised as how stakeholders are expected to respond to the inputs or activities or to other intermediate effects of the policy. Intermediate effects can also include the measures that are enabled or incentivised by the policy. The following are examples for how stakeholders may respond to inputs, activities or other effects:

- Comply with regulations
- Access subsidies or incentives
- Sign up or commit to programmes
- Purchase new equipment in order to comply with a policy
- Plant trees for payments received
- Sign up for training and increase knowledge level regarding technologies or practices
- Change livestock feeding strategies
- Change herd management strategies
- Change pasture management

- Change livestock population sizes
- Change soil management practices (e.g., improve degraded grazing lands by implementing rotational grazing, implement no-till practices)

Intermediate effects can also be characterised as land-based or market-based:

- **Land-based effects** occur when a land use shifts from one land category to another. For example, when agriculture expands into forest land.
- **Market-based effects** occur when the policy reduces the production of a commodity causing a change in the supply and market demand equilibrium that results in a shift of production elsewhere to make up for the supply. For example, when production of livestock decreases due to decreasing stocking rates on grazing lands, livestock production on feedlots may increase to compensate for a loss of supply.

Intermediate effects can be characterised as intended or unintended. Unintended intermediate effects occur as a result of compensating actions (i.e., rebound effects). Unintended effects can impact other sectors and members of society not targeted by the policy. In particular, agriculture policies can have unintended effects on the forestry sector. Users should consider both intended and unintended intermediate effects.

When identifying intermediate effects it may help to consider this general framing question: If the 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.

Consultations with all identified stakeholder groups can help to identify a full range of intermediate effects, and can help to identify and address possible unintended or negative impacts early on. Refer to ICAT *Stakeholder Participation Guidance* (Chapter 8) for information on designing and conducting consultations.

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
- Timing of effect

It is useful to create a table of effects to describe these characteristics. Example tables (Table 6.2 and Table 6.3) for describing intermediate effects are provided at the end of this section.

Affected land category

Intermediate effects can be a change in how land is used or how it is managed. When this occurs, describe the affected land area by its size and using the land categories found in the IPCC 2006 GL,

Volume 4, Chapter 2.[1] Using the IPCC land categories will help with the estimation of GHG emissions in Chapters 7 and 8. Use the following IPCC land categories to describe land upon which the intermediate effect occurs:

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

When intermediate effects are a change in how land is used, described the change in terms of a land category being converted from one type to another, for example:

- Land converted to cropland or, more specifically, forest land converted to cropland and grassland converted to cropland
- Land converted to grassland or, more specifically, forest land converted to grassland
- Land converted to forest land or, more specifically, cropland converted to forest land and grassland converted to forest land
- Land converted to settlements
- Land converted to other land (category)

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 (the land category does not change), for example:

- Cropland remaining cropland; more specifically, annual cropland converted to perennial cropland

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 IPCC guidelines. The activity data categories are used to estimate GHG emissions following guidance in Chapters 7 and 8.

Direction and amount of effect

When labelling intermediate effects, identify the direction of the effect. For example, label the activity as "increase" if the policy leads to an increase in an identified activity, such as an increase in area of forest land or an increase in numbers of livestock receiving a particular type of diet.

[1] Land categories are set out in the IPCC 2006 GL, Volume 4, Chapter 2. Available at: http://www.ipcc-nggip.iges.or.jp/public/2006gl/vol4.html.

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 reforestation of 10,000 hectares of cropland land, the intermediate effect can be described as: "increase the amount of cropland converted to forest land by 10,000 hectares." The direction of the effect is to increase. With this example, note the use of IPCC land categories in the description "cropland converted to forest land."

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 degraded land converted to crop land in the Cerrado 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 unintended intermediate effects to occur outside of the intended jurisdiction of the policy. In cases where the policy causes a shift in activity to outside of the jurisdiction, the effect can be described as out-of-jurisdiction.

Timing of the effect

Effects can occur both in the short- or long-term. Users should describe effects as 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 last five years. This information will be used for estimating of GHG emissions and monitoring implementation 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 the amount of cropland converted to forest land in the southern tropical region of the jurisdiction by 10,000 hectares by 2030."

Example of describing intermediate effects

Table 6.2 provides an example table for how to describe intermediate effects of inputs and activities, and Table 6.3 provides an example table for how to describe other intermediate effects.

Table 6.2: Example of how to describe intermediate effects of inputs and activities

	Detail/explanation	Geographic location of effect	Timing of effect
Inputs			
Incentive payments made to ranchers for improved pasture management	Participants receive a start-up payment dispersed annually over five years to cover costs of capital and labour. Total value of payments will range from USD 50/ha to USD 100/ha. Participation will be capped to keep	National scale, all non-federal pasture land eligible	2021 - 2035

	the programme costs under USD 400 million over 15 years.		
Budget deployed for technical assistance and programme operations	The national government will increase funding to the agriculture extension service by USD 2 million per year for 15 years to provide training and support to participating pastoralists.	Funding will be coordinated centrally in the headquarters office and dispersed to regional agriculture extension centres, where training and support services will be provided. Funding allocations will be based on demand for participation in the programme.	2021 - 2035
Activities			
Ranchers enroll	Ranchers voluntarily sign up to participate in the programme	Eligible non-federal pasture land	Rolling enrolment throughout duration (2021-2035) based on demand.
Agriculture extension provides training to participants	The agriculture extension service will provide training to ranches in improved pasture management through regional agriculture extension offices. Training culminates in preparation of an individualised plan for participants for implementing improved pasture management.	Regions where enrolment meets minimum threshold for launching training and support programmes at regional agriculture extension offices (Thresholds are to be determined).	On-going during 2022-2035 (training starts next year after first enrolment period)
Payments administered to participants	Ranchers enter voluntary five-year contracts with the Ministry of Agriculture to receive annualised payments for five years for implementing sustainable intensification practices.	Regions where training and support services have been provided, and where participants have completed training and developed a management plan.	On-going during 2023-2035 (payments dispersed only after first year of training is completed provided)
Agriculture extension conducts site visits	Agriculture extension specialists will conduct routine site visits to assist with and monitor implementation of management plans. Specialists will use visits to verify implementation of practices according to annual reports submitted by participants.	Regions where payments have been dispersed	On-going during 2023 - 2035
Participants submit annual reports	Participants submit annual report providing at a minimum data on average stocking density (# animals/ha), forage species abundance estimates (percent cover), and average annual output of milk and/or beef.	Regions where payments have been dispersed	Annually starting in 2024 - 2035
Pastureland management changes	Participants implement management plans	Regions where payments have been dispersed	Annually starting in 2024 - 2035

Table 6.3: Example table to describe other intermediate effects

Intermediate effects	Detail/ explanation	Affected parameter	Direction of effect	Amount of effect	Geographic location of effect	Timing of effect
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 1.08 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	Sometime after 2024, difficult to predict
Cattle gain weight faster	Higher quality diet causes animals to grow faster	Average annual weight gain (kg/head/yr)	Increase	Unknown	Regions where incentive payments are dispersed	Sometime after 2024, difficult to predict
Dairy cattle produce more milk	Higher quality diet causes animals to produce more milk	Average daily milk production for human consumption (kg per head per day)	Increase	Unknown	Regions where incentive payments are dispersed	Sometime after 2024, difficult to predict
Improved soil quality	Pasture species selection, rotational grazing, and other interventions have the potential to increase soil quality, leading to increased soil carbon stocks.	Soil carbon density (tonnes C/ha in soils)	Increase	On approximately 1.2 million hectares	Regions where incentive payments are dispersed	Sometime after 2024, difficult to predict
More carbon stored in woody biomass	Trees planted for silvopastoral systems can result in increased carbon stocks in living biomass.	Biomass carbon density (tonnes C/ha in biomass)	Increase	Unknown	Regions where incentive payments are dispersed	Sometime after 2024, difficult to predict
Increased wood supply	Trees in silvopastoral systems provide more wood, reduces demand/pressure on wood removals from forest, which cause forest degradation.	Wood removals from pastureland (volume/ha)	Increase	Unknown	Regions where incentive payments are dispersed	Sometime after 2024, difficult to predict

Reduced pastureland expansion	Sustainable intensification of existing pastureland reduces demand for new pastureland, reducing rates of land conversion to grassland (including deforestation)	Amount of land converted to grassland (hectares)	Decrease	Unknown	Forest Land and non-grazed grassland (e.g., woodland), particularly forest edges close to pasture land enrolled in the programme	Sometime after 2024, difficult to predict
Herd size increase	Economic gains for ranchers leads to ranchers using additional revenue to expand herds. This effect may be partially offset by increased meat supply impacting local meat price.	Livestock population numbers (average annual # of head)	Increase	Unknown	Regions where incentive payments are dispersed	Sometime after 2024, difficult to predict
Liming	Farmers may apply liming practices to neutralise soil acidity and promote growth of pasture for forage on acidic soils.	Limestone or dolomite applied to soils (mass/year)	Increase	Unknown	Regions where incentive payments are dispersed	Sometime after 2024, difficult to predict
Nitrogen Fertilisation	Farmers may apply synthetic or natural fertilisers to promote growth of pasture for forage.	Nitrogen applied to soils (mass/year)	Increase	Unknown	Regions where incentive payments are dispersed	Sometime after 2024, difficult to predict

6.1.2 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.

It is *a key recommendation* to identify all potential GHG impacts of the policy. To ensure a complete assessment, users should consider all identified intermediate effects and associate them with specific GHG impacts. Table 6.4 provides a list of common intermediate effects from mitigation practices and technologies that reduce emissions from enteric fermentation. Similarly, Table 6.5 provides for enhanced removals with soil carbon.

All potential GHG impacts should be identified at this stage so that they can be used to develop the causal chain following the guidance in Section 6.1.3. A subset of GHG impacts will be identified and included in the GHG assessment boundary following the guidance in Section 6.2.

Enteric fermentation

GHG emission reductions from enteric fermentation are often achieved with practices and technologies that improve the efficiency and reduce the GHG intensity of production. GHG intensity is the emissions per unit of animal produced or per unit of product (milk and/or meat) produced.

For enteric fermentation, methane (CH_4) is the main GHGs targeted. Enteric fermentation policies can also reduce carbon dioxide (CO_2) from fossil fuel combustion or remove CO_2 emissions through soil sequestration. Table 6.4 lists common intermediate effects of mitigation practices and/or technologies that reduce enteric fermentation emissions.

Table 6.4: Potential activities and effects for main types of mitigation practices/technologies and policies for enteric fermentation

Activity, practice or technology	Intermediate effects			Potential GHG Impact
	Effect 1	Effect 2	Effect 3	
Intended effect				
Feeding strategies such as improving quality of forage, processing feeds to improve digestibility, adding grain-based concentrates to feed, or providing dietary supplements and feed additives	Digestibility improved	Livestock heath improve and livestock grow faster	Production efficiency improves	Decreased CH_4 per unit of production
Changing herd management practices such as changing breed type, reducing herd size, and reducing slaughter age	Herds are more suited to conditions or livestock are slaughtered earlier	Production efficiency improves		Decreased CH_4 per unit of production
Optimising health and reproductive capacity, such as having veterinary visits, preventing disease, providing shelter for animals, and following best practices for husbandry	Livestock health and reproductive capacity improves	Production efficiency improves		Decreased CH_4 per unit of production
Pasture management, such as maintaining growth of preferred grazing species, removing weed invasions on bare ground, reducing areas where animals do not graze, restoring compacted areas and livestock paths, improving ground water absorption and reducing runoff	Quality of forage improves	Livestock heath improves and livestock grow faster	Production efficiency improves	Decreased CH_4 per unit of production
	Pasture conditions improve	Pasture productivity increases		Impact on soil sequestration, as described in Table 6.5
Silvopastoral systems adopted and trees planted	Quality of forage improves	Livestock health and reproductive capacity improves	Production efficiency improves	Decreased CH_4 per unit of production

	Pasture conditions improve	Pasture productivity increases		Impact on soil sequestration are provided in Table 6.5
Rotational grazing	Quality of forage improves	Livestock health and reproductive capacity improves	Production efficiency improves	Decreased CH_4 per unit of production
	Pasture conditions improve	Pasture productivity increases		Impact on soil sequestration are provided in Table 6.5
Unintended effect				
Feeding strategies	Production of supplements and feed additives	Fossil fuel usage for manufacturing increases		Increased CO_2 emissions
Increased pasture management and adoption of silvopastoral systems	Synthetic fertiliser application (e.g., nitrogen fertiliser)	Nitrogen leaches into the environment because not all of it is absorbed by plants	Denitrification and volatilisation occur	Increased N_2O emissions
	Production of synthetic fertiliser increases	Fossil fuel usage for manufacturing increases		Increased CO_2 emissions
	Liming to address soil acidity and improve productivity	Carbonate limes dissolve and release extra bicarbonate (HCO_3) into soils	Additional chemical reactions occur, depending on soil factors and climate regime	Increased CO_2 and N_2O emissions
Rotational grazing	Use of machinery increases to install or maintain rotational grazing	Fossil fuel usage increases		Increased CO_2 emissions
Improvements in herd management or efficiency in production	Number of animals increase	Amount of excretion per animal increases		Increased N_2O emissions
	Amount of excretion per animal increases			

Soil Carbon Management

Changes in management or land use of cropland and grassland can reduce CO_2 emissions from, or enhance removals in, carbon stored in soil and/or biomass. Mitigation practices or technologies to improve pasture, grazing lands or cropland management can also impact N_2O emissions from fertiliser and other nitrogen inputs, CO_2 from fossil fuel combustion, or CH_4 emissions from livestock. Table 6.5 provides common intermediate effects that occur as a result mitigation practices and/or technologies that reduce emissions or enhance removals from soil carbon.

Table 6.5: Potential intermediate effects for mitigation practices or technologies to reduce emissions from, and enhance removals in, soil

Activity, practice or technology	Intermediate effect			Potential GHG Impact
	Effect 1	Effect 2	Effect 3	
Intended effect				
Minimal or no tillage	Soils are less disturbed or undisturbed; crop residues are not incorporated or are less incorporated	Organic matter decomposition is slowed compared to disturbed soils (due to reduced aeration and oxidation)	Soil organic carbon content increases; soil quality and resilience is enhanced; formation of more stable humus is increase	increased CO_2 sequestration
	Mechanical tilling decreases	Fossil fuel consumption decreases		Decreased CO_2 emissions
Retain crop residue	Soil organic matter is retained	Soil organic content increases from residue input to soils		Increased CO_2 sequestration
Organic fertiliser application	Productivity increases	Soil organic matter increases		Increased CO_2 sequestration Possible increased N_2O
Increase the use of perennial crops (e.g., perennial crops planted.)	Aboveground biomass increases (e.g., trees)			Increased CO_2 sequestration
	Root systems increase	Soil erosion reduces and soil organic matter is maintained		Increased CO_2 sequestration
Mulching	Soil stability increases	Soil organic matter is maintained		Increased CO_2 sequestration
	Soil moisture retention increases	Productivity increases	Soil organic matter increases	Increased CO_2 sequestration
Synthetic fertiliser application	Productivity increases	Soil organic matter increases		Increased CO_2 sequestration Increased N_2O emissions
Rotational grazing or cultivation	Soil stability increases	Soil organic matter is maintained		Increased CO_2 sequestration
Rotational grazing	Pasture productivity increases	Soil organic matter increases		Increased CO_2 sequestration
		Livestock health improves		Impacts on enteric fermentation, as described in Table 6.4

Agroforestry or silvopastoral systems	Number of trees planted increases	Aboveground biomass increases (e.g., trees)		Increased CO_2 sequestration
		Soil organic matter is maintained		Increased CO_2 sequestration
Unintended effect				
Minimal or no tillage in waterlogged soils				Increased N_2O emissions
Organic and Synthetic fertiliser application (e.g., N fertiliser)	Nitrogen leaching into the environment increases because not all of it is absorbed by plants	Denitrification and volatilisation increases		Increased N_2O emissions
	Production of synthetic fertiliser increases	Emissions from production increase		Increased CO_2 emissions
Liming to address soil acidity and improve productivity	Carbonate limes dissolve and release extra bicarbonate (HCO_3) into soils	Additional chemical reactions occur, depending on soil factors and climate regime		Increased CO_2 and N_2O emissions
Rotational grazing or cultivation	Use of machinery to install or maintain rotational grazing or cultivation increases	Fossil fuel usage increases		Increased CO_2 emissions

6.1.3 Develop a causal chain

It is a *key recommendation* to develop a causal chain. 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 of the detailed information about stakeholders, inputs, activities and intermediate effects that was described, following the steps in Sections 6.1.1 and 6.1.2, should be included in the causal chain. Figure 6.2 provides an example causal chain to illustrate the process.

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 development and/or validation of the causal chain by integrating stakeholder insights on cause-effect relationships between the policy, behaviour change and expected impacts. Refer to the ICAT *Stakeholder Participation Guidance* (Chapter 8) for information on designing and conducting consultations.

6.2 Define the GHG assessment boundary

It is a *key recommendation* to include all significant GHG impacts in the GHG assessment boundary. The GHG assessment boundary defines 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[2] are significant and should be included in the analysis. This is done by evaluating the likelihood and relative magnitudes of each of the GHG impacts identified in Section 6.1, using the following steps:

- Step 1: Assess the likelihood that each GHG impact will occur
- Step 2: Assess the expected magnitude of each GHG impact
- Step 3: Determine the significance of GHG impacts

Step 1: Assess the likelihood that each GHG impact will occur

For each GHG impact identified in Section 6.1, assess the likelihood that it will occur by classifying each impact according to the options in Table 6.6. 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.”

[2] The term carbon pools is used here instead of sinks because 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.

Table 6.6: Assessing likelihood of GHG impacts

Likelihood	Description	Approximate likelihood (rule of thumb)
Very likely	Reason to believe the impact will happen (or did happen) as a result of the policy.	≥90%
Likely	Reason to believe the impact will probably happen (or probably happened) as a result of the policy.	<90% and ≥66%
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.	<66% and ≥33%
Unlikely	Reason to believe the impact probably will not happen (or probably did not happen) as a result of the policy.	<33% and ≥10%
Very unlikely	Reason to believe the impact will not happen (or did not happen) as a result of the policy.	<10%

Source: Adapted from WRI 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, expert judgment, or other methods.

Users should consult stakeholders when assessing the likelihood of impacts. Refer to the ICAT *Stakeholder Participation Guidance* (Chapter 8) for more information on how to consult with stakeholders.

Step 2: Assess the magnitude of each GHG impact

Next, classify the magnitude of each GHG impact as major, moderate or minor according to Table 6.7. This involves approximating the change in GHG emissions and removals resulting from each GHG impact. 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 to result. The size of the GHG source or carbon pool can be estimated based on GHG inventories or other sources. The relative magnitude of each GHG impact should be estimated based on the absolute value of total change in GHG emissions and removals, taking into account both increases and decreases in emissions and removals.

This determination requires some level of expert judgment 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. Users can also estimate changes in activity data rather than changes in emissions to assess the magnitude of the GHG impact, where relevant.

Table 6.7: Estimating relative magnitude of GHG impacts

Relative magnitude	Description	Approximate relative magnitude (rule of thumb)
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 WRI 2014

Step 3: Determine the significance of GHG impacts

Once the likelihood and magnitude of each impact has been determined, review the classifications for likelihood and magnitude to determine whether each impact is significant. In general, users should consider impacts to be significant unless they are either minor in size or unlikely or very unlikely to occur (see Figure 6.3). Impacts that were considered to be minor in size or unlikely or very unlikely to occur at the time of an ex-ante assessment should be reevaluated for significance during an ex-post assessment. Table 6.8 and

Table 6.9 provide additional guidance on what to consider when evaluating which GHG sources and carbon pools to include in the GHG assessment boundary. The tables cover enteric fermentation and soil carbon sequestration, respectively.

The ICAT *Forestry Guidance* lists considerations for which GHG sources and carbon pools to include in a GHG assessment boundary for mitigation activities that lead to enhanced CO_2 sequestration and reduced CO_2 emissions in forests.

Figure 6.3: Recommended approach for determining significance based on likelihood and magnitude

Likelihood	Magnitude		
	Minor	Moderate	Major
Very likely	Insignificant	Significant	
Likely			
Possible			
Unlikely			
Very unlikely			

Source: Adapted from WRI 2014.

Table 6.8: Considerations for evaluating significance of GHG sources and carbon pools for policies targeting enteric fermentation

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.
Biomass carbon sequestration	CO_2	This source may be significant when the policy intervention increases adoption of silvopastoral systems with trees resulting in increased density of trees on affected land compared to baseline. The magnitude of the effect varies considerably.
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. For example, when improved pasture management and silvopastoral systems are part of the policy (a) more fertiliser may be added to promote 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 expansion of and overall demand for fertilisers pastures compared to baseline and this will reduce N_2O emissions.
Manure management	N_2O, CH_4	This source may be significant when the policy intervention impacts the amount of time 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	N_2O	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.
Electricity/heat/fuel combustion	CO_2	Electricity emissions are expected to be insignificant for most policy interventions and can be excluded from the GHG assessment boundary. There may be some situations where this source needs to be considered more carefully before excluding, for example when construction of new facilities (e.g., for livestock research/breeding/health) are included in the policy interventions.
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 is difficult to assess.

Table 6.9: Considerations for evaluating significance of GHG sources and carbon pools for policies targeting soil carbon sequestration

Source/ Carbon pool	Gas	Considerations
Soil carbon	CO_2	This source should be considered significant for all policies with interventions that target soil carbon sequestration.
Biomass carbon	CO_2	This source may be significant when the policy intervention involves increasing the density of trees on affected lands relative to baseline. The magnitude of the effect varies considerably.
Biomass burning	CO_2, CH_4, N_2O	If controlled burning occurs in the baseline, this source is likely not going to change significantly. In addition, overall this source has a relatively small magnitude of effect.
Nutrient management	N_2O	This source may be significant when the policy intervention involves increasing or decreasing nitrogen inputs to soils relative to baseline management practices. However, the net direction and magnitude of effects can vary greatly.
Manure management	CH_4, N_2O, CO_2	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.
Fuel combustion	CO_2	An increase in this source is likely to occur when policy interventions require increased use of machinery, such as moving earth to construct terraces and contour strips. A decrease can occur when the policy intervention leads to switching from conventional tillage to no-till or conservation tillage agriculture. However, the magnitude of the effect is probably minor.
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. 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. 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 five percent of the country's total production), the estimated volume of goods displaced can be used to estimate the hectares 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. As part of its Jurisdictional and Nested REDD+ programme, the VCS Program provides guidance for quantifying the effective area needed to

		maintain production[3] and guidance for evaluating the volume of foregone commodity production.[4] Both of these resources can be adapted to assess the significance of an agricultural policy on supply or demand.

6.3 Define the assessment period

It is a *key recommendation* to define the assessment period. The assessment period is the time period over which impacts resulting from the policy are assessed. The starting date and the duration of the assessment period may vary depending whether or not an ex-ante or ex-post assessment will be conducted.

Where possible, users should align the assessment period with other assessments being conducted using ICAT guidance. For example, where users are assessing the agriculture policy's sustainable development impacts using the ICAT *Sustainable Development Guidance* in addition to assessing GHG impacts, the assessment period should be the same for both the sustainable development and GHG impact assessment.

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 (as described in Section 6.1.1, Step 3).

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 emission by 50% by 2020)
- The length of time for which the policy is funded or expected to be funded
- A period in time that has otherwise been identified as the policy implementation end date
- 20-year assessment period (based on rationale discussed below)

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

[3] Guidance for quantifying the effective area needed to maintain production is provided in the Verra *Global Commodity Leakage Module: Effective Area Approach*. Available at: http://verra.org/methodology/vmd0036-global-commodity-leakage-module-effective-area-approach-v1-0/

[4] Guidance for evaluating the volume of foregone commodity production is available in the Verra *Global Commodity Leakage Module: Production Approach*. Available at: http://verra.org/methodology/vmd0036-global-commodity-leakage-module-effective-area-approach-v1-0/

reached. IPCC suggests a default 20-year transition period for soil carbon dynamics to reach a new equilibrium.[5]

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.

Ex-post assessment

For an ex-post assessment, the assessment period can be the period between the date the policy or action is implemented and the date of the assessment or it can be a shorter period between those two dates. The assessment period for a combined ex-ante and ex-post assessment should consist of both an ex-ante assessment period and an ex-post assessment period.

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.

6.4 Identify sustainable development impacts (if relevant)

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.

Refer to the ICAT *Sustainable Development Guidance* for guidance on conducting an assessment of sustainable development impacts. Table 6.10 lists examples of sustainable development impacts that may be associated with agriculture policies, categorised according to the ICAT *Sustainable Development Guidance*. The Sustainable Development Goals (SDGs) most directly relevant to each impact category are indicated in parentheses.

[5] IPCC 2006.

Table 6.10: Examples of sustainable development impacts relevant to agriculture policies

Dimension	Groups of impact categories	Impact categories
Environmental impacts	Air	• Air quality • Visibility • Odours
	Water	• Availability of freshwater (SDG 6) • Water quality (SDG 6, SDG 14) • Biodiversity of freshwater and coastal ecosystems (SDG 6, SDG 14)
	Land	• Biodiversity of terrestrial ecosystems (SDG 15) • Depletion of soil resource (SDG 15) • Land-use change, including deforestation, forest degradation, and desertification (SDG 15) • Soil quality (SDG 2) • Soil erosion
	Waste	• Treatment of solid waste and wastewater (SDG 6)
	Other/cross-cutting	• Resilience of ecosystems to climate change (SDG 13) • Energy (SDG 7) • Depletion of nonrenewable resources • Toxic chemicals released to air, water and soil • Terrestrial and water acidification (SDG 14) • Infrastructure damages from acid deposition
Social impacts	Health and well-being	• Hunger, nutrition, and food security (SDG 2) • Access to safe drinking water (SDG 6) • Access to land (SDG 2)
	Education and culture	• Capacity, skills, and knowledge development (SDG 4, SDG 12) • Climate change education, public awareness, capacity-building and research
	Institutions and laws	• Strengthening land tenure • Public participation in policy-making processes • Access to information and public awareness (SDG 12)
	Welfare and equality	• Poverty reduction (SDG 1) • Protection of poor and negatively affected communities (SDG 12) • Gender equality and empowerment of women (SDG 5) • Indigenous rights
	Labour conditions	• Labour rights (SDG 8) • Quality of jobs (SDG 8) • 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) • Economic productivity (SDG 8, SDG 2)
	Employment	• Jobs (SDG 8) • Wages (SDG 8) • Worker productivity
	Business and technology	• New business opportunities (SDG 8) • Innovation (SDG 8, SDG 9) • Competitiveness of domestic industry in global markets
	Income, prices and costs	• Income (SDG 10) • Prices of goods and services • Costs and cost savings • Market distortions (SDG 12) • Internalisation of environmental costs/externalities • Cost of policy implementation and cost-effectiveness of policies
	Trade and balance of payments	• Balance of trade (imports and exports) • Foreign exchange • Government budget surplus/deficit